Examining the Effects of Socially-Shared Emotion Regulation on Team Coordination in a Physics Programming Competition

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Abstract

Coordination is at the heart of effective teamwork and contributes to shared mental models and mutual trust of team members (Salas, Sims, & Burke, 2005). However, successful coordination does not always occur. This research looks at the components that lead to effective coordination and team performance. In particular this dissertation examines the prerequisites for effective coordination and identifies the role of socially shared emotion regulation (SSER; Järvelä & Hadwin, 2013) in the management of challenges that hinder the development of the afore-mentioned coordination mechanisms.

This mixed design study examined 48 international participants who interacted in 16 teams of two to five in a two-day physics programming competition (i.e., hackathon). A qualitative approach was used to identify the types of challenges that teams faced in this socio-emotionally challenging context, as well as the SSER strategies they applied to overcome obstacles. An inclusive list of 16 challenge types that teams faced during teamwork was created and classified into major categories of cognitive, motivational, emotional, and behavioural challenges. The findings also resulted in a process model of "team emotion regulation" that expands Gross's (1998) individual emotion regulation model. A quantitative analysis revealed that teams who applied more SSER strategies demonstrated higher levels of (a) mutual trust, and (b) shared mental models at challenging moments. These findings have implications for enhancing team performance in teams with coordination breakdowns by focusing on SSER strategies that can lead to resolutions of challenges in complex collaborative settings.

Résumé

La coordination est un élément essentiel à un travail d'équipe efficace et contribue au modèles mentaux partagés et à la confiance mutuelle des membres de l'équipe (Salas, Sims & Burke, 2005). Cependant, il arrive que la coordination ne soit pas optimale au sein d'une équipe. Cette recherche observe les composantes qui mènent à une coordination efficace et à la bonne performance d'une équipe. Plus particulièrement, cette dissertation examine les prérequis à la coordination efficace et identifie le rôle de la régulation des émotions socialement partagées (RESP; Järvellä & Hadwin, 2013) dans la gestion de défis qui entravent le développement des mécanismes de coordination.

Cette étude se base sur l'observation de 48 participants internationaux qui ont interagi en 16 équipes de deux à cinq personnes lors d'une compétition de programmation d'une durée de deux jours portant sur la physique (hackathon). Une approche qualitative a été utilisée pour identifier les types de défis rencontrés par les équipes dans ce contexte émotionnellement et socialement éprouvant ainsi que les types de RESP qui ont été utilisées pour franchir ces obstacles. Une liste inclusive de 16 types de défis rencontrés par les équipes pendant le travail d'équipe a été créée puis ces défis ont été classés en quatre catégories: cognitifs, motivationnels, émotionnels et comportementaux. Les découvertes ont aussi résulté en un "modèle de régulation des émotions d'équipe" qui va plus loin que le modèle de régulation des émotions individuelles de Gross (1998). Une analyse quantitative, quant à elle, a révélé que les équipes qui ont appliqué plus de stratégies de RESP ont fait preuve de plus grand niveaux de (a) confiance mutuelle, et (b) modèles mentaux partagés lors des moments plus difficiles. Ces résultats ont des implications qui touchent à l'augmentation de la performance d'équipe en mettant l'emphase sur les stratégies de

RESP lorsque la coordination fait défaut. Ces stratégies peuvent faire en sorte que les équipes surmontent les défis qui prennent forme dans des contextes collaboration complexes.

Dedication

I lovingly dedicate my doctoral dissertation to the best lady of my life, Zahra (PBUH).

I also dedicate this thesis to my husband, Hossein Mirzapour. Google Scholar's motto is "stand on the shoulders of giants". You are the giant whose shoulders I stood on! You, who are already way ahead of me, multi-dimensionally…

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CHAPTER 1

INTRODUCTION

Learning has been shifting from a purely teacher-centered endeavor to learning collaboratively in social environments; such as small group learning, problem-based learning and learning in teams (Isohätälä, Järvenoja, & Järvelä, 2017). Teams have the potential to provide more complex, innovative and comprehensive solutions to assigned problems than any one individual can offer (Gladstein, 1984). Teamwork also has advantages for individuals in that it can serve as a powerful tool to foster 21st century core competencies such as leadership, responsibility, and adaptability; and can also enhance student inspiration and motivation (Salas, Reyes, & McDaniel, 2018). At the heart of successful teamwork is effective *team coordination*, with key components such as shared mental models and mutual trust (Salas, Sims, & Burke, 2005). Shared mental models are the common knowledge structures of team members that enable them to describe, explain and predict the behavior of their team (Cannon-Bowers et al., 1993, p. 228). Mutual trust refers to the shared belief that team members will perform their tasks and protect the interest of other team members (Salas et al., p. 561). Studies, conducted mainly in the organizational psychology domain, have shown that teams can reach their full potential if these coordination mechanisms are applied effectively (Salas et al., 2018).

However, the empirical literature has also shown that collaborative learning teams face challenges that may hinder their coordinating attempts and decrease team performance and overall learning gains (Isohätälä et al., 2017; Järvelä, Volet, & Järvenoja, 2010; Volet & Mansfield, 2006). For example, Reise et al. (2015) found that students sometimes spend more time in the resolution of socio-emotional conflicts than working towards their projects. Therefore, it is important to identify such challenges and be aware of them. Dealing with such

challenges also requires team members to apply effective interpersonal skills such as socially-shared emotion regulation, which encompasses shared and interactive regulatory processes where team members manage their shared emotionally challenging situations together (Gross, 2002; Järvenoja & Järvelä, 2009; Järvenoja, Volet, & Järvelä, 2013; Thompson & Fine, 1999; Ujitani & Volet, 2008). Socially-shared emotion regulation (SSER) is especially important when socio-emotional obstacles such as different goals and varied levels of engagement, concentration and commitment between collaborative learners hamper the overall team performance towards reaching the team's shared learning goals (Ainley, 2007). This growing body of work has highlighted the need for fostering SSER to promote collaborative learning and manage team socio-emotional obstacles.

However, while studies of emotion regulation within the individual learning context are well established (e.g. Folkman & Lazarus, 1988; Gross, 2015), researchers have just recently begun showing interest in studying SSER in collaborative settings. Likewise, there is a paucity of empirical investigations that have examined the consequences of students' SSER decisions and efforts on team coordination in the academic domain. Accordingly, the present research examines the relationship between students' SSER attempts and whether and how it influences shared mental models, and also mutual trust in learning teams, specifically within socio-emotionally challenging contexts.

Theoretical Framework

A social constructivism framework is used as the basis for understanding team coordination. Social constructivism is a theoretical paradigm that emphasizes the pivotal role of the social context for knowledge construction (Greeno, Collins, & Resnick, 1996). Team coordination refers to the harmonious collaboration of team members that need to work together

in a timely and orderly fashion in order to achieve a shared goal (Salas et al., 2005); for example, accomplishing a complex collaborative project. As mentioned earlier, two of the key team coordination mechanisms are shared mental models and mutual trust (Salas et al., 2005). Shared mental models are developed only when *agreement* is reached around co-constructed *understandings.* However, members may have diverse perspectives and paradoxes or conflict (de Wit, Greer, & Jehn, 2012) may emerge when they attempt to accept a novel solution. The inability to build a mutual understanding may occur when such conflicts occur leading to a productive or counterproductive argument. Trust is built on expectations of other team members that have an emotional component (Jones & George, 1998). If these expectations are broken, individuals often experience negative emotions (e.g. anger) that may lead to trust dissolution.

Unresolved challenges may lead to undesired emotional arousal and reduced team coordination (van den Berg et al., 2014). SSER refers to the social, shared, and interdependent emotional regulatory processes that team members harmoniously apply to regulate the emotions of the team (rather than individuals) to reach a shared outcome (Järvenoja & Järvelä, 2009; Panadero & Järvellä, 2015). Therefore emotion regulation strategies (including SSER) may help mitigate such challenges and ameliorate team coordination. The SSER concept is also grounded in social-constructivist theory and Vygotsky's (1978) view that higher psychological processes are socially embedded or contextualized through social interaction (McCaslin, 2009; Wertsch & Stones, 1985).

Study Aims and Research Questions

This study aims to understand effective teamwork by identifying the types of challenges that occur in collaborative learning contexts and how SSER strategies are used to mitigate such challenges. Furthermore it examines the role of SSER on coordination mechanisms, namely

shared mental models and mutual trust towards reaching effective team performance. In brief, the study addresses the following research questions:

1. What are the challenges that impede the development of shared mental models and mutual trust in socio-emotionally challenging learning environments?
2. What SSER strategies do teams apply in managing emerging challenges that hinder their coordination?
3. Is there a relationship between applying SSER and building team coordination mechanisms within socially-challenging learning teams?

A programming competition, referred to as a hackathon, was chosen for the context of the study as its authenticity and competitive collaborative nature can provide rich opportunities for addressing the research questions. Hackathons (Raatikainen, Komssi, Dal Bianco, Kindstom, & Jarvinen, 2013) or coding marathons are a specific type of computer-supported collaborative learning context (Nussbaum et al., 2009). Hackathons by their nature require teamwork and rely on effective communication skills, highly convergent shared mental models and mutual trust levels for learners to tackle problems together and accomplish their projects. Competitive hackathons, in essence, present a challenging atmosphere where programming teams strive to meet their designed goals to win the competition within time limitations. Hackathons have been used in different contexts (e.g., computer science, robotics, medicine, and physics) and have been found to be an innovative and exciting way to engage students to learn collaboratively (Aungst, 2015; Mtsweni, & Abdullah, 2015). However, despite the increasing popularity of hackathons, negligible empirical data has been reported about their effectiveness or the nature of the team experiences.

Overview of Chapters

This dissertation is organized into five chapters. Chapter 2, *Literature Review*, examines the prior literature on how shared mental models and mutual trust can be fostered in computer-supported collaborative learning environments to increase team performance, as well as the empirical literature on the role of SSER in contributing to the maintenance and development of the two afore-mentioned team coordination mechanisms. Chapter 3, *Methodology*, describes the hackathon context that was analyzed to test these hypotheses, while Chapter 4, *Results*, documents the study's qualitative findings. Challenging factors that can impede the development of shared mental models and mutual trust, and regulatory processes that can benefit teams in managing such challenges are provided in detail with example excerpts. Next, quantitative findings are described to identify the relationship between SSER and two coordination mechanisms. Chapter 5, *Discussion*, summarizes the findings of this study in light of the literature, discusses implications for future research and practice, acknowledges the study's limitations, and highlights its novelty and contributions to the literature.

CHAPTER 2

LITERATURE REVIEW

This chapter is based on the comprehensive examination of the literature in terms of challenges within teamwork, and emotion regulation strategies in the context of such challenges. We also aimed to understand the theoretical relationship between (a) SSER and mutual trust, and also (b) SSER and shared mental models. The chapter starts by describing team performance and the development of key team coordination mechanisms (i.e., shared mental models and mutual trust), and ends with scoping current analytical approaches towards examining team coordination and SSER mechanisms.

Team Performance and Team Coordination

Research so far has achieved remarkable progress in the knowledge base and in practice of teams. Almost a century of research has uncovered knowledge about team-related processes and outcomes (Salas et al., 2018). Findings have revealed evidence-based frameworks and methodologies that can be applied to a range of teams; from simple to complex. To date, there have been numerous theoretical frameworks developed to account for team performance (Marlow, Lacerenza, & Salas, 2017). These theories have guided a plethora of empirical research, offering a better lens to examine team dynamics.

The existence of multiple theories, however, has its own disadvantages, one of which is labeling issues that make it difficult to articulate the contributions of various authors who use the same words to mean different things (e.g., team in contrast to group) or use different labels for the same concept (e.g., shared mental models, team knowledge, common cause maps, shared frames, teamwork schemas, team situational awareness, socio-cognition, collective cognition). Apart from this limitation, in the globalization era, new formats of teams have emerged (e.g.,

virtual teams, multicultural teams, teams of teams, and interdisciplinary teams) that use new means of collaboration and coordination and need deeper examination, understanding and testing (Salas et al., 2018). Global phenomena (e.g., natural disasters, global competitions) have witnessed how breakdown in teamwork has led to life-threatening situations and severe loss of opportunities, and how success in teamwork has yielded safe practices and remarkable accomplishments. Scientific research teams in industries such as avionics, health care, management and sports still invest in understanding what facilitates or hinders effective coordination and collaboration (Thomas, 2018). Likewise, in the educational context, researchers have become more interested in enhancing learners' collaborative skills for their better learning gains (Eccles & Tennenbaum, 2004; Weaver & Salas, 2010). The relevance of teamwork in the way learning and work is done in the 21st century necessitates a deeper understanding of how to manage and measure team performance to keep pace with new demands of the interconnected, multidisciplinary, multicultural, and ever changing world we live in (Salas, Kozlowski, & Chen, 2017; Driskell, Salas, & Driskell, 2018).

In this section several team-related concepts (i.e., team, teamwork, team performance and team effectiveness) and a newly-emerged type of team (hackathon) will be initially defined. Further, a team performance framework that has been validated through robust empirical research will be presented. And finally, team coordination mechanisms, namely shared mental models and mutual trust, and their development will be deeper examined.

Clarification of Key Team-Related Concepts

Team. A team is defined as "two or more individuals with distributed expertise interacting adaptively, interdependently, and dynamically toward a common and valued goal" (Salas et al., 2005, p. 582). Given this definition, it is important to distinguish teams from

groups, as within groups members can be homogeneous with respect to expertise and responsibilities, in which case they will not necessarily be interdependent vis-à-vis one another. Interdependence refers to the extent to which "individuals' outcomes are affected by other team members' actions" (Johnson & Johnson, 1989, p. 2). Thus while all teams are groups, the converse is not necessarily so (Klimoski & Mohammed, 1994). This definition highlights that teams are specifically used when the task complexity surpasses the capacity of an individual to address the problem (Kirschner, Kirschner, & Janssen, 2014) cognitively, emotionally, motivationally and/or behaviorally; and requires collective expertise to overcome the complex multidimensional challenges that arise during task performance.

Learning team. A learning team is a specific kind of a team comprising a collaborative group of learners with ascribed roles and specified interdependent tasks that complement each other towards reaching shared learning goals (Sweet & Michaelsen, 2012). These shared learning goals involve processes of knowledge co-construction towards achieving deep learning while students collaboratively work on a multifaceted assignment, design a project, or solve a complex problem (e.g., a team of students working on a complex authentic problem-based learning project on forest preservation from greenhouse gas emissions).

The extent to which collaborations between team members lead to the learning goals depends on the quality of the interactions, especially the process of building and maintaining shared understanding (Kirschner, Beers, Boshuizen, & Gijselaers, 2008; Roschelle & Teasley 1995). Also, mutual trust has been shown to be key to successful collaboration (Fransen et al., 2013; Fransen, Kirschner, & Erkens, 2011; Marks, Mathieu, & Zaccaro, 2001). Extant literature has reported that learning within teams has benefits over individual learning for: (a) the *team*, enabling increased achievement, enhanced productivity and the generation of more complete

reports, (b) the *individual members*, enhancing their levels of motivation, enriching their learning gains, and advancing their 21st century skills through engaging in complex discussions (Järvellä, Järvenoja, & Veermans, 2008; Laal & Ghodsi, 2012); and, (c) the *tutor*, freeing up time to listen to and observe students (Sibley & Parmelee, 2008).

Learning teams share similarities with various group-based learning environments such as cooperative learning, collaborative learning, small group learning as well as problem-based learning (Schoor, Narciss, & Körndle, 2015), but have a unique difference in that the learning team is a group of interdependent learners who have differentiated responsibilities to complement each other in reaching an overall learning goal in a timely and orderly manner. However, learning teams have specific characteristics that resemble with collaborative learning groups where members share information and resources for mutually-accepted goals. In certain instances and depending on the task type, a collaborative learning group can turn into a coordinated team of learners (Mattessich & Monsey, 1992).

Computer-supported collaborative learning teams. A specific type of coordinated team of learners is computer-supported collaborative learning teams (CSCL teams). CSCL is an evolving branch of the learning sciences that examines how learners can learn together with the aid of computers (Stahl, Koschmann, & Suthers, 2006). Research on CSCL has considerable overlap with research on teams (Fransen et al., 2013; Roschelle, 2013); and concepts of shared knowledge building of CSCL closely resonate team concepts such as SMMs. Fransen and colleagues (2013) have emphasized that learners in CSCL actually function as teams in order to fulfill their task work and teamwork. However, the wealth of research in team studies and organizational literature is neglected in CSCL and educational contexts.

CSCL is designed to enhance learning through collaboration and technology, and can be concerned with face-to-face or online collaboration (Stahl et al., 2006). Students learn by discussing, debating, teaching each other and collaboratively constructing knowledge with the support of computers. In some cases, CSCL uses a variety of interactive tools (e.g., multimedia, shared online workspaces, shared metacognitive widgets) to support shared understanding, and displays (e.g., graphical or text-based representations of other team members' actions, and rapid analysis and representation of complex task work and teamwork) to provide continuous updates of the team interactions (e.g., Derry & Lajoie, 1993; Martinez-Maldonado, Dimitriadis, Martinez-Monés, Kay, & Yacef, 2013). These tools can enhance individual and shared cognitive performance (Kirschner et al. 2014), and stimulate knowledge co-construction among CSCL team members (Stahl, 2004). In other cases, CSCL takes the form of face-to-face collaborative learning with the aid of computers, where students might use a computer as simple as browsing through information on the web to discuss and learn collaboratively, or more complex where student teams are developed to learn while building novel and creative software programs collaboratively.

Most CSCL research has studied virtual learning environments (e.g., Kazemitabar et al., 2016) as a tool for quantitative evaluations of student learning. However, in the case of virtual environments, it is often difficult to measure natural communications and collaborations between students. Therefore, the scope of empirical research needs to direct more attention towards conducting face-to-face CSCL in real world collaborative studies where it is possible to observe the natural behavior of students in the process of knowledge co-construction with their peers via support of computers (Nussbaum et al., 2009; Stahl et al., 2006).

A recently emerging face-to-face CSCL environment is a hackathon (e.g., Li, & Johnson, 2015; Linnell, Figueira, Chintala, Falzarano, & Ciancio, 2014). As mentioned earlier, hackathons or marathon coding events, include rapid software development where teams of hackers (i.e., individuals who are technically adept and have passion for solving technology-related problems collaboratively), in collaboration with researchers and related stakeholders, design, code, and build testable software prototypes (Briscoe & Mulligan, 2014; Cooper, Siefert, & Weinreb, 2018). Hackathons have mainly been used in large organizations such as Google and Microsoft (Briscoe & Mulligan, 2014) in order to build new solutions and recruit bright software developers, and are only slowly finding a niche in the academic domain (e.g., computer science, robotics, electronics, physics, etc.) to motivate students to embrace latest technologies and enhance student learning. Hackathons are mainly centered on a theme or a problem proposed by the organizers, and provide students opportunities to work collaboratively on practical projects that offer real-world experiences and engaging challenges (Mtsweni & Abdullah, 2015).

It is important to note that hacking is not only limited to computers or software, but could be applied in a number of domains, such as music, electronics, or any level of ‘science or art’ (Raymond, 2017). This culture spawns from the open source approach of developing technological solutions within a community, where everyone, irrespective of background or expertise, is encouraged to contribute towards addressing existing real-life challenges. Hence, the hacking culture is not only about programming or software coding, but involves a number of iterative steps (e.g. research, design, and analysis) to address complex and simple computing challenges.

The key elements of hackathons are hands-on engagement on authentic problems, computing projects, networking, mentoring, and teamwork. Therefore, hackathons have several

social benefits such as high collaboration, deep inspiration, and enhanced motivation to learn and contribute; and thus the hackathons are usually repeated in the near future (Raatikainen, Komssi, Dal Bianco, Kindstom, & Jarvinen, 2013). However, due to their new emergence, minimal empirical research has been conducted to analyze student learning within such contexts (Cooper, Siefert, & Weinreb, 2018). One major contribution of the current research is its focus on an academic hackathon; a novel and authentic face-to-face CSCL setting.

Teamwork. Teamwork is a "set of interrelated thoughts, actions, and feelings of each team member that are needed to function as a team and that combine to facilitate coordinated, adaptive performance and task objectives resulting in value-added outcomes" (Salas et al., 2005, p. 562). Teamwork is different from task-work which refers to the knowledge, behaviors and attitudes to accomplish individually-assigned tasks. In contrast, teamwork refers to interdependent competencies of team members to coordinate and cooperate in order to effectively progress towards the shared goals as task demands shift throughout a performance period. In other words, task-work refers to what needs to be accomplished, and teamwork refers to how work needs to be accomplished (Mohammed, Ferzandi, & Hamilton, 2010).

Team performance. Team performance is a multifaceted process of individual- and team-level taskwork and teamwork (Kozlowski & Klein, 2000). The process towards developing shared mental models is one such type of team performance that has been the focus of much research (Denzau & North, 1994; Mathieu, Heffner, Goodwin, Salas, & Cannon-Bowers, 2000). This established area of research suggests that effective team performance requires team members to hold shared understanding of the team mission, role responsibilities, available resources and appropriate procedures.

The team performance model. The literature has identified a vast range of factors that influence team performance (Baranski et al., 2007; Urban, Weaver, Bowers, & Rhodenizer, 1996) ranging from team composition (e.g., personality, cognitive ability, motivation, cultural factors) and context structure (e.g., team norms, communication structure, learning assignments), to task characteristics (e.g., workload, task type, interdependency). Based on these factors, numerous models and theoretical frameworks have been developed to structure team performance. These frameworks may pertain to factors affecting team performance such as team coaching (Hackman & Wageman, 2005), team leadership (Zaccaro, Rittman, & Marks, 2002), team communication (Marlowe, Lacerenzab, Paolettia, Burke, & Salas; 2018), team training (Cannon-Bowers & Salas, 1997), shared mental models (Mohammed & Dumville, 2001), virtual teams (Schiller & Mandviwalla, 2007) etc., or have a narrower focus on specific contexts that cannot be generalizable (e.g. Baker, Cote, & Abernethy, 2003; Reader, Flin, Mearns, & Cuthbertson, 2009). In the ever changing climate of team research and with the emergence of new variables into original team settings and enriched studies of team science, these factors need to evolve and models require advancement to embrace new concepts (Marlowa, Lacerenzab, Paolettia, Burke, & Salas; 2018).

For example, the increasing popularity of globally distributed learning teams raises the possibility that the existing models (generated primarily on the basis of data from Western populations) may be inadequate to describe teams with multicultural compositions (Klein & McHugh, 2005). In addition, a majority of these models reveal inconsistent factors that contribute to the understanding of team performance. As Marlow et al. (2017) argue, the increased incongruence may be due to a lack of agreement as to which factors are appropriate and which are not. Although based in organizational science, these authors have established a

general framework to address team performance that can be empirically supported and practically relevant in other contexts. This framework, entitled “the big five in teamwork” (Salas et al., 2005) is one of the most commonly used frameworks as it offers an inclusive taxonomy of components that most heavily influence team performance (Hosseini, Martek, Chileshe, Zavadskas, & Arashpour, 2018; Kirschner, Kreijns, Phielix, & Fransen, 2015; Rosenfield, Newell, Zwolski, & Benishek, 2018).

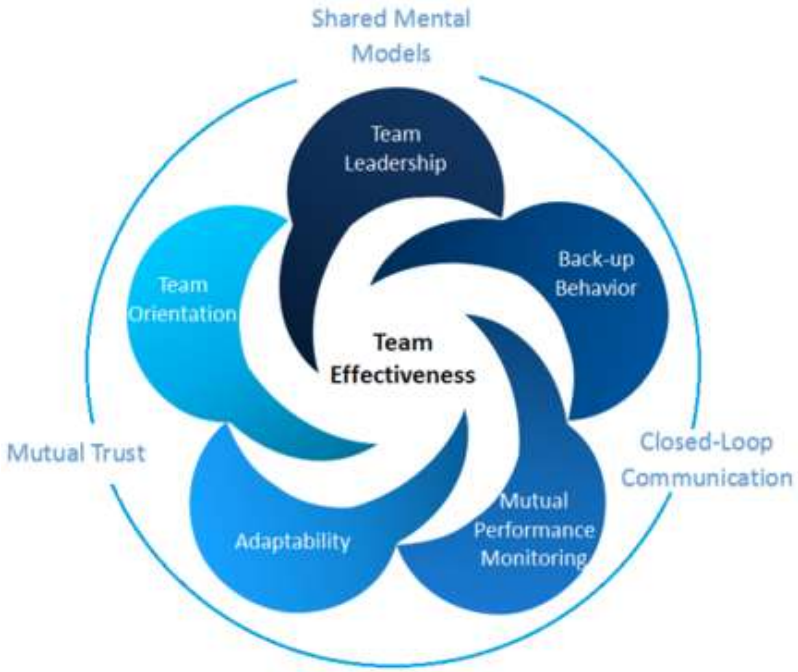


Figure 1. The big five of teamwork (Salas et al., 2005).

These components are derived from a thematic analysis of the most frequent variables used in previous literature to address team performance, and are labelled as leadership, mutual performance monitoring, team orientation, backup behavior, and adaptability. Figure 1 depicts a graphical representation of the five core factors influencing team performance. For reasons of space and clarity of presentation, a definition of these factors is provided as a table in Appendix A. Through this framework, coordination strategies are essential mechanisms that need to meld the five factors together. These coordinating mechanisms are labelled as (a) closed-loop

communication, (b) shared mental models and (c) mutual trust; and are further elaborated in the proceeding section.

Team Coordination

Coordination plays a central role in effective team performance and refers to the organization and alignment of the cognitions, behaviors, emotions and motivations of a team of individuals in order to work together effectively (Elias & Fiore, 2012; Fisher, 2014; Salas & Rosen, 2013). Coordination refers to the synchronization and harmonious alignment of different parts of a team or a system that need to work together in a timely and orderly fashion in order to achieve a superordinate goal. A simple example of a system can be a bicycle where all parts need to work accordingly in order for the whole to move a person from one point to another. The dysfunction of even a small part may reduce the functionality of the bicycle and if the movement of all of the gear wheels are not coordinated with one another, the bicycle will not move forward at all. This is similar to the functionality of a team of individuals, where the performance of each member contributes to the collective success. Similar to the bicycle example, the causes of team failure may belong not only to member inability, but also to the collective breakdown of a team to coordinate and synchronize their individual contributions (Easterbrook, 1995; Wilson, Salas, Priest, & Andrews, 2007).

The coordination model. As mentioned earlier, Salas et al. (2005) propose the coordinating mechanisms for effective teamwork which include the development of shared mental models (e.g., Stout, Cannon-Bowers, Salas, & Milanovich, 1999), achievement of mutual trust (e.g., Webber, 2002), and engagement in closed-loop communication (e.g., McIntyre & Salas, 1995). Through sharing similar goals of the teamwork and holding common norms for working with each other, knowing each other's strengths and weaknesses and making use of

them, and trusting each other to do what has been agreed upon, Fransen and colleagues (2013) have argued that even randomly assigned groups of learners can develop into well-functioning coordinated teams.

In the following section, the three afore-mentioned principal mechanisms will be deeper elaborated with a specific focus on shared mental models and mutual trust as these factors provide the baseline for addressing the questions of this study.

Closed-loop communication. Communication is the activity of sharing information between two or more individuals through a common system of language and signs irrespective of the medium (McIntyre & Salas, 1995). There are different types of communication, such as vocal verbalizations, behavioral signaling, or text-based sharing of information. The quality of communication in different contexts depends on the extent to which the message is precise, clear, timely, with appropriate vocabulary, and closed-loop. Closed-loop communication refers to a reciprocal procedure of information exchange, acknowledgement of receipt and confirmation that the planned message was delivered (McIntyre & Salas, 1995). It should be noted that this definition of communication is from the standpoint of an information processing paradigm, in which communication refers to information sharing as unidirectional instructing or commanding from one person to others. Shifting from this paradigm and through the lens of the knowledge construction theory, communication encompasses a wide array of knowledge co-construction skills such as the bidirectional ability of members to negotiate, compromise, reconsider, explain, and listen to each other (Järvenoja & Järvellä, 2009). In this case, communication refers to someone socializing an idea or a comment, and others building upon that idea (Kanuka & Anderson, 2007).

Shared mental models. As described earlier, shared mental models refer to "knowledge structures held by members of a team that enable them to form accurate explanations and expectations for the task, and in turn coordinate their actions and adapt their behavior to demands of the task and other team members" (Cannon-Bowers et al., 1993, p. 228). Shared mental models contribute to the understanding of the nature of coordinated team performance, team problem solving, and team decision making (Cannon-Bowers et al., 1993; Hung, 2013; Roschelle & Teasely, 1995).

It should be clarified that shared mental models are not identical mental models, but rather compatible mental models that lead to common structuring of the team goals, role responsibilities and task requirements. Various terms have been used to capture "shared" including similar, convergent, compatible, consistent, overlapping, and common (Mohammed et al., 2010). This property of shared mental models is also called similarity. Similarity refers to "the extent to which individual team member mental models are shared" (Wildman, Salas, & Scott, 2013, p. 3). However, relying only on similarity in highly convergent mental models may be inaccurate and may cause errors in predicting team performance. Therefore researchers also focus on the accuracy of shared mental models or "the extent to which the team's mental model is correct as determined by comparison to an expert model" (Wildman et al., 2013, p. 3) and suggest that only accurate shared mental models can reflect the accurate state of the world (Edwards, Day, Arthur, & Bell, 2006). Similarity and accuracy of shared mental models are respectively analogous to reliability and validity of scientific research. The literature has shown that it is through a combination of similar and accurate shared mental models that the greatest team performance benefits can be achieved (Edwards et al., 2006).

The development of shared mental models. In order to achieve shared representations of key team processes (i.e., task-work and teamwork) and form team learning, changes in the knowledge structure of the team members needs to occur. This change happens through the development, modification and reinforcement of individual mental models (Mohammed & Dumville, 2001), via interaction between the team, which serves as a principal source to mental model convergence (Van den Bossche, Gijselaers, Segers, Woltjer, & Kirschner, 2010). However, the content of an interaction between team members may not always be processed sufficiently and attentively to become part of a mental model and cannot always be called a team learning interaction. Thus relying only on team conversations to infer mental model convergence may lead to an overestimation of a team's shared mental models (Jeong & Chi, 2007). Rather, a deliberate effort is required to process and integrate a contribution within an existing mental model. Based on what Van den Bossche et al. (2010) found, the team learning interactions refer to a two-step process of (a) mutual understanding, and (b) mutual agreement. Mutual understanding, or understanding each other's representations, occurs through construction and co-construction of meaning. Further, mutual agreement refers to accepting and incorporating each other's ways of seeing (Dillenbourg & Traum, 2006; Gabelica, Van den Bossche, Fiore, Segers, & Gijselaers, 2016). The two step process implies that shared mental models are developed only when *agreement is reached around (co-)constructed understandings*. These shared mental models provide the basis for successive team actions.

The process of building mutual understanding of a problem or situation begins with the externalization of personal information and ideas in the team environment while other team-members actively listen (Kirschner et al., 2014). When team members try to grasp the given explanation, they engage in constructing meaning to understand the situation at hand (Webb &

Palincsar 1996). In this situation team members may attempt to build on or modify the original contribution in some way. Therefore, construction evolves into collaborative construction (co-construction), which is a shared process of collaboratively building new meanings that were not previously available to the team. These meanings must also be accepted and internalized in order to form the basis of subsequent action. If accepted, the offered meaning can become part of the shared mental model that is the agreed-upon interpretation of the situation.

However, diversity of perspectives and perhaps conflict (De Dreu & Weingart, 2003; de Wit et al., 2012) emerges when attempting to accept an unforeseen solution. Team members may diverge in their interpretation and tackle the situation from different perspectives. This rejection of the built understanding may lead to a productive or counterproductive argumentation. Conceptual advancement may result from further elaboration and negotiation of the different meanings brought into discussion. But on the other hand, as De Dreu and Weingart (2003) state, these differences may be viewed as a paradox in the interpretation of the problem (i.e., task conflict) or a personal rejection of incompatibilities among team members (i.e., relationship conflict). Recent research investigating the consequences of different types of conflict shows that unproductive conflict interferes with building shared mental models, decreases member satisfaction, and raises negative emotions within the team (Peterson, Mannix, & Trochim, 2008; McKibben, 2017; Nair, 2008; van den Berg, Curseu, & Meeus, 2014). The team will only benefit if divergence in meaning is valued and can lead to deep-level processing of the different information and multiple viewpoints in the team (Homan, van Knippenberg, van Kleef, & De Dreu, 2007) towards convergence of meaning and development of shared mental models.

The link between shared mental models and team coordination. Stout et al., (1999) suggested that the manner in which shared mental models operate is related to task demands. In

low work pressure and when team members can freely communicate information with each other, having pre-established shared mental models will not be crucial to strategize further steps. However, under high task load and time pressure when communication gets difficult, shared mental models become vital to effective team coordination and performance because they allow members to predict the actions and requirements of other teammates. Hence, members are able to further act appropriately according to their shared understanding of the estimated emerging task-work and teamwork demands. It is this ability to adapt quickly that enables teams to be coordinated and successful even in dynamically evolving situations. In this regard, the empirical literature has contributed strong evidence to support the effects of shared mental models in enhancing team coordination (e.g. DeFranco, Neil, & Clariana, 2011; Edwards et al., 2006; Gardner, Scott, & AbdelFattah, 2017; Johnson et al., 2011; Lim & Klein, 2006; Maynard & Gilson, 2014; Stout et al., 1999; Wood, 2013).

Mutual trust. In the big five framework, mutual trust is the last although not least factor that contributes to team coordination. In order for team members to increase their coordinating efforts, they need to be able to trust each other and the overall team environment. Scholars have widely agreed that trust can lead to enhanced teamwork among individuals in teams (e.g., Fallon, Panganiban, Chiu, & Matthews, 2017; Paul, Drake, & Liang, 2016; Wildman et al., 2012). This is especially the case in team tasks that entail uncertainty, since "when there is uncertainty, there must be some element of trust" (Jones & George, 1995, p. 533). Rousseau et al. (1998) defined trust as 'a psychological state comprising of the intention to accept vulnerability based upon positive expectations of the intentions or behaviors of another' (p. 395). From this perspective, trust leads to a set of expectations among team members, allowing them to manage the

uncertainty or risk associated with their interactions so that they can jointly optimize the gains that will result from their collective endeavor.

Within team environments, the reciprocal trust between team members is termed as *mutual trust* which refers to the "shared belief that team members will perform their tasks and protect the interest of other team members" (Salas et al., 2005, p. 561). This definition is composed of two parts, the first highlighting that team members must feel that the team is competent enough to accomplish their task, and the collective belief that the team can be effective. Different researchers have termed this concept as potency, collective efficacy, group efficacy, or team confidence (Collins & Parker, 2010; Ilgen, Hollenbeck, Johnson, & Jundt, 2005; Moolenaar, Sleegers, & Daly, 2012). The second part emphasizes that members must feel that the team does not harm an individual in the team or his or her values and interests. This concept is referred to as psychological safety (Ilgen et al., 2005; Reynolds & Lewis, 2018). Psychological safety is "the belief that one will not be punished or humiliated for speaking up with ideas, questions, concerns, or mistakes. It is a dynamic, emergent property of interaction and can be destroyed in an instant with an ill-timed sigh" (Reynolds & Lewis, 2018, p. 2). In the absence of trusting behaviors that maintain an acceptable level of psychological safety within a team, members may tend to become introverted, not fully contributing; and anxiety and defensive behavior may prevail (Peterson & Behfar, 2003).

Mutual trust is a principal factor in influencing the coordination of interpersonal interactions within social contexts in general, and teamwork in particular (Lee, Gillespie, Mann, & Wearing, 2010; Mach, Dolan, & Tzafrir, 2010; Martinez-Miranda & Pavon, 2011; Palanski, Kahai, & Yammarino, 2011). It should be noted that Salas et al. (2005) have emphasized on mutual (two-way) trust rather than one-way trust. They state that teams where

only one or a few members are trustworthy and reliable may not progress as well as teams where bidirectional mutual trust exists between all members. In the latter case, all members see each other as responsible and reliable (even if roles and workload may be different). The next section elaborates on how trust is conceptualized and what its features and dimensions are.

A multidimensional model of trust. Despite an overall agreement that trust is a complex multidimensional construct, scholars have not offered an in-depth discussion on how the cognitive, emotional and motivational elements of trust interact in order to direct consequent thoughts and behaviors (Pesämaa, Pieper, da Silva, Black, & Hair; 2013). One main categorization (e.g., Fallon et al., 2017; McAllister, 1995; Newell & Swan, 2000) mentions that relationships of interpersonal trust among team members are described by two dimensions of cognition-based trust (i.e., competence-based trust, measured through the extent of dependability and reliability) and affect-based trust (i.e., emotional trust or faith, measured through showing genuine care and concern). However, Jones and George (1998) argue that rather than asserting that different determinants lead to different types of trust (e.g., cognitive or affective), trust is like a dynamic experience in which multiple elements operate synchronously to produce an overall state of (conditional or unconditional) trust or distrust. The two concepts of conditional and unconditional trust will be elaborated in the following sections.

In examining the consequences of trust and the implications for team coordination, this research adopts Jones & George's (1998) interactionist model of trust that conceptualizes it as a changing and evolving experience, in which values, attitudes, and emotions operate simultaneously to produce a general state of trust or distrust in an individual within a social setting. In this definition (a) values determine standards of which types of behaviors, events, situations, or people are desirable or undesirable; (b) attitudes provide knowledge of other team

members' trustworthiness; and most importantly (c) emotions are signals by which members recurrently evaluate the ongoing quality of their trust experience in team interactions. Research has shown that positive emotions such as happiness and gratitude increase trust, and negative emotions such as anger decrease trust (Dunn & Schweitzer, 2005; Schniter & Sheremeta, 2014). This is because trust is built on evaluations and expectations of other team members that are partially emotional (Creed & Miles, 1996; Jones & George, 1998; McAllister, 1995). When these expectations are fulfilled, individuals experience positive emotions and strengthened bonds of trust; but when the expectations are broken, individuals often experience negative emotions that indicate trust impairment and the need to protect the at-risk interaction (Frijda, 1988). Also, since emotions refer to instantaneous feelings (Scherer, 2005), they contribute more than values or attitudes to the dynamic experience of trust (Jones & George, 1998).

Evolution of trust. In the interactionist model, trust evolves around three states of distrust, conditional trust, and unconditional trust. At the beginning of a team formation, each member does not simply assume that the other is trustworthy; rather, each member avoids beliefs that the other may not be trustworthy (Jones & George, 1998). The experience of future trust will be determined by the quality of the interactions between team members and the evolving attitude developed toward each other regarding the extent of member trustworthiness. At every interaction, the initial encounter on emotions affects the ongoing quality of interactions through influencing team members' immediate perceptions towards the trustworthiness of each other. Successful collaborations are accompanied by positive emotions, which help to "cement the experience of trust and set the scene for the continuing exchange and building of greater trust" (p. 536). In contrast, negative emotions are accompanied by undesirable judgements of another member and indicate trust deficiency. At significant points in the ongoing relationship such as

important accomplishments, members experience positive emotions which provide signals to them that they have not been put at risk by the actions of others and thus have succeeded in building positive attitudes and trust between each other. The point at which team members: (1) have strong confidence in each other's trustworthiness, (2) have desirable attitudes toward the success of their team members, and (3) experience positive affect in the context of the relationship, is a turning point in the evolution of trust.

In order to understand the experience of trust prior and subsequent to this point, Jones and George (1998) refer to two states of conditional and unconditional trust. They define conditional trust as a state of trust which is conditional to the constant appropriate behavior of team members, and members' attitudes (as their engine of sustaining conditional trust) toward each other are satisfactory enough to support upcoming collaborations; and are strengthened by adequate positive affect and sufficient absence of negative affect. In conditional trust, members build stable habitual trust expectations of each other (Hung, Robert, & Dennis, 2004) that standardize their interactions and make them predictable and reliable. In this state, people may have both trusting and distrusting intentions and expectations towards another, specifically if their relationship is complex and has different facets (Lewicki & Brinsfield, 2012). For example, they may trust each other in getting on time to an appointment, but not trust each other in finding the address without need of a map.

Unconditional trust exemplifies an experience of trust that arises when individuals terminate the belief of untrustworthiness towards each other and "believe" they can trust each other no matter what. This level of trust is because shared values (as the primary vehicle to the unconditional experience of trust) now structure their further interactions and orient them towards the future. With unconditional trust, team members' trustworthiness to each other is

secured and is backed up by repeated empirical evidence that their trust to each other was not violated. At this stage, positive moods and emotions strengthen the affective bonds between members and fortify their experience of unconditional trust. Thus relationships become significant and include a sense of mutual "identification" where each member fully internalizes the preferences of the other (Shapiro, Shepard, & Cheraskin, 1992; Webber, 2008). At this stage, individuals sense a feeling of belonging, connectedness and acceptance by other team members. Team members turn into friends rather than colleagues and can develop synergistic relationships that lead to superior team performance (Jones & George, 1998). Thus, unconditional trust can be especially beneficial in important team-level social interactions; e.g., academia, business, sports, medicine and familial relations (Johnson et al., 2011).

Dissolution of trust towards distrust. When a team member signals positive expectations to another and the other reciprocates those expectations, mutual trust spirals upwards. This is otherwise referred to as the "upward spiral of trust" (see Figure 2).

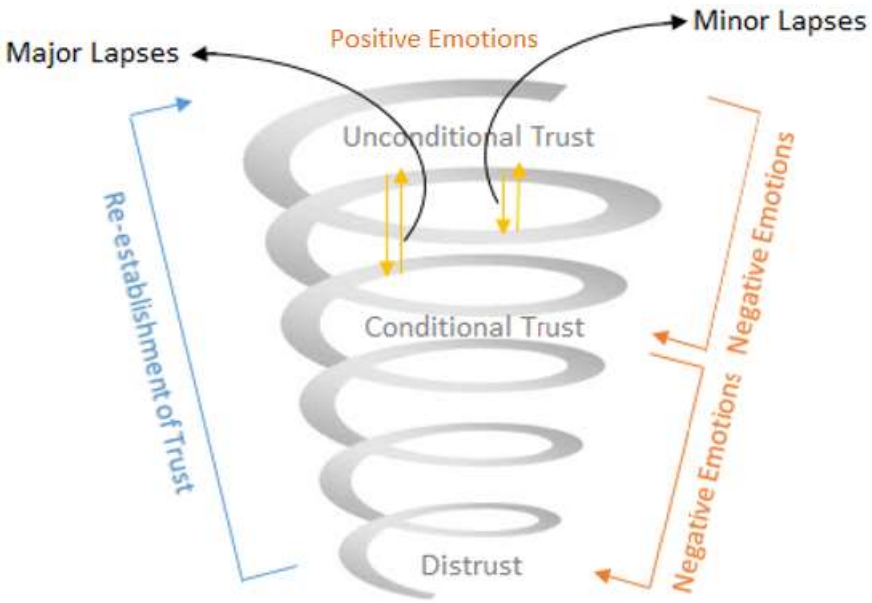


Figure 2. Upward and downward spiraling of trust

When expectations are not reciprocated, trust spirals downwards and dissolves, and this is referred to as a "downward spiral of distrust" (Friend, Costley, & Brown, 2010). The downward spiral of distrust is undesirable and can endanger conditional trust and also penetrate into unconditional trust. Within unconditional trust, minor interactional "lapses" by one member are likely to be forgiven by the other(s), since shared values orient the members to future interactions. However, depending on the weight of violations (i.e., major or minor), emotional outbursts may weaken and eventually dissolve the trust bond since they are the key mechanisms that trigger reappraisal of the trust relationship and re-question member trustworthiness. The reactions of members to this issue can recover the experience of trust. But if changes in interactions do not occur, over time unconditional trust spirals downwards towards conditional trust. If trust continues to decline, desirable attitudes toward the other lean towards unfavorable attitudes and negative affect replaces positive affect. At this point, conditional trust descends to distrust since members feel they might be at high risk by the other in the future. In this position, trust cannot be re-established unless the members renegotiate their problems and restore the former positive attitude toward each other. Unfortunately, it should be noted that complete re-establishment of trust may be challenging after exploitation has occurred (Fallon et al., 2017).

The link between trust and team coordination. Although both conditional and unconditional trust are precursors to effective team coordination, Jones and George (1998) propose that the nature of team coordination will be profoundly different under these two states of trust. When a team needs members to perform coordinated tasks that are intense and laborious, and entail some self-sacrifice without any tangible reward, conditional trust may not be enough.

But when unconditional trust is pivotal in team interactions, members are more likely to coordinate and develop synergistic team relationships that lead to advanced performance benefits, such as the development of unique team capabilities and extra-role behaviors that can give a team a competitive advantage. Shared values and positive attitudes and emotions are manifested in unconditional trust that in turn lead to the strong ambition of team members to contribute to the overall goals and facilitate superior team performance. When unconditional trust exists the interactions among shared values, positive attitudes and emotions are likely to lead team members to: (a) define responsibilities more broadly than mere accordance with expected role responsibilities, (b) form communal relationships that are characterized by helpfulness and responsibility rather than showing calculative exchange relationships and only assisting each other to compensate for former help received or in anticipation of upcoming help needed, (c) hold high confidence rather than "guarded" confidence in others that may be due to uncertainty about others' intentions or ultimate goals, (d) ensure against feelings of inadequacy and worry and encourage members who are in need to seek help from each other, (e) feel free to share knowledge beyond task-work and build closer interactions, (f) feel assured that the team acts in good faith and everyone avoids free rides to pursue team goals, and (g) become fully involved in a team endeavor.

Trust in rapidly-built CSCL teams. Studies have found the existence of agreeable levels of trust during initial relationships among CSCL team members although they might lack sufficient time to build proper expectations from prior interactions (Robert, Dennis & Hung, 2009; Jarvenpaa, Shaw, & Staples, 2004). Similar to what Jones and George (1998) stated regarding the initial encounter of team members, each member does not simply believe that other members are trustworthy; rather, each member avoids beliefs that others may not be trustworthy.

This explanation is similar to "swift" trust (Germain & McGuire, 2014) that is a rapidly-developed belief of trustworthiness of team members built on categorical cues embedded in the team environment (e.g., task or expertise-related labeling). These attributional cues contribute to the swift formation of trust by allowing team members to act according to role responsibilities of other members rather than acting based on others' physical appearance, individual characteristics, or personal relationships (especially if the CSCL setting is online and not face-to-face). As individuals gradually gather perceived knowledge of others' ability, integrity, and benevolence, they can cognitively evaluate the other members' trustworthiness (Crisp & Jarvenpaa, 2015; Hung et al., 2004), similar to what has earlier been referred to as conditional trust. Further as individuals build a history of consecutive positive and successful trust transactions, they form a habitual pattern of making trust judgments, and even begin to see other members as themselves. This is the same as what was earlier referred to as unconditional trust (Jones & George, 1998) that involves strong emotional bonds and concerns for the others' well-being. Thus trust formation in temporary CSCL teams is similar to long-term teams, with a difference that the temporary nature of such teams slows down the progression among the states of swift trust, conditional trust, and unconditional trust (Fuller, Marett, & Twitchell, 2012).

In the previous sections, the procedure of developing shared mental models and mutual trust within teams was discussed. The next section highlights how such coordinating mechanisms can be sustained and continuously developed as the team progresses in an up and down curve to reach their desired goals. Specifically, the impact of emotions and their regulation in learning team coordination will be discussed.

Maintaining Coordination in Learning Teams

As mentioned before, in spite of the benefits of coordinated teamwork successful coordination does not always occur. This has guided research to determine the prerequisites for effective coordination. Research (Hobman et al., 2002) has shown that one main hindrance to the development of shared mental models and mutual trust is the emerging challenges that arise as teams proceed to reach their goals. An example of hindrances includes difficulties in understanding others' thinking or negotiating multiple perspectives (Kirschner et al. 2008). Research has shown that challenges can have reverse effects on team performance and the team may miss important deadlines, have low productivity or deliver faulty reports (Cannon & Edmondson, 2001; Daim et al., 2012). Kirschner et al. (2014) refer to the effort and time to control these challenges as transactional costs involved in teamwork. They argue that if transactional activity costs exceed the benefits of teamwork, teams will not function effectively or will not even function at all.

These deficiencies have led researchers to recognize a need for supporting the challenging factors of teamwork and determine the prerequisites of effective coordination. In order to ensure successful collaboration, recent emerging research (e.g., Panadero, Kirschner, Järvelä, Malmberg, & Järvenoja, 2015) has shown that team members need to primarily realize the type of challenge(s) they are facing, and accordingly regulate their internal constraints (e.g., change their strategy or their task perceptions), or proceed although having external limitations (e.g., downgrade to lower-level goals).

As mentioned earlier, recent research has shown that the role of emotions is noteworthy in influencing coordinating strategies such as shared mental models and mutual trust within learning teams (e.g., Panadero & Järvellä, 2015). Teamwork can create positive emotions and

support socio-emotional dimensions of the team environment towards advancing team interaction and engaging in the internalization of co-constructed knowledge. Yet, teamwork can also evoke negative emotions and create novel motivational challenges for individuals when their characteristics, goals and demands conflict (Järvellä, Lehtinen, & Salonen, 2000; Kreijns, Kirchner, & Jochems, 2003). Thus in order to prevent or overcome such issues efficiently, not only do team members need to understand their challenges, but they also require to develop and apply effective regulatory strategies. The following section introduces emotion regulation as one of the key regulation strategies in face of team challenges.

Emotion Regulation and Team Coordination

Studying emotion regulation in the social context is especially important since individual emotions can strongly be influenced from the social setting and intensify into more positive or more negative emotions (Barsade & Gibson, 1998). More positive emotions can motivate team members towards higher team coordination and therefore better team performance, and conversely more negative emotions can demotivate members and downgrade them towards lower team coordination and poorer team performance (Rafaeli, Ravid, & Cheshin, 2009). Although the influence of emotions and their regulation on advancing teamwork has been theoretically established within psychological literature, empirical studies within the academic and organizational contexts have not targeted this area sufficiently (Järvelä & Hadwin, 2013; Järvelä et al., 2014; Järvenoja et al., 2013). Built on the recent handful of publications, the next section elaborates on how socially-shared emotion regulation can serve as an influential strategy to foster team coordination in CSCL teams.

The Effects of Socially-Shared Emotion Regulation on CSCL Team Coordination

More than half a century has passed from the time Argyris (1962) emphasized the impact of emotion regulation in interpersonal competence. From that time and especially more recently, the literature has evolved significantly and has provided evidence on the relationship between emotion regulation and personal well-being, sustained relationships and productive teamwork (Goleman, Boyatzis, & McKee, 2013; Gross & Thompson, 2007; Järvenoja et al., 2013; Troth, Jordan, & Lawrence, 2012). According to Gross (1998), emotion regulation is a specific type of self-regulation that refers to "the processes by which individuals influence which emotions they have, when they have them, and how they experience and express these emotions" (p. 275). While studies of emotion regulation within the individual learning context are well documented (e.g. Folkman & Lazarus, 1988; Gross & Muñoz, 1995), researchers have just recently begun showing interest in studying shared emotion regulation. Emotion regulation in the social context spans over a continuum from self-regulation of emotions to co-regulation of emotions, and finally to socially-shared emotion regulation. Figure 3 presents a graphical model comparing the three types of emotion regulation.

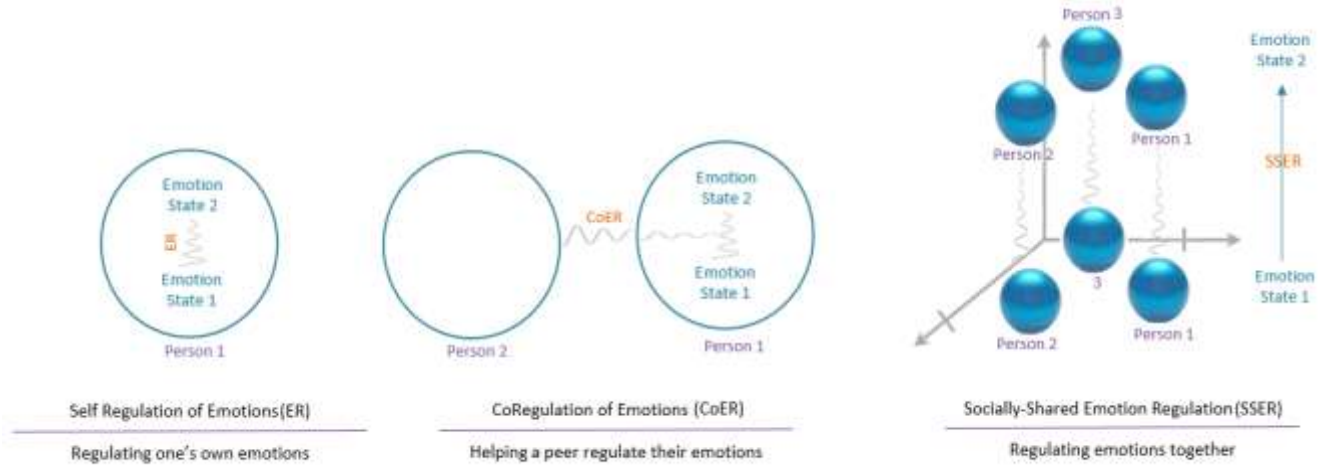


Figure 3. A model of three emotion regulation mechanisms present in teams (ER, Co-ER and SSER).

The leftmost figure models an individual regulating their own emotions (otherwise known as *intrinsic* emotion regulation, Gross, 2008). An example can be: "I convinced myself that the problem could actually be a good thing" (Järvenoja et al., 2013, p. 57). Co-regulation of emotions (model in the middle of Figure 3) refers to an individual helping another regulate their emotions (otherwise known as *extrinsic* emotion regulation; Gross, 2008), for example, "I reassured him that he was almost there" (Järvenoja et al., 2013, p.57). Finally, socially-shared emotion regulation (SSER, rightmost model) refers to the social, shared, and interdependent emotion regulatory processes that collaborative members harmoniously apply to regulate the emotions of the team in order to reach the shared outcome (Järvenoja & Järvelä, 2009; Panadero & Järvellä, 2015; Winne, Hadwin, & Perry, 2013). Simply speaking, self-regulation refers to regulating oneself, coregulation refers to helping others regulate, and SSER refers to regulating together (Miller, Järvelä, & Hadwin, 2017; Kirschner, Jarvela, Hadwin, Jarvenoja, Miller, Laru; 2018). An example of SSER can be: "We accepted that different members have different goals and we need to organize our working according to that" (Järvenoja et al., 2013, p. 57). Although each form of regulation focuses on a different target (self, others and the team), these regulatory processes are theoretically interdependent to each other and can coexist simultaneously (Grau & Whitebread, 2012).

Within a team environment SSER should be supported as should self- and co-regulation of emotions. Since team members can interpret a challenging situation differently based on their original values (Gross, 2015), needs and reasons for regulating emotions can therefore differ among members. For example, consider a team that has faced a serious challenge in progressing towards the assigned learning goal. If one member's central personal goal is to maintain emotional well-being, an option may be to disengage from the task and/or leave the team

altogether. Alternatively, if the individual's main personal goal is to grasp deep learning through collaboration with others, this would require facing the emotional challenge and addressing the problem that is hindering the learning process. These two divergent regulatory processes, originating from different goals, lead to different actions and may further intensify challenges within the team. Therefore SSER is required to produce a harmonious team-level regulation in the face of such challenging situations.

SSER falls under the broader concept of socially-shared regulation, a new branch of collaborative learning research that focuses on the social processes teams use to coordinate their teamwork on an assigned task (Rogat & Linnenbrink-Garcia, 2013, p. 102; Järvellä & Hadwin, 2015). As mentioned before, one coordination criteria is shared mental models. The following section elaborates on the role of SSER in the development of shared mental models within team settings.

SSER and shared mental models in learning teams. Despite the theoretical link between SSER and team coordination, to our knowledge, no empirical investigations have yet examined the link between SSER and the development of shared mental models in learning teams. However, some studies have focused on managing conflict (e.g., Hamilton, Shih, Tesler, & Mohammed, 2014), as a key emotionally challenging hindrance to the development of shared mental models. Therefore, this section examines the effect of SSER on managing emergent conflicts within teams to sustain the development of shared mental models (see Figure 4).

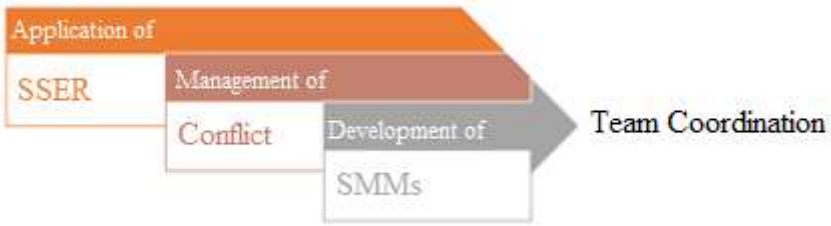


Figure 4. The indirect relation between SSER and the development of shared mental models in the literature.

A number of factors that contribute to conflict have been cited in different bodies of literature (e.g., Brett, Behfar, & Sanchez-Burks, 2014; Gelfand, Harrington, & Leslie, 2014; Naykki et al., 2014). These factors can be internal, relating to personal deficiencies and teamwork incompetence or external to the task or team dynamics (see Figure 5).

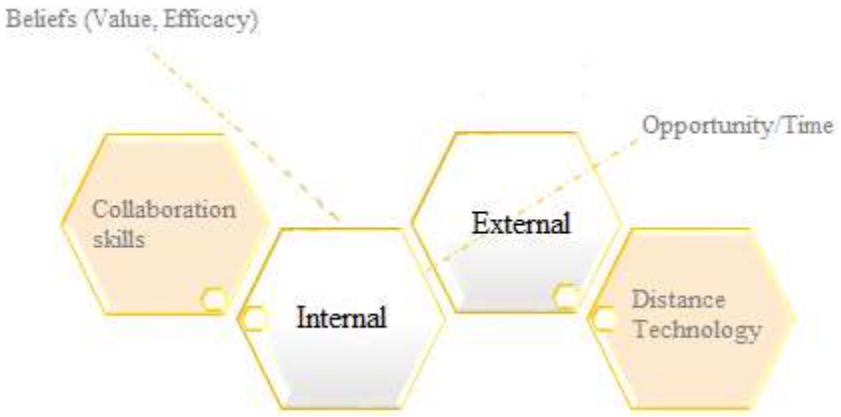


Figure 5. Factors that contribute to conflict within a team

Styles of communicating as well as environmental barriers and technical hurdles constrain externalization of individual mental models (Järvenoja et al., 2013). As an example of communication conflicts, imagine discussions in a team where students refer to the same concept and use the same words, but their understanding of the concept is different. Inevitably, this conflict creates challenges that may undermine team productivity. Research has shown that conflict has an emotional component (Ayoko, Ashkanasy, & Jehn, 2014; Behfar et al., 2008; Jordan & Troth, 2004; van den Berg et al., 2014). Depending on the conflict type, intensity and duration, the level of emotions can vary from low to high (Bodtker & Jameson; 2001).

If taken advantage of, conflict can stimulate innovation and creativity within the team (i.e., constructive conflict), but if biased with subjective disagreements (Rispens, 2014), it may be harmful for the team performance (i.e., destructive conflict). Constructive conflict refers to “a

productive negotiation process that reaches out of the participants' comfort zone and uncovers diversity in opinions and identity within the group" (Naykki et al., 2014, p. 2). This type of conflict is appreciated as it raises member confidence and commitment and enhances team cohesion. However, as learners are challenged out of their respective comfort zones, constructive conflicts are likely to give rise to relational and teamwork conflicts which can be destructive and may create off-topic disagreements within the team. Such disagreements often involve frustration and personal clashes and are negatively related to feelings of belonging, team cohesion, commitment, respect, satisfaction and performance (De Dreu & Weingart, 2003; Garrison et al., 2001).

Nair (2007) postulates a reciprocal relation between destructive conflict and emotions and proposes that negative emotions induce destructive conflict, and destructive conflict induces negative emotions. The disharmony induced due to this type of challenge in learning teams has also led to tensions within the team and has reversely affected learning and team performance (Liu, Magjuka, & Lee; 2008). In order to manage negative emotions induced due to destructive conflict in the team environment, recent research has underlined the power of emotion regulation (Jiang et al., 2013, Troth, Jordan, & Westerlaken, 2014, van den Berg et al., 2014). For example, when encountering conflict at work, patience facilitates respect among team members and reduces the expression of offensive words or behaviors that may lead a fragile team into breaking apart (Alessio, 2012). As an example, van den Berg et al. (2014) conducted empirical study testing the moderating role of emotion regulation on task conflict in 23 multi-team client/supplier systems and found that team members effectively engaged in emotion regulation and resolved conflict within and between their teams. Examples of the emotion regulation strategies van den Berg et al. (2014) used to control their task conflict as well as examples derived from other

studies (Behfar et al., 2008, Järvenoja et al., 2013, Lajoie et al., 2015; & van den Berg et al., 2014) are included in Table 1.

Table 1

Examples of SSER as a Resolution Strategy to Solve Task-work and Teamwork Conflict

No.	Examples
1	We should consider each other's feelings when criticizing each other's work
2	To resolve conflict we need to keep open-minded and learn from one another
3	Our discussions should be friendly and polite
4	We have to incorporate everyone's ideas
5	We need to remind each other to not make a mountain out of a molehill
6	Frustration can't help our problems
7	If we want to resolve conflict, we should talk it out and/or share our emotions
8	We need to take arguments positively and not personally
9	We need to merge our goals closer to one another
10	Let's try to compromise and accommodate everyone's goals

The last two items in the table are specific to managing personal and teamwork conflicts due to different personal values that members hold within a team setting (Järvenoja et al., 2013). As mentioned before, different values trigger different priorities and goals, and display varied levels of individual commitment in a team endeavor. If the goals are not convergent to a sufficient extent, or if members cannot merge their goals to a unique team goal, they may face deep-rooted obstacles. Näykki et al. (2014) referred to the effectiveness of SSER in managing conflicts that are raised by value divergence as well as other individual differences. In their study, collaborative members had differences in interest and value to the collaborative learning goal, and this raised emotionally charged discussions and disappointments. In order to manage such conflicts, participants in the learning team applied several SSER strategies. Through attention deployment, they together tried to (a) steer the unpleasant conversation to safer secondary topics. In further attempts and noticing that the disengaged active participant was still uncomfortable to rejoin the discussions, the team attempted to modify the negatively affected

situation by (b) referring to earlier jokes that they had shared in the conversation, (c) nodding and smiling to each other, and (d) directly asking questions of the silent participant to welcome her back in to the discussions. These attempts were successful to rebuild a positive atmosphere and unblock participants sharing ideas and comments, which subsequently restructured and enriched shared mental models and furthered the team's progress to fulfill their task requirements in a coordinated manner.

One principal factor contributing to conflict and challenging the development of shared mental models is barriers to "externalizing" individual mental models (Kirschner et al., 2014). Mental models are a mixture of what is learned explicitly and absorbed implicitly (Kim, 1998). The implicit integration of knowledge into an individual's cognitive knowledge structure makes mental model sharing difficult, and externalizing it requires effective communication patterns. Therefore externalization challenges are to a high extent due to communication barriers. These barriers may refer to different communication styles, not knowing what to communicate, language difficulties, technology-induced delays in communication, lack of time or opportunities to develop similar interpretations and sufficiently converging mental models, etc. In internationally distributed team environments, the challenge is even more pronounced because geographical as well as cultural boundaries make it difficult for team members to foster a consistent understanding of their assigned teamwork and taskwork. As an example, Hsieh (2006) showed that Jamaican and Indian team members differed significantly in their views of power relations among team members. Jamaican members viewed the Indians as too monocratic while the Indians viewed the Jamaicans' team decision-making as too much time consuming and ineffective. This contradiction in the structural property of power eventually created conflicts in the team leading to delays in team productivity and effectiveness.

SSER can also facilitate perspective-taking in order to avoid conflicts. An open-minded discussion of diverse views is a critical social process by which a more complete appreciation of the complexity of the situation at hand is developed and allows incorporating diverse ideas (Chen, Tjosvold, & Fang, 2005). Goldman-Segall (2007) emphasized the need to embrace diverse perspectives in order to analyze a situation from different viewpoints and avoid biases that may lead to misinterpretations. Attending to and comprehending contradictory or diverse opinions requires sufficient emotional capacity and emotional management. Druskatt and Wolff (2001) argue that perspective taking is more than a cognitive ability, and also includes an emotional component. When an emotionally competent team engages in reappraisal to understand different perspectives, team members feel that their views are being understood and considered, and make them more available to each other. These dynamics facilitate the development of shared mental models and result in advanced team performance (Lovelace, Shapiro, & Weingart, 2001). This may be why Hadwin and Järvellä (2011) have referred to emotion regulation as a resource for successful perspective taking, since it will lead to the convergence of meaning and support reaching agreements to co-constructed solutions.

This section looked at factors that contribute to emotionally charged conflict in a team, and described how SSER can help manage such conflicts in order to maintain and foster the development of shared mental models. Although not examined in this paper, but the indirect relation between SSER and shared mental models seems to be reciprocal, implying that SSER can facilitate the development of shared mental models, and in turn advanced shared mental model bonds can ease application of further SSER strategies. In the following section, the relationship between SSER and mutual trust will be examined.

SSER and mutual trust. Referring back to the multidimensional model of trust, Jones and George (1998) emphasized the significant role of emotions in producing a general state of trust or distrust in an individual collaborating with others in a social setting. They proposed that emotions provide signals through which members recurrently evaluate the ongoing quality of their trust experience in team interactions. They further elaborated that trust is built on expectations of other team members that if fulfilled, produces positive emotional responses within individuals and strengthened bonds of trust (Dunn & Schweitzer, 2005). But when the expectations are not met or broken, individuals often experience negative emotions that indicate trust impairment and the need to protect the at-risk interaction.

The literature has shown several strategies that a trustee (the trusted person) can use to repair distrust, including accepting mistakes and apologies (e.g., Mbuva, 2017), promises (Schweitzer et al., 2006), reparations (Bottom et al., 2002), excuses (Shapiro, 1991; Tomlinson et al., 2004), denials (e.g., Kim et al., 2006), and also silence while reflecting (Ferrin, Kim, Cooper, & Dirks, 2007). Although efficient, these strategies present the trustor (individual who trusts) as a passive observer of efforts to trust repair. In order to accelerate the amelioration of trust in situations where trust is fundamental in reaching the team goals (e.g., action teams of limited time, such as rescue teams, world-cup football teams, competition teams, etc.), Kim et al. (2006) argue that both trustee and trustor should play an active role in the trust restoration process. This section highlights the role of SSER in trust restoration by helping the trustor regulate negative emotions induced due to expectation violations.

There are several points in the trust dissolution path where SSER can intervene. One main point is around expectations, another is around violations of these expectations, and a third is around emotional reactions. The first two points are before emotions are elicited, but the third

is after emotion elicitation. Examples of SSER self-reflective strategies on each point can be: (a) is our expectation reasonable; (b) is our perception of violation accurate; and (c) are we not overreacting? These examples demonstrate how cognitive reappraisal of a team's expectations of a trustee's responsibilities, violation criteria of these expectations, and emotional reactions to violations can help restore trust in the team atmosphere. However, since emotions are signals of trust in uncertain situations, caution should be taken in their appropriate regulation to not put the team at high risk of the misbehavior of violating members. Lewicki and Brinsfield (2012) refer to trust as not always advantageous since it may lead to sacrificing high quality outcomes in the name of wanting to not damage trust.

This section provided a new lens to team coordination and analyzed the impact of emotions and SSER in the development of shared mental models and mutual trust towards increased team performance. The next section provides methodological advancements that have been applied by the literature in analyzing SSER and team coordination. The benefits or challenges that are associated with conducting such methodological approaches are also examined with the hope to provide gateways to future research.

Methodological Approaches for Measuring Shared Mental Models, Mutual Trust and SSER

The interdependent nature of team structures presents challenges that are incomparable to studying individuals learning alone. From the time team constructs have appeared in the academic literature, their measurement has been of focus as well. This section provides a review of established methodological approaches and a variety of analytical advancements to measure team constructs such as shared mental models and mutual trust, as well as SSER.

Approaches for Measuring Shared Mental Models in Teams

The literature has provided a vast collection of shared mental model measurement approaches, ranging from simple to complex, quick to time consuming, and unnoticeable or intrusive. However, still more accurate measures that are online, dynamic, unobtrusive, diagnostic, and multilevel that capture cognitive, physiological, and affective states as well as behavioral actions are needed (Salas et al., 2017). Current measures mainly capture shared mental models regarding similarity and accuracy of task-related knowledge or team-related knowledge between the members. The selection of team cognition measures requires researchers to be aware of the theoretical underpinnings of team cognition as well as practical feasibilities of each method (Wildman, Salas, & Scott, 2013). Different theories provide different gateways to shared mental model measurement. Recent advancements in team literature conceptualize team cognition as knowledge co-construction through communication between team members. In this case, team cognition is seen as a dynamic process, and not a static property or a product of interaction (Cooke, Gorman, Myers, & Duran, 2013). This is different from research that simply uses communication records as a resource to pull information about static shared mental model structures. Studies that view team cognition as dynamic processes observe team interactions and code particular nonverbal behaviors and verbal communications as instances of various cognitive processes such as knowledge co-construction over time. Nonverbal communication includes using gestures, gaze direction, movements, body orientation and touch (McNeese, Cooke, Gray, & Fedele, 2017) and is especially important in dynamic team settings. For example, in basketball it has been shown that the rate at which teammates touch each other during play is directly related to their level of coordination and on-court performance (Kraus, Huang, & Keltner, 2010).

Overall, the literature has provided six data sources: (1) interview transcripts, (2) audio transcripts, (3) video records of behavior, (4) direct observations of behavior, (5) self-reported perceptions of team cognition, and (6) self-reported individual knowledge. Amongst these approaches, each has its own advantages and disadvantages that depending on the type of data and the setting, can be chosen while taking into account reliability and validity, implementation procedure (easy/difficult), time (short/long), obtrusiveness (non-intrusive, interfering), and monetary expenses of the procedure (inexpensive/expensive; Wildman et al., 2013).

From the methods mentioned, the use of video recording is of the least intrusive approaches that can result in some of the most in-depth objective informative data on team cognition. One main advantage of recorded data channels is that they can be back-played to revisit missed information. However it takes time to transcribe data into written scripts of behavioral and dialogic interactions. Other shortcomings include the permissibility of video recording software in different contexts and that such data also require a large amount of digital storage accommodation. Audio recordings have also been used to serve as channels to understand team cognition. They are widely available and relatively inexpensive and can yield rich informative data. Self-reported knowledge measures capture in some form the actual knowledge or cognition of individual team members with the intent of aggregating this information to represent knowledge structure at the team level. However, caution should be taken in analyzing self-report approaches since they have important limitations such as social desirability biases and recall issues (Scherer, 2005).

In choosing the appropriate method to measure shared mental models, two decisions should be made: first, deciding what approach will be used to gather the data, and second,

determining how to analyze that data in order to represent team cognition. An overview of analytic techniques to shared mental model measurement is provided in the next section.

Analysis Techniques

As mentioned previously, one rich method of analyzing the structure and development of shared mental models is through analysis of communication (verbal or nonverbal) between team members. Therefore, in this section we aim to explore how communication should be analyzed effectively in order to provide accurate understandings of a team's cognitive processing. Following is a description of some most commonly used methods for the measurement of communication.

Content analysis. Through this method researchers select or develop a theoretical coding scheme to code linguistic and semantic content of verbal interactions, such as discussion topics or frequency of using certain words. An example to this method is Latent Semantic Analysis (LSA, Cooke, & Gorman, 2009) that identifies the latent space of semantic factors and their relatedness by plotting utterances (e.g., words, sentences) in the semantic space.

Pattern analysis. This method focuses on examining the pattern and/or sequence of interactions between team members within a team regardless of the content of those interactions. Two examples of this method are communication flow analysis and sequential analysis (Cooke & Gorman, 2009). Another pattern analysis method involves event data analysis, used to analyze observational data as a sequence of events (Cooke & Gorman, 2009). In this case, particular team member behaviors of interest must occur, within an operationally relevant task scenario. The researchers identify specific and observable responses within these scenarios that can be recorded on a "hit or miss" checklist in case of occurrence (Chernobilsky, Nagarajan, & Hmeo-Silver, 2005).

Social network analysis. An extension to pattern analysis is social network analysis (SNA) that takes into account the content as well as the structure of interactions. This method refers to the analysis of interwoven relations of social actions of team members, and comprises a body of quantitative and qualitative measures for describing the dynamic social network structure of team interactions. By plotting nodes representative of individual team members and ties as relations between the members within a spatial graph, SNA determines if there are regular patterns in interdependent social relationships and how these patterns may be related to attributes or how they structure participants' behavior (Scott, 2012).

Visualizations. Visualizations help identify patterns within data from an overview rapidly. As classified by Henderson and Segal (2013), visualization tools can be used to portray words (e.g., tag clouds, word clouds and cluster analysis), sentences (e.g., word trees, sentiment analysis, and phrase nets) and themes (e.g., heat maps, matrices, and spectrums). Such approaches that represent text graphically provide opportunities for analyzers to interact with and think about data differently and to share their results in ways that can introduce new insights.

A specific visualization tool that is used to analyze themes is the Chronologically-ordered Representation for Tool-Related Activity (CORDTRA; Chernobilsky, Nagarajan, & Hmelo-Silver, 2005). This method uses a diagram that contains parallel timelines allowing a researcher to compare a variety of discourse, gestural, or tool-related codes of different members simultaneously to understand team interactions over time in reaching their performance goals (Chernobilsky et al., 2005). CORDTRA analyses are an important addition to multilevel coding schemes, allowing researchers studying collaborative learning to go beyond coding and counting to seeing the larger patterns that emerge (e.g., see Kazemitabar, 2014).

Eye tracking. A more recent method to determining shared mental models is through the use of eye tracking data that tracks eye movements and focuses on shared points of interest (Wildman et al., 2013). Through focusing on the points of interest (POIs) a team member is attending to, eye tracking can allow a greater understanding of individual and team cognitive processes over time. Research has shown that the duration and frequency of eye fixation is associated with positive cognitive engagement in a task (Maughan et al., 2007). For example, van de Merwe, van Dijk, and Zon (2012) analyzed shared mental models of a team by tracking *co-occurrences* of team members' eye fixation and gaze on information seeking and acquisition. Another form of eye communication that could represent shared mental models is blinking (Bousmalis, Mehu, & Pantic, 2009; Malmberg, Järvelä, Holappa, Haataja, Huang, Siipo; 2019). More research needs to explore how eye tracking can be used to understand knowledge co-construction and shared mental models as well.

The aforementioned analyses can be used across a number of data channels and perhaps multiple analyses are required for better understanding of shared mental models. For example, the added information from eye tracking data of a team of individuals could enhance the validity and richness of team cognition measures. Future research should investigate the feasibility of including other objective cognitive measures (e.g., EEG, facial expressions, hand and head agreement gestures such as nodding, thumbs up, high fives, etc.) into team cognition research and what the potential value of these objective cognitive measurements might be in understanding and validating shared mental models.

Approaches for Measuring Mutual Trust in Teams

The literature has provided two dimensions to measure trust: (a) self-reports of trust beliefs, and (b) measurement of trusting behaviors (Lewicki & Brinsfield, 2012). The first

category has been the focus of literature using self-report measures and directly asking about trustworthiness of peers within teams. Given that trust is grounded in optimism, hope, confidence, and positive expectations from others, and conversely distrust is based in pessimism, fear, lack of confidence and negative expectations from others; self-reports address trust through extracting beliefs about these criteria (e.g., Butler, 1991; McAllister, 1995; Currall & Judge, 1995; Cummings & Bromiley, 1996). Sample items that measure trust using a Likert scale are: "We are usually considerate of each other's interests when making decisions", or "We can rely on our team members to help run this project together". Also, some example items of self-reports capturing distrust are "In our team people monitor each other's works," or "We prefer that our peers don't have influence over decisions that are important to us" (Järvellä & Järvenoja, 2011). However, sometimes such reportings may be inaccurate as members may have wrong judgements towards each other, or they may intentionally (or unintentionally) hide the complete story, making their peer(s) seem untrustworthy. Furthermore, social desirability biases and recall issues, being common disadvantages of self-reports, make results obtained from this method in need of being triangulated with other trusted measures to increase validity.

The second categorization of trust measurement (modality) refers to analyzing trust behavior. Since trust itself cannot be seen or observed directly, researchers have identified several indirect approaches to measure trust behavior. One behavioral trust measure can be gleaned from video analysis of observable behavior of team members. Literature has shown that two main channels of inferring trust are: observable indicators of reliance on another's words and actions, and disclosure of sensitive (work-related or personal) information. Content analysis has also shown the relation between using more positive emotions as an indicator of interpersonal trust (Leichtenstern, et al., 2011).

A recent advancement in objective measurement of trust is through using physiological measures including heart rate (e.g., Leichtenstern, Bee, Andre, Berkmuller, & Wagner, 2011), galvanic skin response (GSR; e.g., Khawaji, Zhou, Chen, & Marcus, 2015), and amygdala responses of brain activities (e.g., Engell, Haxby, & Todorov, 2007). These measures provide an inverse relation between physiological activation and trust; in other words, the lower physiological activations is, the higher will trust be. Also, research on eye gaze data has shown relations between trust and eye fixation rates. For example, one study found that people maintained more continuous focus on the webpages that they trusted (Leichtenstern et al., 2011). Research in this area is in its infancy, and the extrapolation of this interaction with an inanimate object has as yet to be justified when it is used with individuals.

Approaches for Measuring SSER in Teams

Research methods that consider social regulatory processes in authentic learning activities are still at early stages (Panadero & Järvelä, 2015). One cause of knowledge inadequacy with regards to methodological approaches may pertain to the use of different terminology in previous research. For example, SSER might have been labelled as interpersonal emotion regulation, social control, social emotion regulation, shared emotion regulation, collective emotion regulation, collective emotional intelligence or group emotion regulation.

In examining previous research with the aforementioned keywords, similar to measurement approaches for shared mental models and mutual trust, the most predominant method conducted by researchers to analyze SSER is self-report interviews and questionnaires (e.g., Pérez, Petrides, & Furnham, 2005). Questionnaires use Likert scales to capture the extent of agreement or disagreement of participants with pre-determined SSER strategies. Interviews use open-ended questionnaires to extract participants' beliefs about their team's SSER strategies.

Some studies have also focused on content analysis to infer SSER. The grain size of analysis in these studies has been team-level episodes as well as micro-level discourse. For example, one study analyzed six teams' verbal utterances in a series of three challenging mathematics tasks to explore the role of emotions on socially-shared regulation of learning (Rogat & Linnenbrink-Garcia, 2011). The researchers included the following categories in analyzing the videotaped observations: positive socioemotional interactions, negative socioemotional interactions, collaborative interactions, and non-collaborative interactions. These macro-level categories were further broken down to include more detailed categorizations of the verbal utterances of the participants. Team-level episodes were analyzed to infer instances of emotion regulation strategies that were co-constructed and shared among all members (e.g., A: let's merge our goals closer to one another, B: yes, this way we'll be more efficient).

Another study analyzed verbal utterances of medical students interacting in an online problem-based learning environment to solve an emotionally challenging task (Lajoie et al., 2015). Similar to the previous study, these researchers examined participants' verbal utterances under the general division of positive vs. negative socio-emotional interactions. They further divided socio-emotional interactions into affective, interactive and cohesive social presence categories where each had its own subcategories. A third macro-level category labelled neutral was also developed to capture moments of silence within students' interactions. Although nonverbal behavior has shown to provide a rich data source to emotion regulation, until now and to our knowledge as yet there have been no reported studies that have analyzed SSER through observational mechanisms. One approach might be to analyze emotional contagion and see whether this may be a source to observable SSER. For example, a team member's smile in a stressful occasion may transmit to others in the team a certain message and decrease the overall

level of team anxiety. Based on studies that have looked at individual emotion regulation through physiological signals of the human body, another approach may be to determine SSER in a learning team through processing co-occurrences of physiological data channels of the team members. We hope that through such techniques a wider lens to less subjective approaches of understanding SSER within learning teams can be provided.

Summary

Research so far has achieved remarkable progress in the knowledge base and in practice of teams. Findings have revealed evidence-based frameworks and methodologies that can be applied to a range of simple to complex team environments and across many disciplines. But the wealth of research in team coordination literature is neglected in educational contexts. Specifically, we focused on the recently developed field of socially-shared emotion regulation and identified its role in managing conflicts and uncertainties that hinder the development of shared mental models and mutual trust within learning teams. Several socially-shared emotion regulation strategies that can be applied to foster shared mental models and mutual trust were identified and extracted from multi-disciplinary literature. In the last section, methodological approaches and advancements for capturing SSER, mutual trust and shared mental models in teams were also described. These findings aim to provide a gateway to advance our knowledge of fostering coordinated learning teams.

CHAPTER 3

METHODS

This chapter presents the mixed methods design that was used to answer the research questions presented in Chapter 1. In brief, the study aim was to identify challenges teams faced during complex teamwork, the SSER strategies they applied in face to those challenges, and whether the the SSER strategies teams applied were correlated with the number of challenges they faced. Data analysis was based on a qualitative theory-driven thematic analysis of verbal transcripts and questionnaire data, and deductive theory-driven coding and theme development. As mentioned in Chapter 2, the theoretical foundation behind the study was social constructivism theory and socially-shared emotion regulation. Further, mutual trust and shared mental models were analyzed, and challenges that teams faced as well as the pertinent SSER strategies they applied in addressing the challenges were identified. Descriptive statistical analysis was used to identify the most important challenges that hamper shared mental models, and also mutual trust; and correlation analyses were used to predict the relationship between SSER and shared mental models, and also SSER and mutual trust.

Participants

The study was conducted at a hackathon (http://www.physics.mcgill.ca/hackathon2016/). The hackathon was a 2-day Physics programming competition organized by a North American university's Physics department and sponsored by technical organizations. Hackathon participants were initially informed of the current study through a survey monkey link sent to their emails by the organizers of the hackathon in advance to the event. The study was also introduced at the introduction session of the hackathon where the principal investigator presented a few slides and answered students' questions regarding the study and how it would be

conducted. Of the 59 hackathon participants, 53 students (89%) voluntarily gave consent to participate in the study. Of these participants, two were minors, two participants only attended the first day of the event, and one was from a team where others had not provided consent. Thus, the final sample of the study consisted of 48 participants (71% male, mean age =22 years, *SD* = 3.28). Although there have been efforts to attract women to participate in programming contexts, male participants are still the majority (Baser, 2013). From now onwards we will refer to hackathon participants as hackathonists to differentiate from the study participants. The study participants were undergraduate or graduate students and their background expertise was mainly in Physics (42%), software engineering and computer science (19%), but there were also participants from electrical, mechanical, and civil engineering fields (31%). Average GPA was 3.87/4.3 (*SD* = 1.18). Students' ethnicity was 31% Asian, 21% Middle Eastern, and 48% Caucasian. All participants signed the consent form that was approved by the McGill Research Ethics Board (REB# 70-0716). A copy of the consent form is provided in Appendix B. Participants were offered a chance of winning one of the ten $40 gift cards on top of the hackathon awards to appreciate their time to participate in the study.

Team formation. The organizing committee of the hackathon allowed participants to form their own teams of choice. Students who participated in the study included 16 teams of 2 to 5 participants (see Table 2 for basic team information). Students had the opportunity to form teams using an online platform in advance of the event. Students of different expertise backgrounds (programmer, physicist or a designer) and levels (novice, intermediate, expert) could form teams without being pre-assigned by the organizing committee. They were open to choose how to form their teams and what roles each member could take. Naturally, students with higher technical proficiency inclined toward the programming tasks, and those interested in

graphic design worked on the aesthetic quality of the project. This role differentiation provided team members the opportunity to engage in parts of the project that were aligned with their competencies and skills, in contrast to common educational programs where all students engage in similar tasks.

Table 2

Hackathon Teams' General Information

Number[a]	Team name	Gender composition	Programming level	Prior familiarity	Team size	*M* age
1	Nanomon Go	Mixed	Low to moderate	Yes	2	24.5
2	NMR fun	Mixed	Moderate	Partial[c]	3	22.3
3	Team Guestlist	Male only[b]	Moderate to high	Partial	5	18.8
5	BIO-Hazard	Mixed	Moderate to high	Yes	2	24
7	Team Hype	Mixed	Moderate	Partial	4	19.3
8	Pendulums	Male only	Moderate to high	Partial	3	22
9	Fire Workers	Mixed	Low to moderate	No	3	19.7
10	Team Nix	Mixed	Moderate	Yes	2	21
11	Apollo	Mixed	Moderate	Partial	3	23.3
14	Space Rangers	Male only	Moderate	No	5	24.4
15	Physics Hot	Mixed	Low to moderate	Partial	3	22
16	Team Rocket	Mixed	Low to moderate	Yes	4	22.7
17	Hack Formula	Mixed	Moderate	Yes	3	26
18	Light	Mixed	Moderate	Partial	3	20
19	ECSE200	Male only	Moderate	Yes	2	19.5
20	Fluid Guys	Male only	Moderate	No	2	23[d]

[a] Numbers indicate team-labelled numbers at the event.
[b] There were no teams composed of only females, and the mixed-gender teams generally included only one female.
[c] Only some of the participants knew each other prior to the hackathon.
[d] Participants age range fell within early adulthood.

Task. Teams were asked to collaboratively build a novel computer program that could demonstrate a physics phenomenon of their choice artistically. Project guidelines were designed

to offer minimal rules to inspire maximum creativity. However, the organizing committee had prepared several ideas in advance (including Kinematics, Metaphysics, nuclear magnetic resonance, Quantum theory, etc.) in case some teams struggled in identifying a project to build (see Figure 6 as some examples of physics phenomena).

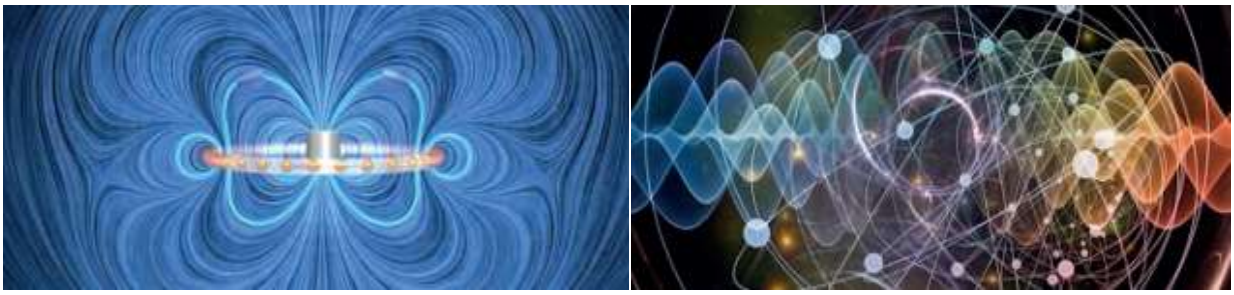


Figure 6. Examples of physics project ideas that students could choose to program artistically.

Mentors. Since students were not necessarily acquainted with programming skills, mentors (computer science graduate students) were available in the venue and also online via a private platform named Slack chatroom where students could interact with mentors through private or public chat spaces to ask and receive scaffolding on programming issues they needed assistance.

Judges and judging criteria. All of the teams were judged and ranked by a team of four expert judges at the end of the competition (see Figure 7), and winners were awarded valuable prizes. The judges comprised of a physics professor, a Microsoft technologist, a Nexalogy technologist, and a Lenovo salesman. The judging criteria for ranking team projects was a holistic coding scheme that included four items: (a) Science (exposing a scientific physics concept clearly and accurately), (b) Computing (using programming tools to create something novel and exciting), (c) Teaching (creating a project that can guide learners through a concept and expose the science behind it), and (d) Art (having some aesthetic quality in graphic design of the application or an artistic rendering of the physical system). Three winning prizes were

allocated to the first to third-ranked teams. Since the judging criteria focused on the final project not the performance of the members, it did not include team effectiveness factors (e.g. high mutual trust, high shared mental models, and effective communication between members). Therefore winners identified by the judges were not necessarily high performing teams, and teams of high performance did not necessarily win. However, as will be discussed in the Results section, only a few teams had high performance, from which two were winners (ranked first and third).

Figure 7. Judges rating a team presentation at their team pod.

Winners. Three teams were chosen by the hackathon judging committee as winners. The first-ranked winning team was comprised of three male participants. The project they built was a magnetic pendulum simulator. The second-ranked winning team was composed of a dyad (mixed gender) working on a BioHazard network simulating a disease infection in a society, and the third-ranked winning team included five participants (all male) that worked on a multifaceted project entitled “Team Guestlist.” Other teams were not ranked.

Context

The location of the event included two spaces; a hall with twenty stations or “team pods” where team members had access to internet and power sockets for laptop use; and a dome with 360 degrees projection where presenters could project their work to the audience (Figure 8).

Figure 8. Location of the event: the hack hall (left upper image), a team pod (right upper image) and the presentation dome (two lower images).

To answer the research questions addressed in Chapter 1, a variety of team-based learning contexts were examined. Some contexts had negligible challenges (e.g., a medical workshop where multidisciplinary teams of students joined to work on medical cases), and in some contexts the challenges were too strong and students could not afford to participate in an external study (e.g., an international management case solving competition). This hackathon had a fair balance of competition and tight deadlines and would likely lead to reasonable levels of challenges in team performance.

Schedule of the Event

The event began with an opening ceremony on day one, where invited speakers highlighted the importance of physics programming, and the director of the hackathon laid out the premise of the hackathon in the dome. During this occasion, the investigator of the current study briefly introduced the research through several slides and explained what student participation would entail. After the opening ceremony, students had the opportunity to form teams (if they hadn't already through the online platform), and shape their ideas towards a feasible programming project. At 12:00 P.M. on Day 1, the programming competition officially started and continued until 12:00 P.M. on Day 2 for a consecutive 24-hour period. Students were provided with snacks and meals throughout the event to remain fresh. Simultaneous to programming in the hack hall, students were welcome to attend optional informative talks and interact with computer scientists in the dome. After the end time of the competition on day two, each team was individually requested to present their project at their team pod to the judges. The judges rated teams based on the judging criteria as they observed presentations and finally after internal discussions announced three teams as winners. The event was followed by winner presentations in the dome and the awards ceremony. During the awards ceremony, 10 study participants whose names were randomly chosen for study gift cards were also congratulated and compensated.

Materials

Questionnaires. After completing the consent form, participants were asked to report their general demographic information and fill in several questionnaires. These questionnaires are described below.

Value. The value questionnaire was derived from Section 1 of the validated AIRE instrument (Järvenoja et al., 2013) for identifying team members' goals for participating at the hackathon including 13 items, for example "My main goal was to make new friends" or "My main goal was to socialize with other students," measured using a four-point Likert scale from 1 (*Not very important for me*) to 4 (*A top priority for me*). Cronbach's alpha was not reported for this measure in the original article.

Challenges. The challenges questionnaire was derived from Section 2 of the AIRE instrument (Järvenoja et al., 2013) for capturing team-based challenges; including 12 items (e.g., "Our goals for the competition are different") measured using a five-point Likert scale from 0 (*It did not happen*) to 4 (*It was a big challenge*). Each item (or scenario) was intended to describe a socially distinct challenging situation. Cronbach's alpha was previously reported as $\alpha = 76.5$ (Järvenoja et al., 2013) reflecting an acceptable level of internal consistency among scenario items. At the bottom of the challenge questionnaire, students were requested to identify the challenges they perceived triggered the strongest negative emotions among their team.

Trust. The trust questionnaire is a validated self-report inventory (Costa & Anderson, 2011) for measuring trust between team members including 21 items, for instance "We are mostly open to advice and help from others." These items fall into four broader categories including (a) propensity to trust (i.e., general willingness to trust others), (b) perceived trustworthiness (i.e., perceived competence, honesty and benevolence of others to whom one is willing to become vulnerable), (c) cooperative behaviors (i.e., the extent team members rely on each other, communicate openly about their work or themselves, accept the influence from each other, and are personally involved with the team), and finally (d) monitoring behaviors (i.e., the extent team members feel a necessity to check other members' progress or behaviors). The last

category is reversely related to team commitment. Cronbach's alpha was not reported for this measure in the original article. All items were measured using a seven-point Likert scale from 1 (*Completely disagree*) to 7 (*Completely agree*). The measures provide insight into one-way trust (trust perception of a trustor in a trustee), thus for identifying mutual trust between members, aggregate responses from all team members were considered.

Shared mental models. The validated shared mental models questionnaire (Johnson et al., 2007) was used for measuring individual members' perceptions of shared cognition among their team members. The full measure consisted of 42 items that fall within five factors: (a) general task and team knowledge (e.g., "My team have general ideas of specific team tasks"); (b) general task and communication skills (e.g., "My team discusses its goal and attains the agreement of teammates"); (c) attitude towards teammates and tasks (e.g., "My team is committed to the team goal"); (d) team dynamics and interactions (e.g., "My team understands their roles and responsibilities for doing various team tasks); and, (e) team resources and working environment (e.g., "There is an atmosphere of trust in my team"). Of these factors, items of the third and fifth factors were similar to items of the trust questionnaire. To avoid redundancy, these two factors were removed from the questionnaire. Cronbach's alpha for the remaining three factors (total 25 items) from Johnson et al.'s (2007) article was reported as α = .76 (task and team knowledge), α = .89 (task and communication skills) and α = .81 (team dynamics and interactions) showing adequate internal consistency. Approval to use the shortened version of the questionnaire was obtained from the authors. All items were measured using a five-point Likert scale from 1 (*Completely disagree*) to 5 (*Completely agree*).

Socially-shared emotion regulation (SSER). The SSER questionnaire was adapted from section three of the AIRE instrument (Järvenoja et al., 2013) for measuring shared emotion

regulation strategies teams applied to regulate their team emotions at times of experiencing challenges. The original questionnaire included four items for measuring self-regulated emotions (e.g., “I convinced myself that it could actually be a good thing”), four items for measuring co-regulated emotions (e.g., “I tried to explain to others that we needed to understand different goals”), and four items for measuring SSER (e.g., “We solved the situation by compromising to accommodate everyone’s goals”). Since the focus of the current study was on the role of SSER, we did not analyze individuals’ self or co-regulated attempts to manage socio-emotional challenges in the team.

Concerning the limited number of items measuring SSER in the original measure, the list was further expanded. Inclusion of new items was according to two considerations. First, similar to the four items of the original SSER questionnaire, inclusive pronouns were used to identify SSER; for example, *we* understood…, *we* decided…, *we* accepted… Second, based on theory (Panadero et al., 2015), SSER strategies stem from the self-regulation of emotion strategies. Therefore, strategies used for individual emotion regulation were reworded to reflect SSER attempts. The final questionnaire included 21 items. Similar to the individual emotion regulation literature and the five ER strategies proposed by the process model of ER (Gross, 1998), the questionnaire was further divided into five categories. In order to measure the reliability of the adapted questionnaire, Cronbach’s alpha was calculated for each factor and revealed a value above the 0.7 threshold: For instance, for situation modification, $\alpha = .79$ and for cognitive change, $\alpha = .718$ indicating acceptable consistency among items. All items were measured on a five-point Likert scale from 1 (*Strongly disagree*) to 5 (*Strongly agree*).

Adapting questionnaires to the study context. All of the questionnaires were reviewed by a hackathon organizing committee member for relevance of terms and wordings; a few items

were removed since they were irrelevant (e.g., “We had different personal life circumstances, making it difficult to organize meetings”) and some were slightly reworded to reflect the study context (e.g., “I enjoy being in class was changed to I enjoy being in this team”). Caution was taken to only remove irrelevant items that had low loadings in their factor analyses in order to maintain questionnaire reliability and validity. A complete version of all questionnaires is provided in Appendix C. It should be noted that the constructs measured in the challenges, trust, shared mental model and SSER measures are conceptually meaningful at the team-level. Therefore, the data gathered from individual team members to assess these team-level variables were aggregated at the team level.

Video/audio data of teams. Approximately eight hours of video data and 16 hours of audio data from team interactions and interviews were recorded. There was more audio data since interviews were only audio recorded, and some participants only provided consent for audio recording. Video data was used to identify communicators in a team and not necessary for identification in a one-to-one interview session where only one participant was being recorded. Video and audio data were transcribed verbatim. A sample of the transcription is provided below:

> A team of four boys are sitting around two computers. Two boys are watching what one is typing on his computer. Now they switch and are looking at another screen. It seems like they are comparing something and seeing if their codes work together.
>
> P1: “just try, we have 20 minutes to actually put something together.”
>
> P2: “We’re actually putting something together! That’s what we’re actually doing. It’s going to get messy.”
>
> Seems like only one guy is working, while the rest are watching, and one seems to be half

paying attention. The main guy seems to be talking out loud explaining what he's doing. Another guy says, "Do you want me to create random values for you in java script?" He nods no and asks another guy to do something. "Do you want me to look up coordinates or something?" The main guy says no and keeps working. One guy is just texting. The main guy is typing constantly while the others hang around. One guy said "are you running it locally?" The main guy explains what he's doing and doesn't seem mad at all that he's the only one working at this point in time. He says "I just want to see which one survives." The others all hover over. The guy behind main guy says "Go back, go back. Where are the pictures?" One guy is standing in the back yawning and seems very uninterested. Three of them are actively involved right now with the main guy and are trying to follow what he's doing. One guy raised arms in a way to show "I have no idea what's going on."

Since the quality of recorded files was sometimes low due to the background noise of other teams, the data were transcribed by two transcribers complimenting each other's transcriptions. At some points during their teamwork, some students would switch to speaking French as their native language. In order to keep the language of the text consistent and facilitate coding, a French translator translated all French sections to English later on. The final English transcription document including both team interactions and interview data was 105 pages.

Interviews. After the competition deadline and before the hackathon ending ceremony, there was an open window of time allocated by the hackathon organizing committee for project presentation and judging. This open timeframe was an excellent opportunity to interview teams after they presented their project to the judges for evaluation. Therefore, while the next team presented their project to the judges, the preceding team was interviewed (voluntarily).

The interview time per team was approximately 10 minutes. To ensure all members of each team could be interviewed simultaneously (at separate locations), multiple trained interviewers were ready in site. The interviewers were research assistants trained in advance by the principal investigator to follow a prescribed interview protocol. The guiding questions for each interview were based on members' general experience within their team, the specific challenges they had reported in the distributed questionnaires, and whether and how they dealt with such challenges (see Appendix D). All the interviews were audio recorded and transcribed verbatim. Intervieweees were reassured that the audio and content of their interview would remain confidential, not accessible by their teammates, the hackathon committee, and nor the judges. Further, all information would be anonymized for the study purposes.

Procedure of Data Gathering

Equipment. Prior to the start of the hackathon, questionnaires were printed and audio/video equipment, extra batteries, and power extension cords were prepared. To maximize data collection from in-session team interactions, all available audio/video resources were used, including eight cameras and tripods as well as 11 audio recorders. However, the number of participating teams ($N = 16$) was beyond available resources and some team interaction data was not recorded.

Setup. On the day of the event, cameras were positioned beside different team pods, and audio recorders were placed on tables. Caution was taken to only record teams where all members had provided consent for audio/video recording. Video recorders were positioned to detect who was talking with whom and to record students' postural behavior while working in their team, and audio recorders were aimed to capture team dialogue. Since teams were all in one location rather than in separate rooms, the recorded data from teams contained noise from other

teams. This noise was unavoidable, but at times of recording in coordination with the hackathon organizing committee, the music volume in the venue was decreased so that data noise would become as minimal as possible.

Data. Three sets of data were gathered: questionnaires, in-session audio/video records of team interactions, and post-competition interviews. All team members were provided with in-session questionnaires and were interviewed after presenting their projects to judges, however due to limited audio and video equipment, in-session team interaction data were only recorded from some of the teams. The selection of teams to be audio/video recorded was random at initial hours of the hackathon. However as teams proceeded, and based on what they reported in the questionnaires, teams of interest (reporting stronger positive or negative emotions, shared mental models, or trust) were identified and were later purposefully recorded. Identified by their assigned numbers, the chosen teams were Teams 3, 7, 8, 9, 14, and 16. Team selection was also approved by the hackathon mentors and director who privately informed the study researcher of the teams who were making more progress or facing more challenges.

Data collection timeline. Based on the schedule of the hackathon, several time points were chosen for data collection. These timepoints included beginning, midpoint, directly before submitting projects, and directly after submitting projects (see Figure 9). At the beginning, hackathonists were provided with consent forms. Participating teams in the study were identified and their team pods were assigned a number (see Table 2). Each study participant was also assigned a code number (e.g., 9A, 9B and 9C for the three members of Team 9). Students were then provided with a demographic and value questionnaire. On the morning of Day 2 (after 18 hours had passed), the shared mental model and trust questionnaires were distributed among participants, and students were asked to fill in the challenges questionnaire. As mentioned

earlier, after team presentation to judges students were interviewed and were then asked to fill the SSER reflection sheets to describe any strategies they used to deal with the challenged their team faced that they had not included in the interview.

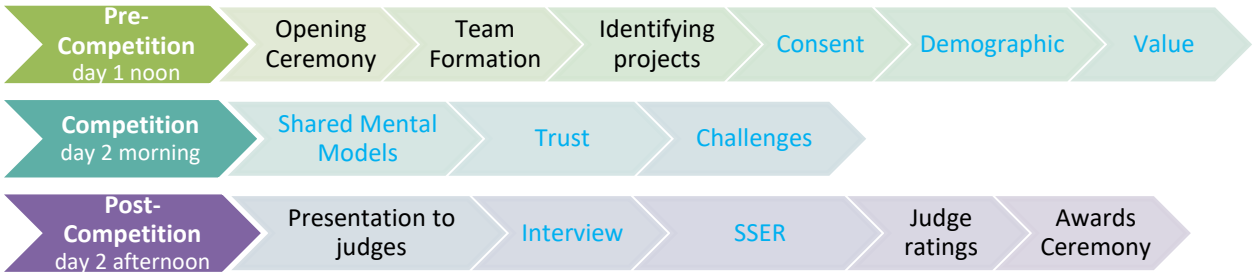


Figure 9. Data collection schedule pre-, during, and post-competition (blue wordings represent data collection steps, whereas black wordings represent hackathon events).

Pre-competition forms required 5-10 min to complete, whereas questionnaires administered during the competition required approximately 15 min to complete. Post competition data collection required 10-20 min (5-10 min interview, and 5-10 min completing the SSER reflection sheet). Although several questionnaires were planned to be administered during the competition, we intentionally did not postpone distributing questionnaires until after the hackathon. This decision was made so as to capture students' perceptions of their teams' mutual trust, shared mental models and experienced challenges, prior to knowing if they would win, and to see whether and how such factors affected their team performance. In addition, research has shown that delayed recollection of such variables distorts the nature or intensity of the emotion (Scherer, 2005). Thus, questionnaires were distributed during the competition period, but at distant time points so that students would be minimally interrupted from their actual project. Specifically, the trust and shared mental model questionnaires were provided at 8 am of Day 2, while the challenge questionnaire was distributed three hours later, at 11am (the same day). After each team had presented their project to the judges, each member of the team was interviewed separately. Before interviewing teams, the researcher scanned the challenges

questionnaires to identify challenges members reported that their team encountered during teamwork. Students were asked to elaborate on the challenges they reported, with these responses providing a basis for their post-competition discussions.

Coding Schemes

To guide data analysis, objective coding schemes were developed to represent mutual trust and shared mental model building within teams (beyond subjective questionnaire data). Codebooks were also created for challenges and SSER strategies members used to manage the challenges. The coding schemes were initially structured based on a deductive top-down approach, but they were further refined as new codes were discovered while working through audio transcripts (an inductive bottom-up approach). This involved some re-organization of categories as well as specifying in greater detail the sub-categories and providing relevant examples. A total of 2,102 meaning units (Chi, 1997) were identified to be coded from team interactions (N = 1,138) and interview data (N = 964).

As mentioned earlier, transcript data included both verbal and nonverbal information (i.e., paralinguistic features of the voice and facial expressions). In most cases, only verbal utterances were sufficient for analysis purposes, however there were some instances that nonverbal data provided a more accurate understanding of the context of team interactions, that if not applied might have led to errors in data analysis. As an example, in the following transcription excerpt a member tells his peer that she has figured out the problem. Her peer replies and says: “You said that so many times, you have completely ruined that statement for me, I can never believe. I can never trust you again! Alright. [he is smiling].” Smiling while not trusting a member changes the intensity of the challenge one is facing. Therefore, considering nonverbal cues sometimes provided a strong compliment to verbal coding.

There were also cases that within transcriptions of audio video data, certain words were missed; however, generally this did not change the overall meaning of the sentence. It should be noted that in some cases sentence punctuation was not sufficiently considered in transcription which might have caused errors. As an example, the level of surprise is different in these two sentences. "Oh, no I didn't" and "Oh no! I didn't". In order to enhance coding accuracy, when coding coders read transcriptions, *and* listened to team audios in order to code more accurately. Any part of transcriptions that was specifically interesting based on the research questions was highlighted for further attention.

A principal coder and a trained coder coded approximately 10% of the meaning units. The meaning units defined by the coders were not necessarily similar in length, but contained similar verbal reports (Greeno, 2006). A disagreement was assigned when the coders assigned different codes for a meaning unit. Interrater reliability was calculated based on Pearson's percentage of agreement, and an agreement rating of 74% was observed. The majority of disagreements were resolved through discussion. As the overall agreement was acceptable, the remaining transcripts of team interactions and interviews were coded by a single rater.

Throughout coding, the coders remained open to altering the coding scheme (see Weston, Gandell, Beauchamp, McAlpine, Wiseman, & Beauchamp, 2001) to more effectively fit team interactions or reflections about team performance during interviews. When a new code or sub-code was identified, the coders went back and recoded the transcripts as necessary to reflect any changes. The final version of the coding categories are provided in details along with descriptions and examples in the Results section in Tables 5 and 6.

Summary. Table 3 summarizes the three guiding research questions, data used to answer the research questions, along with the analysis methods and expected findings or hypotheses.

Table 3

Summary of the Research Questions (RQs), Data Used to Answer the RQs, Analysis Methods and Expected Findings or Hypotheses

#	RQs	Data	Analysis	Expected findings / Hypotheses
1.	1.1. What are the challenges teams face?	• AIRE questionnaire • Transcriptions of team-interactions and interview data	• Qualitative theory-driven thematic analysis of transcript data. • Deductive theory-driven coding and theme development	Categorization of challenges into four macro-level themes: cognitive, motivational, emotional, and behavioral (conative)
	1.2. Which challenges hamper team shared mental models and which challenges hamper mutual trust?	• AIRE questionnaire • Interview transcripts	• Descriptive statistical analysis of the challenges affecting shared mental models, and mutual trust	Identifying challenges that are more powerful in impairing shared mental models, and mutual trust
2.	2.1. What are the SSER strategies that teams apply to manage coordination breakdown?	• Students ER reporting • Transcriptions of team-interactions and interview data	• Qualitative theory-driven thematic analysis of transcripts data. • Deductive theory-driven coding and theme development	SSER strategies can be divided into five categories of the process model of emotion regulation (Gross, 1998). Extension of individual emotion regulation model to team emotion regulation
3.	3.1. Is there a relationship between SSER and shared mental models? 3.2. Is there a relationship between SSER and mutual trust?	• AIRE • Shared mental model scale • Trust scale	• Regression analysis to predict the relationship between SSER and shared mental models, and SSER and mutual trust • IV: SSER ; DV: shared mental models • IV: SSER ; DV: Trust	Higher emotion regulation skills in teams predict higher levels of shared mental models Higher emotion regulation skills in teams predict stronger bonds of mutual trust.

CHAPTER 4

RESULTS

The present research examined the types of challenges students face in teamwork, SSER strategies they applied in managing such challenges, and the relationship between students' SSER and team coordination in socio-emotionally challenging learning teams, specifically academic hackathons. Three data channels were used to answer the research questions: interview data, questionnaire data, and team-interaction dialogues. Using multiple data sources enriches the data analysis and provides more confidence in claiming findings (Carter, Bryant-Lukosius, DiCenso, Blythe, & Neville; 2014). Individual responses/reactions from all team members were considered to identify challenges teams faced and whether and how they applied SSER. In the following chapter, each research question and the respective results are presented individually, structured based on Table 3 discussed in the Methods section.

Research Question 1: What are the Challenges that Impede the Development of Shared Mental Models and Mutual Trust in Competitive Learning Teams?

In order to address this research question, the challenge questionnaire was analyzed. Each team member responded to the questionnaire and identified the extent to which they perceived their team faced a challenge. A heat map representation of the challenges teams reported is illustrated in Figure 10. A heat map is a graphical representation of data where individual values contained in a matrix are represented as colors (Wilkinson & Friendly, 2009). Colors range from dark red (representing strong challenge) to bright red (representing moderate challenges) and finally to white (representing zero or negligible challenges). Individual students' ratings for each team for each item are provided in columns instead of aggregated reports of each team. For example, 1A and 1B refer to the two members of Team 1.

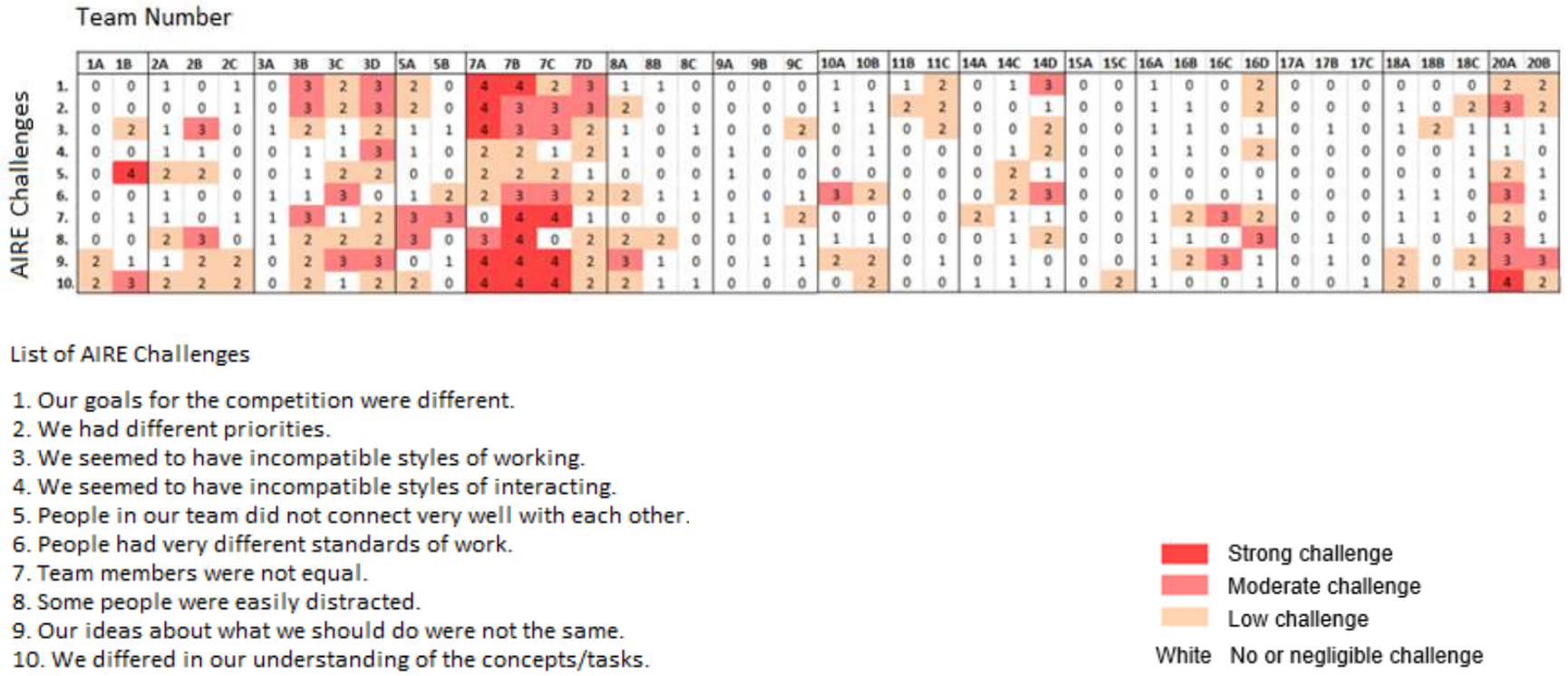


Figure 10. Heat map representation of challenges teams faced: darker cells indicate stronger challenges.

Based on Figure 10, Teams 9, 15, and 17 reported experiencing minimal challenges, whereas Teams 3 and 7 reported facing more challenges. Team-interaction and interview transcriptions were analyzed to gain a better understanding of the type of challenges teams faced. Interview data (similar to questionnaire reports) provided a subjective source to data analysis, whereas team interactions provided an objective source to the analysis of data. In the first iteration of coding, statements were coded using the challenge categories from the AIRE instrument (Järvenoja et al., 2013). Some of these categories were redundant (e.g., different goals and different priorities), some were not relevant to the study context (e.g., different personal life circumstances), and some challenge types were not identified in this list. Therefore, coding was continued in a second iteration where predominant emergent themes were noted and used to refine the existing coding categories for a more complete list of challenges team members faced during the competition. The final codes resulted in 16 categories of challenges.

As a next step, the 16 challenges were classified into seven macro-level categories. Four of the categories were labelled as motivational, emotional, cognitive and behavioral challenges; two categories represented a combination of such factors, and one category was labelled as external challenges. Motivational challenges referred to challenges that were due to motivational inconsistency among team members (e.g., differences in members' goals, priorities, and commitments; Blumenfeld et al., 1996; Järvellä et al. 2008). Emotional challenges were challenges that hampered the team's socio-emotional atmosphere; through inconsistencies among members' emotions (fear vs. risk-taking) or different arousal levels (one expresses high emotional reactions while another shows minimal emotional reactions to achievements/failures). Cognitive challenges referred to problems that hampered the team's shared cognition (e.g., difficulties in understanding others' thinking or negotiating multiple perspectives; Kirschner et

al. 2008). Finally, Behavioral challenges referred to actions of one or multiple members of a team that challenged team performance (e.g., different interpersonal dynamics, varied working styles and divergent communication patterns; Järvenoja & Järvellä, 2009). In some cases, challenge types were found to impact multiple of the afore-mentioned macro-level categories. These challenges are categorized as cognitive/behavioral and general (if they affected team performance motivationally, emotionally, cognitively, and behaviorally). Apart from challenges that were based on team dynamics, some challenges were external and were labelled accordingly. Examples of "external" challenges included environmental constraints, time pressure, task complexity, and high work load.

The refined codebook was then used to complete a third iteration of coding. Using the new version of the codebook, a volunteer researcher coded a random subset of 40 meaning units and an acceptable Cohen's kappa of κ =.85 was obtained. Table 4 contains descriptions of each of the 16 categories along with the frequency and percentage with which team members faced each type of challenge.

Table 4

Challenge Categories (Macro-level) and their Subcategories (Micro-level), Respective Descriptions and Frequencies.

Macro-categ	*n*	%	Micro-categories	Description	*n*	%
Motivational	37	5.8	Different goals/priorities	Having different priorities for participating at the hackathon: one wants to win, another wants to spend a good weekend.	38	5.8
Emotional	88	13.4	Unreliable members	Working with members that are not trustworthy. Not being sure if others can do their assigned tasks.	49	7.3
			Emotional inconsistencies	Showing different emotional reactions to achievements/failures.	25	4.0
			Negative attitudes	Complaining in difficulties. Contagion of negative emotions.	14	2.1
Cognitive	186	28.3	Low SMMs	Differences in team's understanding of the tasks/responsibilities. Reaching few agreements.	96	14.7
			Being off track	Being lost. Making mistakes.	74	11.3
			Being idealistic	Expecting much from others. Not accepting the reality and available resources. Setting high standards and not downgrading.	9	1.4
			Low efficacy beliefs	Thinking one cannot contribute. Believing that others know more and one is useless.	4	0.5
			Being biased	Prior bad experiences instigating the present situation as a bad one as well.	3	0.2
Behavioral	74	11.3	Incompatible working styles	Having different styles for working in cooperation.	37	5.7
			Dominating	Not allowing others to contribute. Willingly taking over the work load if other team members don't understand.	37	5.7
Cognitive/ behavioral	101	15.4	Inefficient communication	Not communicating ideas, obstacles, or successes to the team.	36	3.1
			Unequal contributions	Not being equal in producing work: one works efficiently, another contributes significantly less.	65	10.0
General	81	12.3	Low team cohesion	Low connection between members. Working in parallel. Not helping/updating each other while fulfilling responsibilities.	81	12.1
External	89	13.5	High task difficulty	Technical difficulties; like internet limitations, software installment errors, system bugs.	62	9.5
			Limited time	Being under time pressure.	27	3.5

Below is a description of each micro-level category along with examples of students' coded statements to better clarify the type of challenge and how it influenced the team.

Motivational Challenges

Different goals/priorities. This type of challenge is categorized under motivational challenges, causing reverse effects on team members. These challenges pertain to differences in values team members set for participating at the hackathon. These values can range from winning, learning, socializing, practicing teamwork, and/or networking with organizations of interest for a better job market. If team members have values that are considerably different from one another their team may result in lower performances (Järvenoja et al., 2013). Examples of such differences in goals and priorities from the hackathon data include:

> *Example one:* "The team and I were not actually setting for getting into the first three places, but one of our partners was actually aiming at the championship" (Participant 9B).
>
> *Example two:* "I think like the hardest part about team management is that people have different motives. In our team, one member's priority was to learn. One member's priority was to win the competition, and one member's priority was to update and get help with excellent new projects" (Participant 7A).

Emotional Challenges

Unreliable members. This challenge refers to when members are not sure if they can assign tasks to other members since they are not sure if they will do the work. In some teams, the leader assigns a task to his or her team members but members do not take responsibility for working on the task (i.e., a good leader but weak followers). This challenge becomes problematic since division of the workload becomes hard and the team tends towards being polarized into

those who work and those who do not work. Examples of such challenges from the hackathon data include:

> *Example one:* "For example, when I assigned a task to somebody, I knew that okay maybe he'd get it wrong, maybe I'd have to double check so it's a lot of work so I thought I'll just do it myself" (Participant 14C).
>
> *Example two:* "They kept asking questions. Not insistently they were just curious to make it work, and I tried to explain it to them, but I'm not sure if they understood it fully. At that time I thought this is all useless, and there was some inner talking to myself "okay just finish this yourself" (Participant 14C).

Emotional imbalance. This type of challenge refers to when members show diverse emotional reactions to achievements or failures within the team. For example one member may get super happy when a part of the project is finished, while another may show minimal positive reactions and only continue. Likewise in failures, one may get extra anxious while another may feel confident that the failure can soon be surpassed. These differences may challenge the team from proceeding further and alert members that others are "different" than me.

Another situation is when one member is emotionally disrupted and is experiencing undesirable feelings that may impede team performance such as being stressed, furious, frustrated, disappointed, etc. These emotions may be due to prior challenges the member has faced (either cognitive, behavioral or external challenges), or they themselves may become a new layer of challenges that have to be dealt with or otherwise they may turn into a new obstacle. It is important to note that the emotions of each individual member in a team can be contagious and may transfer to other team members, influencing the emotional atmosphere of the whole team (Barsade, 2002). Examples of such types of emotional imbalances in members are:

Example one: “They were the most comprehensive. I was the most uneasy” (Participant 8A).

Example two: “I was kind of bewildered and lost for quite a bit of it unfortunately” (Participant 18B).

Negative attitudes. This challenge refers to when members generally complain about problems that occur in the team and (similar to emotional imbalance) radiate negative energy to the team; for example: “I’m unfortunately really easily frustrated and stressed.*”*

Cognitive Challenges

Low shared mental models. This challenge refers to when members of the team have different understandings of the tasks to be done and responsibilities they have; and/or they have difficulty negotiating, compromising or reaching consensus. Examples of challenges pertaining to low shared mental models are:

Example one: “You start working but then they can’t follow you. You try to guide them forward but it’s useless. So it happened a few times that some team members didn’t have something to do because they didn’t know what to do” (Participant 9A).

Example two: “There was often somebody not doing anything, or somebody doing the same thing as I was. That was really annoying” (Participant 14A).

Being off track. This challenge is a cognitive challenge where members are lost and unclear of what they should be doing, or make errors that delay team effectiveness.

Example one: “At the beginning we didn’t know what to do, so we started on some project and found out it was too complicated. Our ideas were choppy and we were all over the place” (Participant 3C).

Example two: "I'm a physicist and I think I made 5 mistakes in one line of computation. I had the angles wrong, I had the x and y axis inverted. I had everything wrong! And because of that we spent a lot of time trying to fix the bugs" (Participant 8A).

Being idealistic. This challenge refers to having unrealistic goals, expecting too much from others, or setting high standards that are unrealistic according to available resources (e.g., time or member skills). This type of challenge was prevalent among several teams that originally decided on a project and after several hours (or even one day) realized that they did not have the ability to complete the task and had to downgrade to a simpler task. Some examples of challenges due to being idealistic are as follows:

Example one: "We started on some project and found out it was too complicated and we changed our project mid work" (Participant 14A).

Example two: "Yesterday night I was not getting some work done because it was supposed to be easy but it wasn't happening. So I became frustrated and stopped working on that" (Participant 14D).

Low self-efficacy. This challenge refers to the belief that one has little ability to contribute and accomplish a task s/he is assigned to do, or believes that the team cannot succeed much in comparison to other teams. This approach can turn into a cognitive/motivational challenge as it influences how one approaches goals, tasks, and difficulties (Bandura, 1994). Below are some examples of this type of challenge:

Example one: "The other two guys put in more effort. It was a bit of challenge for me because I felt I was much more of a deadweight on the team but I don't think it affected the team much" (Participant 14D).

Example two: "It's just hard to be productive and I guess because people have different skill levels, those who feel they are less skilled do something else, other than the project. That's what I did" (Participant 16D).

Biases. Biases refer to having a preconceived opinion about another team member from undesirable past experiences. In such cases, prior bad experiences may instigate the present situation as a bad one as well. An example of such instances in the hackathon data includes:

"My friend and I have a very long history of conflicts. So this wasn't anything out of the usual. I suppose because the nature of this was less programming and more physics and my friend took a more dominant role, I let her make final decisions on things, some of which I disagreed with later because it made things harder for me" (Participant 18B).

Behavioral Challenges

Incompatible working styles. This challenge refers to when working styles for achieving success are different. As mentioned before, significant differences may lead to strong obstacles towards reaching success. A member may choose to brainstorm ideas as much as possible, while another member may choose to start coding as soon as possible. A member may choose to procrastinate when s/he realizes his task is difficult, while another member may focus more and get help from mentors/peers to pass roadblocks. In this instance the member who has tried more may lose trust in the member who has easily postponed his/her task or given up, and this may in turn decrease further teamwork, thus leading to a poorer achievement or even team failure. Other examples of incompatible working styles include free riding or asking too many questions (thus taking other members' time):

Example one: "The biggest challenges I guess would be that I didn't have the same technology as them so I couldn't use Matlab, so I kind of just worked on my own thing.

And there was one person who did most of the work. But I felt pretty good, I mean I didn't do a lot of the actual work for this" (Participant 16C).

Example two: "When I got frustrated with my codes, I mostly just kept bugging my colleagues" (Participant 16D).

Dominating. This challenge denotes not allowing others to contribute, or willingly taking over the work load if other team members don't understand. Dominating is the opposite of collaborative working where tasks are divided between members based on their expertise. When a member dominates, s/he does not value others' contributions and may discourage them from making a contribution. Therefore, dominating is different than adapting to increased workload where one needs to work additionally because others do not do their tasks.

Example one: "I knew that he really wanted to like to do it himself, he's a guy that normally works alone. But it would be better to ask each other what is the next step rather than deciding it by oneself" (Participant 5A).

Example two: "The team was not on the same skill level, so it happened a few times that some team members didn't have something to do because it was hard to coordinate everything, so one of our team members left yesterday because like we didn't find anything for him to do" (Participant 14A).

Cognitive/Behavioral Challenges

Low or inefficient communication. This challenge refers to little communication and interaction between members (not knowing when and what to communicate), having difficulty communicating (not being able to communicate due to time pressure, language barriers, or working with members that do not understand the task much), or having different styles of

communication (a team of talkative and silent-working members). Examples of this type of challenge from the hackathon data include:

> *Example one:* "At the very end when we were all stressed out and we needed to go very fast, it was harder to communicate and we had difficulty to understand each other and it was happening more because we were all stressed out" (Participant 17C).
>
> *Example two:* "We had difficulty to communicate. He wasn't really talkative. He's more like reserved. So I didn't know what he's up to and so he decided further things himself" (Participant 1B).

This type of challenge was common among low performing teams. Research has shown that communication is a key element of effective team coordination (Salas, Sims, & Burke, 2005). Experts in team analysis refer to lack of communication as a behavioral marker to teamwork breakdowns (Wilson et al., 2007). Wilson and colleagues identify three communication skills that if neglected may lead to teamwork breakdowns: (a) information exchange (i.e., providing information within a timely manner and before others ask, updating the team by providing a big picture of their situation), (b) phraseology (i.e., using proper terminology and communicating audibly), and (c) closed-loop communication (i.e., acknowledging receipt of information, and verifying that information sent was interpreted as intended). Effective communication is a central element in team collaboration.

Unequal contributions. This challenge refers to when team members are not equal in producing work. This type of challenge can be cognitive or behavioral depending on the type of contribution (e.g., idea generation is cognitive, and coding is behavioral). For example, one works more efficiently, whereas another contributes significantly less:

Example one: "I just was disappointed that we could not work equally on the project" (Participant 5B).

Example two: "I don't take much credit for what we produced, kind of just here for fun! Well there was one person that did most of the stuff and other people didn't do as much. Like the other girl did her own research" (Participant 16A).

General Challenges

Low team cohesion. This challenge refers to a low interpersonal bond between members, where members tend to work in isolation, share minimal information and are not willing to help each other out when necessary (Wilson et al., 2007). This challenge may stem from more fundamental challenges such as working with unreliable members or having a team with members of varied competence levels. Previous literature has identified team cohesion as "a dynamic process that is reflected in the tendency of a team to stick together and remain united in its pursuit of its instrumental objectives and/or for the satisfaction of member affective needs" (Carron, Brawley, & Widmeyer, 1988, p. 213). The *low team cohesion* challenge is the only challenge that can be motivationally, emotionally, cognitively, and behaviorally challenging for a team. Examples of this prevailing challenge are provided accordingly:

Motivational: "Every time they asked a question, it took like 15 minutes, like three or four times that this happened. I wanted to go back to my stuff, I didn't want to be explaining to them" (Participant 15C).

Emotional: "It was a bit of challenging for me because I felt I was much more of a deadweight on the team" (Participant 14D).

Cognitive: "I was in the team but I didn't have Matlab, so I wasn't really working on the same project as they were. It kind of separated the team quite a bit" (Participant 16C).

Behavioral: "He's very individualistic, so he works alone" (Participant 1B).

Teams with high cohesion (Teams 3, 8, 9, and 15) reported having less internal challenges and mainly struggled with external challenges (internal/external challenges ratio = 1.32). Reversely, teams with low cohesion (Teams 1, 2, 5, 7, 11, 14, 16, and 18) struggled more with basic issues (e.g., identifying a shared project after a long while; internal/external challenges ratio = 5.48). This important finding reveals that when teams struggle to build a cohesive atmosphere of shared goals and shared understandings, they have less time to go beyond and overcome external challenges. On the other hand, teams that possess a cohesive atmosphere can focus more on overcoming external roadblocks and achieve higher levels of success.

Due to the nature of the competitive and time-limited task that teams were involved in, some teams chose to not put much time on building team cohesion (i.e., Teams 1, 5, 11, 14, 16, and 18). This challenge was reported in the interview data of such teams, aggregated from different team members' reports. In such a case, a team leader may decide to not delegate tasks to less skilled team members or include them in important decisions of the project in order to save time to work on remaining details of the project:

> "There were two electrical engineers but the project that we were working on was sort of a chemical engineering task so they had no clue what we were talking about and they kept asking questions for a while like maybe half an hour… so eventually I got frustrated and I was like okay let's get this done, get it over with. For example, when I assigned a task to somebody, I knew that okay maybe he'd get it wrong, maybe I'd have to double check - so it's a lot of work so just let's get it over". (Participant 14C)

As a result, and especially in teams where members would probably not see each other in the future, some members chose to leave their team midway and the team worked without them (i.e., Teams 1, 11, and 14).

> "We found ugh projects for everyone but then when we finally decided on what to do, we found out that for instance a student, he was first year so he finally found that he couldn't contribute so he left." (Participant 14A)

Participants of teams with low cohesion may finally accomplish their project (e.g., Team 5 that won the second place in the hackathon), however learning may not necessarily occur for the less competent and team performance may not be pleasant for all (Hill, Offerman, & Thomas, 2018).

External Challenges

High task difficulty. This challenge refers to technical difficulties that are not due to member shortcomings; for example internet limitations, software installment errors, system updates. A few such challenges are exemplified below:

> *Example one:* "Last night we didn't make enough progress. The algorithm working people were stuck on their code. The code wouldn't run. Our time passed for just learning JavaScript and equations, we couldn't do more" (Participant 7A).
>
> *Example two:* "The first afternoon was kind of tough because most of, actually all of us weren't really familiar with some of the computer language" (Participant 15A).

Limited time. Apart from task difficulty a major external challenge was time pressure. As one team noted: "*The biggest challenge that our team had was that we took very long to figure out what we wanted to do. After, we needed to go very fast."* Below is an example of team interactions (from Team 14) facing limited time:

P1: You have a minute
P2: I only need 10 seconds
P3: You have 15 seconds
P1: Yeah whatever people are going to be late
P2: 5 seconds
P1: run it
P2: I'm just restarting the server...it's buffering
P1: Try and refresh, it could be quicker…start from the beginning
P2: What?
P3: We only have 1 second!
P1: Refresh!
P2: Just wait! just wait!

Of the less frequent challenges, were language barriers (e.g., "English is not my first language so we had difficulty in communication"), and cultural differences (e.g., "I was looking for someone to tell me what to do, others thought it's better to decide together. This might have roots in my cultural background"). In sum, whether challenges were due to team dynamics or whether they were external, it is clear that the experience of competing at the hackathon was generally thought as a challenging task; for example, "It was a special experience because we were way in the front, we had a lot of time to do little details and then at the end I screwed up and nothing was working" (Participant 9A). Some of the challenges had negative effects on team trust, and some of the challenges hampered shared mental models. In the following section, challenges that hampered shared mental models and challenges that impaired mutual trust are identified.

Challenges that hamper shared mental models and/or mutual trust

After filling out the challenge questionnaire, participants were asked to highlight challenges that specifically hampered their shared mental models in the team and/or decreased their trust towards others in the team. Participants reported having impaired trust in the team for the following challenge items (percentages indicate frequency of participants rating the challenge as a cause to trust violation): different goals/priorities (60%), unreliable members (86%), low

self-efficacy (83%), being biased 56(%), and unequal contributions (67%). Challenges that had negative effects on shared mental models in teams were reported as: being off track (73%), being idealistic (77%), incompatible working styles (50%), low or inefficient communication (62%), and dominating (70%). The following excerpt is an example of a student reporting why dominating decreases shared mental models in a team rather than trust:

> 1B: I felt like we lacked communications.
>
> Interviewer: Would this cause you to have less trust in your team members?
>
> 1B: well it's not about trust, it's more about I know he's competent and I know that he will do well.
>
> Interviewer: You still trust him?
>
> 1B: Yeah, but it's still good to communicate and ask each other what is the next step together rather than deciding it by oneself.

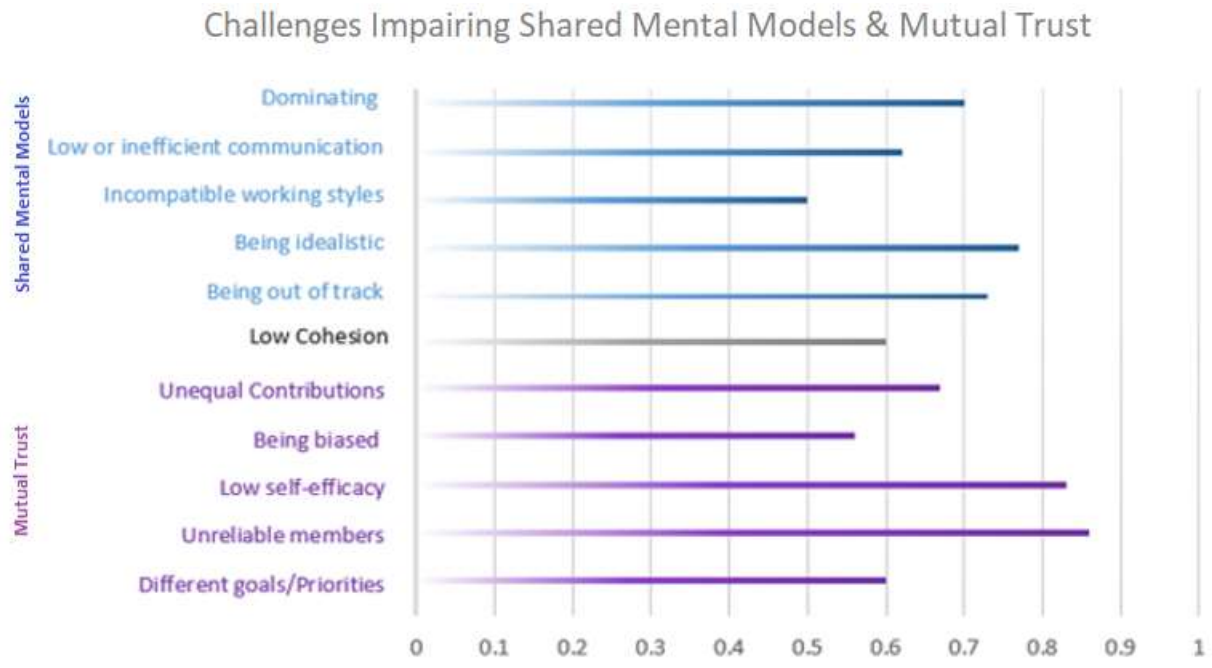


Figure 11. Frequency count of participants rating a challenge as a trust violation (in purple), a shared mental model (shared mental models) impairment (in blue), or both trust and shared mental models (in black).

It should be noted that external challenges were not seen by students as a factor that impaired trust or shared mental models; for example: “Sometimes it was discouraging when things didn’t work, so more like just frustration. I don’t think so much trust issues” (Participant 2A). Low team cohesion was the only reported challenge to have effects on both decreased shared mental models in the team (57%), and lower mutual trust among members (62%; *M* = 59.5%).

Research Question 2: What are the SSER Strategies that Teams Apply to Manage Coordination Breakdown?

To answer the second research question regarding how teams applied regulation strategies to deal with the challenges they experienced, interview transcriptions as well as team interaction transcriptions were coded from the perspective of socially-shared emotion regulation (SSER). Interview data directly asked questions regarding whether and how team members managed their challenges. For team interaction analysis, shared emotion regulation (whether consciously or unconsciously applied) was identified when a regulatory strategy was followed after a challenge that occurred in the team (Järvenoja et al., 2013). In addition to these data sources, the SSER questionnaire (adapted from Section 3 of the AIRE instrument; Jarvenoja et al., 2013) was used to identify common SSER strategies students reported applying when challenges arose.

For each of the two concepts of mutual trust and shared mental models, thematic analysis and deductive coding (Flick, 2014) was applied and predominant emergent themes were derived from the three afore-mentioned sources of data. Tables 5 and 6 respectively present SSER strategies to enhance mutual trust and shared mental models (e.g., Behfar et al., 2008, Järvenoja et al., 2013, Lajoie et al., 2015; van den Berg et al., 2014). As the lists evolved, the concepts of

mutual trust and shared mental models became clearer to understand, and the categories and subcategories provided a brighter gateway to measure such conceptual variables (see Weston, Gandell, Beauchamp, McAlpine, Wiseman, & Beauchamp, 2001 for how codebook evolution adds to concept clarity).

Table 5

SSER Strategies for Mutual Trust

Category	Subcategory (+/-)[1]	Description	Example
1. Supportive behaviors	1. High involvement	Self-sacrifice for the team.	Being present and committed over the course of the hackathon (evident through continuation of work during snack times, midnight, etc.)
	2. Providing aid	Continuously supporting each other's work while undertaking interdependent tasks.	I think I know how to help you solve this problem, watch how I do it on my laptop.
2. Reliance (showing self-reliance or reliance on others)	1. Fulfilling personal tasks	Taking responsibility for tasks one has agreed to work on.	I am about to finish designing the slides!
	2. Considering other suggestions	Coming to agreement when members have differing ideas.	Ok, Let`s try your idea.
	3. Seeking advice	Asking specific questions and/or listening to team members when one is at a loss of what to do.	While we're at it, I have a question for you.
	4. Dividing tasks	Confidence in self and others' task completion.	Please work on the magnetic field while I work on the slides.
3. Showing understanding	1. Appreciating, encouraging contributions	Attempting to encourage the sustained involvement and contributions of other team members.	Providing positive feedback by phrases such as exactly, great, fantastic.
	2. Interpersonal sensitivity	Showing caring and understanding.	Agreed! You have a tough job!
	3. Extending mutual respect	Showing respect and politeness to others.	Sorry to interrupt, Please finish your sentence.
4. Trustful communication	1. Confidence in personal expression of ideas	Speaking out for what we believe is the right strategy or next move.	I think this formula is what we're looking for.
	2. Honesty	Discussing problems openly, Accepting mistakes.	There is a glitch, I must have made a mistake.

[1] *"–" refers to the inverse of a subcategor (e.g. –2.4 refers to not dividing tasks or showing dominance).*

Table 6
SSER Strategies for Shared Mental Model Enhancement

Category	Subcategory (+/-)[a]	Description	Example
1. Knowledge co-construction via Effective Communication	1. Negotiating, Compromising, Reaching Agreement.	A dialogue between members (a discussion chain) where members reach agreement in discussions, and follow each-others' train of thought.	– That's a cool example! – Okay but I think we can't keep this. We should show this one. – Yeah, ok of course.
	2. Information Sharing.	Sharing relevant information to inform and update team members.	Just to let you guys know, the formula now works!
	3. Purposefully using a common language.	Taking into account other members' level of intellect.	Okay. I'll explain differently…
2. Task work Cognition	1. Identifying roles, Setting rules on how to proceed.	Setting teamwork rules based on skills and responsibilities.	Okay guys, let us know when you finish.
	2. Knowing how to search for information.	Knowing from where and whom members can get information when needed.	Asking a mentor for advice when needed.
3. Teamwork cognition	1. Agreeing on tasks.	Collaborating until the team has established shared goals.	Ok, great so we all agree on this now.
	2. Agreeing on roles.	Knowing members' roles and responsibilities.	So when you've finished working on the calculation, work on the design.
	3. Understanding team limitations.	Evaluating team limitations while working.	Not sure if we can work on this idea given our limited time.
4. Cognitive flexibility	1. Being flexible to find a solution to disagreements.	Stepping on ego. Modesty in teamwork. Accepting mistakes.	The velocity was too low Yeah. You want me to increase it? Yeah i think.
	2. Being open-minded and unbiased.	Keeping open minded to learn from one another. Viewing others suggestions as possibilities of improvement.	– But then we would have a problem: if it stops by itself, it could stop there! – No, if the acceleration is super high then you're above it. – Okay, yeah yeah.
5. Maintaining team cohesion	1. Being optimistic.	Focusing on accomplished not uncompleted tasks.	Well, i'm happy that we've done this at least.
	2. Constructive criticisms.	Providing alternative solutions to wrong actions.	You might want to put this instead? Try the best you can.
	3. Downgrading from ideals.	Accepting realities (e.g., differences in team members in terms of expertise) and setting doable goals.	Don't get frustrated. I guess it's too hard. Just work on this part.
	4. Not exaggerating.	Not making a mountain out of a molehill.	Not a big deal. We'll figure it out. Try 0.7

[a]*The + code refers to the presence f a code stated in the table, and the – code refers to the absense of that code in the table. For example, – 3.2 refers to not knowing who is supposed to do what.*

As an example, the following present a few interview excerpts representing shared mental models in teams (i.e., task-work cognition):

Example one: "For the most part, we all had clear roles, because we were all specialists in a special topic. So one of my friends did the coding of the website, I did the physics thinking, and the other did the JavaScript" (Participant 8A).

Example two: "Both of us pitched ideas all the weekend…and then my friend really got a great idea. So we changed for a network graph. I did the network part, and he did like the propagation part of our project" (Participant 5A).

Example three: "Everything was transparent basically. We all knew what we were going to do" (Participant 8C).

In order to develop a unique table for identifying SSER strategies applicable to mutual trust and shared mental model enhancement, the subcategories of Tables 5 and 6 were merged together. Some of these subcategories had some commonalities, for example "considering other suggestions" (from Table 5) was similar to "being open-minded and unbiased" (from Table 6). Thus, in a second iteration redundant subcategories were merged and slightly reworded to reflect SSER emotion regulation strategies within the team. The final list of shared emotion regulation subcategories includes 29 different strategies that teams can use to manage/modify their emotions.

Previous theoretical literature (Panadero et al., 2015) has declared that SSER originates from individual emotion regulation and is therefore isomorphic to individual emotion regulation. Therefore, the established emotion regulation model (Gross, 1998, 2015; developed for categorizing the self-regulation of emotions in solo or social contexts) was used as a basis to categorize the 29 socially-shared emotion regulation strategies. The individual emotion

regulation model includes five macro-level categories: situation selection, situation modification, attention deployment, cognitive change, and response modulation. Situation selection refers to attempts to change the location of team working in order to decrease emotional demands on members. Situation modification (as identified earlier) refers to modifying elements of a situation to decrease the emotional load of a challenge. Attention deployment means changing the focus of attention to experience less (or more) emotions. Cognitive change refers to changing thoughts about the challenges. And finally, response modulation refers to interrupting the physiological, experiential or behavioral responses that team members have in response to challenges they face. The following example provides possible regulatory strategies adapted from the five ER strategies identified by Gross (1998): If technology is providing barriers to externalizing and sharing ideas in a team, using situation selection the team can switch to another technology platform assuming that the environment can easily be changed (e.g., from Skype to Google Hangouts). If not possible, the team can seek to modify the situation by adjusting features of the platform to accommodate to the team's specific needs (e.g., pausing camera view to enhance verbal communication). If this option may not work or be too complicated, a third type of strategy can be to divert attentions to non-technological tasks that the team may discuss about (e.g., reporting on accomplished tasks and organizing new areas of work). As a fourth strategy type, the team may try to alter their cognitions to a more optimistic perspective (e.g., think that such barriers are temporary, and not only they are not unwanted but also provide transitional times for them to have informal talks and get to know more about each other). Finally, the team can choose to manipulate emotional responses by suppressing or expressing feelings of frustration or annoyance. Table 7 presents the SSER strategies integrated into the process model of ER, labelled as the "team emotion regulation model".

Table 7

The Team Emotion Regulation Model (Extended from the Model of ER for Individual Emotion Regulation; Gross, 1998, 2015)

Category	Subcategory (+/-)	Description	*n*	*%*
1. Situation selection	Environment selection	Selecting an environment that would be optimal for the team to proceed.	2	0.5
	Partner selection	Selecting to work together or separated when challenges arise.	9	2.4
2. Situation modification	Collaborative problem-solving	Using the team's shared intellect to reach better solutions. Dividing work.	45	12.1
	Constructive criticism	Explaining a partner's mistake(s) in a positive and respectful manner	2	0.5
	Contribution encouragement	Active listening. Acknowledging contributions. Using inclusive pronouns.	17	4.6
	Adapting to increased workload	High commitment. Taking on additional duties. Sacrificing.	19	5.1
	Help seeking/ help giving behavior	Asking for help when necessary, and providing help when others need.	19	5.1
	Using relaxation techniques	Encouraging all to deep breathing or drinking water	4	1.1
	Interpersonal sensitivity	Showing caring and understanding.	6	1.6
	Confidence in expression of ideas	Speaking out for what we believe is the right strategy or next move.	35	9.4
	Increasing honesty	Self-disclosure when appropriate. Informing others about one's shortcomings.	12	3.2
	Increasing communication	Communicating in details. Updating the team more frequently.	14	3.8
	Downgrading & time management	Re-evaluating team capabilities and assigning goals that are more doable.	10	2.7
	Being open-minded and unbiased	Accepting mistakes. Getting inspired by new ideas.	15	4.0
	Allowing time	Waiting. Giving time and being patient.	4	1.1
3. Attention deployment	Distraction	Diverting attention to unrelated activities to decrease unwanted emotions.	5	1.3
	Concentration	Focusing on task to decrease/eliminate emotions.	16	4.3
4. Cognitive change[a]	Optimism	Seeing challenges as an opportunity not a threat. Reassuring the team.	30	8.0
	Putting into perspective	Standing in the shoes of others to understand their viewpoint.	4	1.1
	Problem shrinkage	Finding approaches to minimize the magnitude of problems.	12	3.2
	Worse-off comparisons	Comparing with worse occasions or worse teams. Catastrophizing.	9	2.4
	Decreasing standards	Accepting that lower ideals are advantageous as well (e.g., learning vs. winning)	17	4.6
	Use of humor	Making light of challenges to instill calmness.	6	1.6
	Decreasing expectations	Not expecting much from other members.	7	1.9
5. Response modulation	Suppressing maladaptive emotions	Withholding maladaptive emotions from negatively affecting the team.	3	0.8
	Expressing adaptive emotions	Sharing positive emotions to cheer the team.	29	7.8
	Resisting maladaptive emotional contagion	Resisting contagion when some members share negative emotions.	5	1.3
6. Regulation failure	ER failure	No particular strategy is described or nothing is done to change emotions.	16	4.3

[a]*Turning to religion has been addressed in some other studies (e.g., Watts, 2007) as a cognitive change strategy, but we didn't find evidence in the hackathon data.*

In the following section, the 29 micro-level SSER strategies are described along with examples from the hackathon data in order to better exemplify the developed categories.

Situation Selection

Environment selection. This strategy refers to attempts to change the location of team working to decrease emotional demands on the team. As an example, “In some cases, when our challenges were emotionally and mentally draining, we took a walk outside” (Participant 7D).

Partner selection. This strategy refers to selecting to work with other team members or selecting to work in isolation (avoiding to work with others). Members may choose to work or avoid working with each other in challenging moments in order to enhance the team’s positive emotions or modify negative emotions in the team. Analysis of the data revealed that some teams preferred to use this option in challenging moments. Examples of partner selection and partner avoidance, respectively, are as follows:

> *Example one:* “When we came to the event, we were supposed to be a team of two, but then I saw this guy who was standing next to our table at the left and he had a box of a keyboard that I really know, because it's a programmer's keyboard and I have one, so I said I feel this guy is quite clever. I just said hey that’s a nice keyboard and we started talking and so we talked about our ideas. Then I said hey I mean if you want, you could be a great part of our team and he said yes! And we were so proud to have him with us!” (Participant 8A).
>
> *Exampe two:* “I literally did not need them at all. I could have done this on my own and it wouldn’t have made zero difference. They were different, and I knew without them I can still work. I was like okay you guys can do that if you want and I can help if you guys

have a real idea that I think is doable, but until then I'm just going to keep working on the other idea" (Participant 7C).

Situation Modification

Collaborative problem-solving. This strategy refers to collaboration in working on the project (rather than working independently from one another). When some parts of the project become complicated, members rejoin, brainstorm ideas and try solutions to overcome the obstacle(s). Below are examples from interview data, as well as an example of a dyad working collaboratively to solve a problem. Examples are provided from two sources of data to provide a richer understanding of the SSER category.

Interview example one: "We figured out a new algorithm easier to code" (Participant 5A).

Interview exampe two: "We were able to fix bugs easily" (Participant 8A).

Team interaction example from Team 9: 9A: I think the velocity should be higher and the circle should be smaller. But you say it doesn't work? Can you make velocity higher? I think it snaps too much

9B: Okay let me show where. Here if the distance is very close, then I say if the velocity has a threshold of 2000 that helps. Okay what if you try this?

9A: It's not going to work, there's no space

9B: No but just in general what would we have?

9A: This is 1300. That's why I put 2000 but if you want we can make the distance closer so like at 5?

9B: Yeah

9A: And let's try this…

9B: Well, let it evolve a bit cause a real pendulum might do something crazy like that

9A: If you remove the friction it's crazy

9B: Yeah we need high friction. That looks better.

Constructive criticism. This strategy refers to explaining a partner's mistake (s) in a positive, respectful and encouraging manner. The following excerpt from team interactions serves as an example of this category:

14A: I understand what you're trying to do but I think it might be better to do it like this [typing codes]

14C: Now write something meaningful for the description so say that it is a height exchanger and we're simulating it for two different scenarios of co-current and counter-current and every physical parameter such as …

14A: I'm writing it here…

14C: I think it's better to change how you write it

14A: I think they are more or less the same. Here is the whole story …

Contribution encouragement. This strategy refers to acknowledging member efforts and encouraging team contributions. This regulatory strategy enables members, even those of less confidence, to speak up about their ideas and enrich team discussions, and ultimately strengthens team cohesion. This regulatory strategy has strong effects on the emotional atmosphere of the team and can empower the team towards getting closer to their goals. This is similar to a football audience cheering their favorite team in an important match to boost the team's energy especially in the final minutes of the game. The following is an example of contribution encouragement:

14C: It works! You see…aw nice, nice

14A: So if we increase the flow rate, should that help?

14E: Actually we should increase the numbers of coins, go back to code

14A: Oh that's what you mean

14C: Yeah

14E: Sorry I forgot that

14C: Yeah this should look nice

14A: It looks better …this one is perfect

14C: Yeah

14A: Good job!

14E: Yeah! Good job!

14A: You guys are actually brains bro masters!

An example of a negative "contribution encouragement" code (i.e., contribution discouragement) is as follows:

9A: No, no!

9B: Yeah but it's not that, stupid

9C: Me, I'm stupid

9A: The acceleration equals [typing on his laptop]

9C: I'm sorry

9A: So which one could we have put?

9B: In a constant manner because we don't want that

9A: No, it doesn't accelerate in a constant fashion

9B: Even a single time?

9A: Yes even. Impulse is like momentum times time, no change in momentum

9C: Yeah

9A: So it's the momentum transmitted, it's the force times the time.

Adapting to increased workload. This strategy refers to taking on additional duties when realizing that one needs to put more effort and time either because the task load was primarily anticipated to be lower, or when other member(s) cannot work as planned and encounter problems that need additional assistance. This strategy is also common in trusting relations where trusted members adapt to increased workload and demonstrate reliance at times of need. A few of such examples are provided below:

Example one: "It happened sometimes that they weren't doing their tasks. Then we might have just done the tasks ourselves" (Participant 14A).

Example two: "He finally found that he couldn't contribute so he left. So, we had to rely more on the team members that were still there" (Participant 14C).

Help seeking/help giving behavior refers to asking for help when necessary, and providing help when other members of the team need it. Although these two categories are rather distinct at the individual level, they both reflect "actively solving a shared problem" at the team level. Therefore, they are considered as one category. An example from team interaction dialogues is provided here:

8A: Why is this not working?

8B: What? What is not working?

8A: Is that correct? [Reading off the computer]

8B: Maybe it's 4 each, you have to remove the parentheses

8A: The syntax looks weird but I'll try it. Yeah looks weird but anyway I'll use the normal one… yeah this is the more normal way to do it (mumbling and typing)

8B: While we're at it I have another question for you: When I create a new object inside a function, when it escapes the function, is the object deleted?

8A: It's inside the scope

8B: Okay so this object will land after the exit?

8A: No

8B: Okay great.

The following are two examples of co-regulation in help giving:

Example one: "They mainly focused on their own tasks but if I had a problem I would ask them. And they would help me, give me a hand" (Participant 15A).

Example two: "I didn't feel pressured, it made me feel like I was there to do my job and that they were there to help me if I needed to. They were not the other way: they were not, not helpful" (Participant 8A).

Use of relaxation techniques. This strategy refers to techniques used to de-stress members (e.g., deep breathing, drinking water). There were very few examples of this technique in the data that were applicable to the team: "Just chill. One thing at a time…yeah just breathe." (Participant 3D). There were also some instances that this strategy was more applicable to an individual. Those cases would not be counted as an SSER strategy although destressing the self would ultimately lead to destressing the team, this is because the direct effect was initially on the self. An example of a relaxation technique used to regulate an individual's emotions is: "I felt frustrated. So I used square breathing. So you breathe in five seconds, hold five seconds and breathe out five seconds. Do that five times" (Participant 7D).

Increasing communication. This strategy refers to updating the team on one's progress or any changes to the tasks to allow a shared understanding for all of the team.

Example one: "Often there were two people understanding one thing because they had the idea together and the third person was either not there, or doing something else at the same time, so then they explained it to the third person… So sometimes there was an idea that was hard to grasp for one of us or both of us and then we spoke about it…" (Participant 15C)

Example two: "We managed it by just explaining. Just having myself explain to the other two people and that person explaining to the one who still didn't understand it" (Participant 15C).

Downgrading and time management. This strategy refers to re-evaluating team capabilities and assigning goals that are more doable in a specific timeline. This is a very important regulatory strategy that if applied can help the team adapt to the realities of the demanding situation instead of being idealistic and not reaching the goal in a timely manner. Some examples from the hackathon data are provided here:

Team interaction example:

9A: I don't think there is a problem

9B: Yeah well its vector subtractions, it's a library of vectors

9A: Ah, no. Well I think it is more realistic and if we want to push it further we'll do it last thing. If it works that`s great, but the first thing I need to do is put the right script on the stars, it's not the right one right now.

Interview example:

"It was difficult for us to choose one out of the two ideas. The first idea was too problematic, so we worked on a second idea that went a lot smoother" (Participant 2A).

A great example of downgrading – although targeted at the self rather than the team:

"So I was proud of me because I was able to say [to myself], "okay he is right I'm going to let go [and stop insisting on my own idea]. Because for the time being, his solution was correct" (Participant 8A).

Being open-minded and unbiased. This strategy refers to accepting mistakes and getting inspired by new ideas. There are many examples of this regulation strategy in team interactions. Also some statements from the interview data referred to applying this type of regulatory strategy. A few examples are provided below for better clarification:

Team interaction example:

8B: Are you okay with this?

8A: I'm okay with this, just can you make the circle smaller? and replace 5 with 3, that way we won't have the number of magnets

8C: Ok

8A: This is like real

8B: This is nice

8A: Good good good!

Interview examples:

"We tried new ways to go for that problem" (participant 5B).

"At that point, they agreed to try my suggestion" (participant 16B).

Allowing time. This strategy refers to waiting, giving time and being patient; for example, "If we're not really agreeing with each other, we sit down, give it a time to cool down, then we continue talking" (Participant 16B).

Attention Deployment

Distraction. This strategy refers to attending to unrelated activities to relieve unwanted emotions. An example of distraction is deliberately ignoring the stressor. This type of strategy has sometimes been used in team interactions:

Example one: "If we would get emotionally imbalanced because of someone, we would ignore the person and work around them" (Participant 14A).

Example two: "We sometimes just listened to music to distract ourselves" (Participant 18B).

Concentration. This strategy is the opposite of distraction. It refers to focusing on the task to decrease/eliminate emotions. When members face challenges they either attempt to work around the challenge, or focus and try working on it as much as until they overcome the challenge. Examples of this type of regulatory strategy include:

Example one: "I knew this would work at the end. We just tried again and again until it works" (Participant 5B).

Example two: "So my friend and I watched him fiddle on his computer until we had a sign of understanding" (Participant 8A).

Cognitive Change

Optimism. This strategy refers to reappraising team capacity to manage situational demands (reassuring). When members focus on the positive aspects of their teamwork, and highlight that, they use optimism as a regulatory strategy. This strategy, otherwise known as reappraisal, is very strong in alleviating desired emotions (Gross, 2002), and in analysis of the hackathon data has been identified quite frequently:

Example one: "Although some of the other members are novices and contribute less, they are all extremely intelligent people and learn fast" (Participant 3C).

Example two: "It was not a problem because we ended up further understanding" (Participant 15C).

Problem shrinkage. This strategy refers to finding approaches to minimize the magnitude of problems. This strategy happens when members of a team face a challenge and don't make a big deal of it:

> "It was mostly a problem of like an idea that was hard to grasp for one of us or both of us, so we were not exactly always at the same speed. But we didn't consider it as anything major" (Participant 15C).

Worse-off comparisons. This strategy means comparing with worse occasions or worse teams. It is the reverse of catastrophizing. Although this strategy was not used often, it was a separate type of regulatory that could not be combined with other types. In analysis of the hackathon data, there were no identified instances were teams compared themselves with worse/better teams. However, there were instances where teams compared their situation with other situations (e.g., obligatory school work) that, in turn, decreased their tense emotions:

> "We weren't really frustrated about this. Like we're worried about other stuff like school work… so that stuff stresses a lot more than this does and so that whole stuff is a whole different thing than this evening. And so for that stuff, our stress management is like terrible but because this was like a break for all of that…" (Participant 7C).

Decreasing standards. This strategy refers to changing ideals (e.g., learning vs. winning). The team attempts to decrease the value and importance of succeeding at the

hackathon to enhance positivity among members: for example, “Let’s forget about trying to win a prize or anything” (Participant 1B).

Use of humor. This strategy refers to making light of challenges to instill calmness in the team. As an example: “Okay we’ll see if it’ll work. It never works the first time. I’ve never seen a program that works the first time...maybe it’s because I make them!” (Participant 9C).

Decreasing expectations. This strategy refers to not expecting much from other members. An example of this type of strategy is: “If they didn’t do their part, we would get our work done and then do others’, because we went in to the hackathon expecting like if we go in for a child: we wouldn’t expect much from them” (Participant 3C).

Response Modulation

Suppression. This strategy refers to withholding negative emotions from affecting the team. Instances representing self-suppression were not easily identifiable. Based on multimodal emotion research (Kazemitabar, Lajoie, & Doleck, 2019), an indicator of possible emotion suppression is when multimodal channels of emotion expression are not in alignment with each other. In other words, when different channels of emotion expression indicate different emotions (e.g., smiling as an indicator of happiness but having a hesitant voice an indicator of anxiety and doubt), this may be an indicator that the person showing emotions is suppressing a deeper emotion (e.g., not being happy). An example of this regulatory strategy from team interactions is provided below. As can be seen, one of the members does not trust another person, and uses firm and strong words, however he smiles at the end. This smile cannot be interpreted as his happiness, and may be an indicator of him attempting to manage the challenge he is facing (having an untrustworthy member). It should be noted that the thick interpretation of suppression

from smile in this example was further triangulated with interview data regarding Team 7 members' trusting attitudes to each other.

7B: I know what's going on, I figured it out!

7A: You said that so many times, you have completely ruined that statement for me, I can never believe. I can never trust you again! Alright. [he is smiling]

7A: No this time I actually figured it out [laughing]. So what the code does is that it takes the end point and it projects it off the circle, but the end point ends here, okay? And look at this [pointing on the laptop]. Do you see that? Do you see how slowly the end projects here?

7B: I don't know. I don't understand

7A: Okay, look at the x,y value

7B: Wait! The endpoint is not at the surface of the circle?

7A: The endpoint is supposed to be at the surface of the circle [laughing while saying]. I screwed up! [laughing and saying with lower pace]

7B: Oh alright! [volume decreased]

Although self-suppression was not easily identifiable, instances where members helped each other suppress negative emotions were easier to detect from team interaction data. Examples of such cases are as follows:

15A: Aww!! not like this!

15B: What?

15A: Okay yeah I'm not adding anymore!

15B: No no! Wait chill chill chill. Show me it. We have time.

Expressing emotions. This strategy refers to sharing positive or negative emotions: Sharing of emotions can be through a myriad of methods, including clear emotion words (e.g., happy, sad, angry), emotion sentiments (e.g., this work is fantastic/awkward), or bodily expressions (e.g., vocal, facial, postural). As emotions may be contagious, one member's emotion sharing can influence others, thus it can be an adaptive SSER strategy (if the emotion is beneficial for the team), or maladaptive SSER strategy (if the emotion is detrimental for the team). An example of sharing positive emotions from the dataset is: "Okay this should work, good, good, good, good!! Okay I'm ready to push it in" (Participant 8B). The following is also an example of sharing negative emotions:

> 9A: I can't get a protocol for the system
>
> 9B: Sighs [no talking]
>
> 9A: I'm fed up!
>
> 9B: I reverted it. I just reverted the thing I don't know if it will work though. I'm kind of scared.

Resisting negative emotional contagion. When a member shares their emotion (e.g., happiness/sadness) with others in a team, they may likely experience that emotion as well and become happy or sad. This is termed as emotional contagion (Hatfield, Cacioppo, & Rapson, 1993). If these emotions are maladaptive, their dissemination may negatively influence the team atmosphere and require extra efforts to retain adaptive emotions in the team (Schwartz, 2012). In some cases during challenging moments of the hackathon (e.g., near the submission deadline), one or more members of a team would become anxious and this anxiety would spread to other members. As emotions may be contagious (Bhullar, 2012), others might also experience anxiety, however at times other members would remain calm although being exposed to such contagious

emotions (i.e., anxiety). Remaining calm would help the team manage the negative emotions and advance further towards overcoming the sources to anxiety. The example below shows one of such instances:

3A: We don't have f*cking time

3B: We have till 12:15

3A: Dude I'm not dealing with this f*cking s*it!

3B: Let me look at it, what's the error?

3A: It's f*cking bullsh*t, that's what the error is!

3B: Position 5, velocity 7

3A: All I see is this, and this is not how to comment sh*t out

3B: I'm going to restart it.

3A: Ok.

In this case, the negative anxiety of speaker one and the positive calmness of speaker two decrease the effect of each other and yield an overall neutral team atmosphere, reaching a neutral sentiment (see Figure 12).

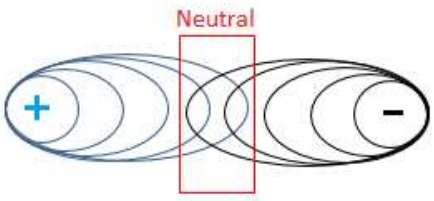


Figure 12. Neutral sentiment – Sum of positive and negative emotional contagion.

The effect of emotional contagion depends on the personality of members: Those who are more sensitive to emotions respond more to the emotions that they are exposed to. Also, the relative power of contagious emotions should be considered in identifying the sentiment content (positive, neutral, or negative) of a select transcription. In cases when the power of negative

emotions is stronger than positive emotions, the overall team emotion may lean more towards negative emotions.

Regulation Failure

SSER failure. This category was coded when no particular strategy was described or nothing was done to change emotions:

> *Example one:* "So because there is nothing we can do, we just gave up. So we were more like okay just going to, not going to win a prize or anything" (Participant 1B).
>
> *Example two:* "We unfortunately have difficulty coordinating things" (Participant 5B).
>
> *Example three:* "I guess we didn't really solve some of our challenges. I guess also we are at fault as well" (Participant 16D).

There were also examples of regulation failure at the individual level; for example: "That's it. I'm a pretty stressed out person. I know I am, I probably need to get medical attention" (Participant 7C).

In the following section a multiple case study analysis of two teams is presented that provides a more in-depth understanding of the effect of emotion regulation on team coordination during socio-emotionally challenging moments. Two extreme cases were chosen for the case analyses, a losing team that faced multiple challenges (Team 7, refer back to Figure 10 for details of challenges) and a winning team that faced few challenges (Team 8). We compared the extent to which these teams used SSER strategies by analyzing team interactions and retrospective interviews to understand the relationship between SSER strategies and how they might be applied in the context of the teams' challenges.

Case Study of Two Teams

The low performing team, Team 7, faced multiple challenges, revealed low team cohesion, demonstrated very few shared emotion regulation strategies, described an unpleasant teamwork experience and did not win a prize in the hackathon competition. On the other hand, the high performing team, Team 8, reported few challenges, demonstrated a high frequency of socially-shared emotion regulation strategies, stated that they enjoyed their teamwork experience and won the hackathon competition. An in-depth description of these two teams are presented below.

Team 7: Low Performers

This team was composed of four members (one female, three males) of low to moderate programming expertise levels. Three of the members reported that they knew each other prior to the hackathon (entitled 7A, 7B, and 7D), and one (7C) joined the team at the hackathon event. Several hours into the competition the participants had not yet agreed upon a project to work on. Their ideas kept bouncing around, generating new thoughts and discussions about which topic to use as a starting point for their project. One of their challenges was that their ideas were overly idealistic given the time frame for completing a project. In his retrospective interview, one of the team members said:

> "We took very long to figure out what we wanted to do. We didn't figure out what we wanted to do until like 5 o'clock yesterday and then we got started. I think that caused a lot of frustration because we didn't make enough progress… Like last night the algorithm working people were stuck on their code and I don't have enough time to learn like how to made the 3D like weblog (so like they don't know about the equation and I don't know how to code in JavaScript) and I think like most of this problem comes from

> we don't have enough time… Next time I will set a topic right away, so just stick with something and not think that this could be easier. Because if you start early and then you try to figure out everything through all the way, I think it's better than you try to find the best and then get started*"* (Participant 7A).

Hours after the start of the competition the other three members suggested a new project topic since they thought the original idea was too simple. However, 7C did not accept their newly proposed idea since a considerable amount of time had already passed and there was limited time remaining to start a new project. In addition, from his point of view their new idea did not fit within the theme of the hackathon (i.e., to artistically program a Physics phenomenon). In his retrospective interview reflections 7C said:

> "The first day, there were the talks. I found myself doing work the whole time while they were doing some talks. And that's fine, like they're interested, that's fine. But so I was doing all the work, meanwhile they still hadn't come up with a topic they wanted to do that made sense. They wanted to do something regarding like social media integration with like physics professors but that doesn't make any sense. Like that's not what this project is about. You're supposed to take a physics phenomenon and then model that. And they didn't really get that. They were going on these ideas so there was no way we could possibly win. At some point I was frustrated with my own code because no one else was like, they were doing their own thing. I understand that you can't have two people working on one thing, that's understandable. But like they didn't understand any of the math or this or that so I was stuck doing the presentation. I did all the talking [to judges] as well because I was the only one that actually understood anything. I literally did not need them at all. I could have done this on my own and it wouldn't have made

zero difference. But I don't really care at this point, I was almost not going to come or like not submit because it doesn't matter in my opinion. I know I learnt a lot. That's really all that really matters to me" (Participant 7C).

The above excerpt (along with other members' interview data and team interaction analyses), revealed low team cohesion between members and a polarized team, where one member worked on one project and others discussed another project. As one member stated in his interview, this might have been due to differences in member motivations in joining the hackathon:

"We had different priorities. Like I came here to make friends basically and learn some programming maybe so like that's my primary goal but I ended up doing both. One came here because one of their friends called her to come to find something to do in the weekend. One wanted to make himself more competitive for jobs. But like one member's priority was to win the competition! So we had different motives. This challenge was emotionally and mentally draining. So if you want to be an efficient team, first you need to know what your teammates want and who is good at what and have like a clear like goal. It doesn't have to be really precise at first but there has to be one goal that doesn't change" (Participant 7A).

This team did not win at the end, and members did not report having an enjoyable teamwork experience. Throughout their team interactions there were minimal SSER attempts to remedy team challenges. An excerpt is provided below that reveals only a few SSER strategies that were applied.

7B: Yeah I can make this a sine wave but then it keeps going up

7A: No idea

No talking 13:15-13:30

7B: okay so I can model the heat flow from the outside….

7A: Why didn't we do that earlier? That didn't work?

7C: No no you don't understand, we have that

7B: Ya I know it's not just …just do 1 minus

7A: Tell me the function

7B: So that didn't work

7A: No no not backups

7B: Alright

7C: I'm going to put it in the comments

7B: Okay where do we submit it? clarification:

No talking for a while, girl is on Facebook the whole time, barely looks up…

7B: What about this? (he turns laptop around to show team members his screen)

7A: Do you want to show that or this?

7B: I would say ….java…no cuz of sine waves

7A: Well they know so…

7A: It's in the announcement!! Go to the top!

No talking for a while. Then closing up computers.

One guy is scrambling through his files and another is looking over his shoulder.

Girl continues to text on Facebook without involving herself much in the project.

This excerpt is representative of the general team interactions. Challenges, like being lost and off track, are not addressed with contribution encouragement, collaborative problem solving, or constructive criticism. Furthermore, one member's working on Facebook adds to several of

the existing challenges and increases team separation. Challenges coded from the interview data are reported as follows, descending from high to low: low cohesion (21%), being off track (18%), low shared mental models (17%), different goals (13%), unequal contributions (10%), different working styles (9%), high task difficulty (7%), negative attitudes (5%), different communication styles (3%), time pressure (2%), as well as once reporting distractive behaviors, low communication, and unreliable team members. The main SSER strategies reported in the individual interviews of the low performing Team 7 were as follows (in descending order): changing task value (18%), adapting to increased workload (12%), optimism (9%), worse-off comparisons (9%), collaborative problem solving (7%), problem shrinkage (7%), concentration (7%), and partner selection (7%). A summary of the total number of reported or observed SSER strategies vs. challenges from the interview as well as team interaction data for Team 7 is provided in Table 8. The last column in the table calculates the SSER to challenges proportion, revealing a low correspondence between challenges and SSER strategies applied in response to such challenges.

Table 8

Team 7 Data (Number of SSER Strategies and Number of Challenges)

Team 7	# SSER strategies[1]	# Challenges	#SSER/#Challenges
Interview	13	184	.07
Team interactions	20	18	1.11
Total	33	372	.089

[1] *SSER failure and ER (individual or co-regulation of emotions) were not counted.*

Team 8: High Performers

This team was composed of three male members with moderate to high programming levels. Two of the members knew each other prior to the hackathon (they were siblings), and one was invited to the team at the hackathon event:

> "When me and my brother came, we were supposed to be a team of two, and then I saw this guy who was standing next to our table at the left and he had a box of a keyboard that I really know, because it's a programmer's keyboard and I have one so I said to my brother that I feel that this guy is quite clever, so I just said hey that's a nice keyboard and we started talking and so we talked about our ideas. Then I said hey I mean if you want, we're two, you could be a great part of our team and he said yes!" (Participant 8A).

During their team interactions, similar to other teams there were challenges, however the challenges were resolved through negotiating, compromising, downgrading, and being unbiased to reach a consensus:

> "At some point there was a frustration. We had a bug, I don't know which one because we had many. We had bugs, well first bug we had, we had a misunderstanding because we had a bug that either we did this and it created bad solution A or we did another thing and created bad situation B. We had a hard time deciding which situation was less bad. So what was frustrating is that it was this morning and we had only four hours to finish and so we wasted about an hour making the best decision. But we were wasting time that could be used on other things. So what we did by the end, we got together, we spoke, we analysed all we could and we went for a middle ground which seems to work so we're quite happy about that…I was proud of myself because at one point, my brother was right about a physics aspect of our project and I was wrong and I'm the physics guy. So I was proud of me because I was able to say, "Okay you're right I'm going to let go." Because we really had no time to waste, time was the money here and I felt that maybe I was right but only if we had more time. For the time being, his solution was correct because

otherwise it would've all been on me, the failure of the whole team, and I didn't want that. I would rather step on my ego than make everybody fail" (Participant 8A).

They created a positive team atmosphere and encouraged themselves with every little success. This preventive SSER strategy was very helpful for them in progressing towards their project goal:

"One thing that was really positive is that since we are in a kitchen, for some reason there is a bell. You see at the middle of our table, there is a bell. And while we were eating chicken yesterday, nothing was working as we wanted, we had lots of bugs. We took the bell and said this is the bell of great ideas. It's a dumb idea but also a great idea to have that bell because every time something worked for the first time, and we felt happy about it, we rang that bell. It made a stupid sound but it made us feel guiltily happy because the others were like, "what is that sound?" and we felt it was the sound of joy. It brought us all together because we were happy to ring that bell, it meant that we made some progress and that was it, the positive aspect, still sitting at the center of the table!" (Participant 8A).

Following is a short excerpt of their team interactions:

8A: But the radius of the circle is exactly this, this is the radius of the circle.

8B: No that's a constant.

8A: Oh yeah you're right, okay my bad, my apologies, this should simply be radius instead so this should be radius. Okay now I understand your equation.

8C: Aren't you doing square root?

8B: No but I'm basically doing the same thing, instead of doing square root or both, I'm keeping the power of the radius.

8A: Okay. I'm so sorry. Now I understand what you did and it should be correct.

8B: Does it work?

8A: Yeah.

8B: Alright!

8A: See when I click on it, it tells me which bracket.

8B: Yess! And if you click outside?

8C: They were detected!

8B: You are a true king!

[All laughing]

8A: It's perfect

8B: it's beautiful! [Laughing]

Their project, the magnetic pendulum simulator, won first prize (see a demo video: https://www.youtube.com/watch?time_continue=4&v=cOctqPqlF5A) and they all reported having a very enjoyable teamwork experience in their interviews (also, refer to the reflection weblog of one of the members: https://medium.com/@jusleg/a-recap-of-mcgill-physics-hackathon-2016-7b6717b016b9). Figure 13 provides a snapshot of the magnetic pendulum simulation.

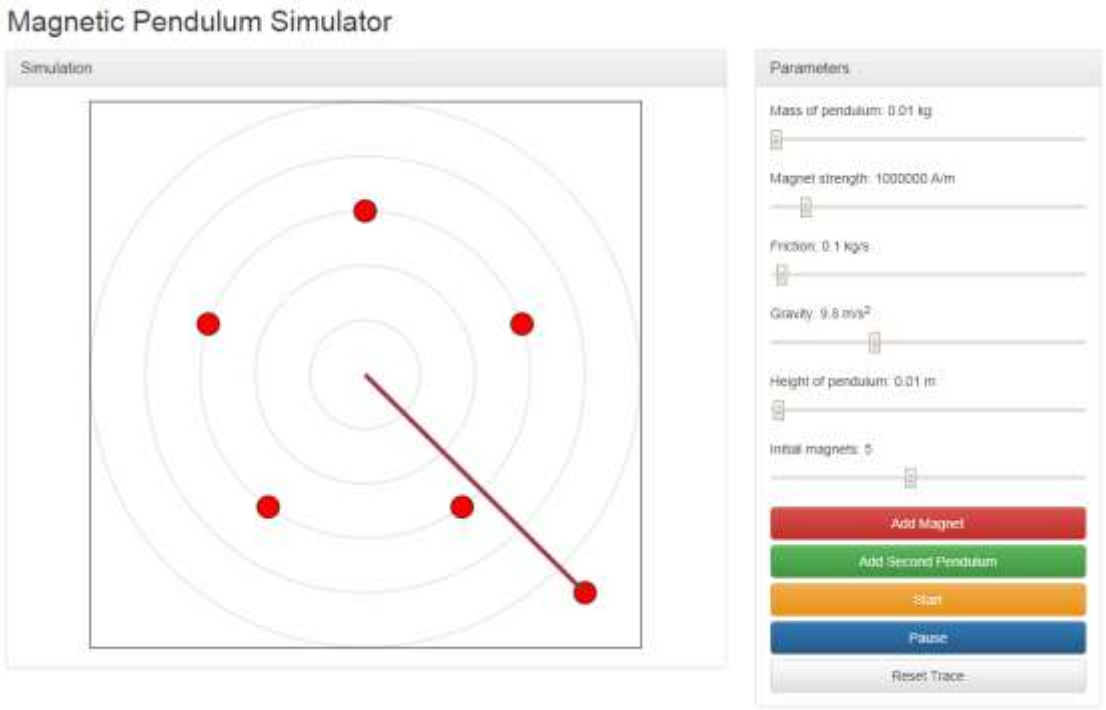


Figure 13. The winning project: Magnetic Pendulum Simulator, copied with permission. Play with the full simulation on the web.

As can be seen from different sources of data (team interactions and retrospective interviews) this team applied several SSER strategies that prevented possible challenges from occurring or decreased the intensity of the challenges the team was experiencing. In their interviews, the challenge types they reported are as follow (in descending order): high task difficulty (36%), being off track (28%), low shared mental models (14%), time pressure (12%), and being idealistic (5%). The SSER strategies applied by the high performing team included (in descending order): collaborative problem solving (18%), contribution encouragement (14%), optimism (12%), emotion expression (12%), flexibility (6%), increasing communication (6%), downgrading (6%), changing task value (5%), help-giving and help-seeking behavior (5%), using relaxation techniques (5%), partner selection (3%), using humor (1%), and constructive criticism (1%). A summary of the total number of reported or observed SSER strategies vs. challenges from the interview as well as team interaction data for team 8 is provided in Table 9.

Table 9

Team 8 Data (Number of SSER Strategies and Number of Challenges)

Team 8	# SSER strategies[1]	# Challenges	#SSER/#Challenges
Interview	78	47	1.66
Team interactions	219	21	10.43
Total	297	68	4.37

[1] SSER failure and ER (individual or co-regulation of emotions) were not counted.

In order to compare the high vs. low performing team, data from Tables 8 and 9 are aggregated into Table 10. As can be seen, the high performing team (Team 8) reported more SSER strategies and less challenges then the low performing team (Team 7). Chi square analyses revealed that the values are significantly different: $X(4)= 10.08$, $p < .001$ indicating that the high performers had a significantly higher value of SSER vs. Challenges ratio compared to the low performers.

Table 10

High vs. Low Performing Teams: A Comparison of Frequencies of SSER Strategies and Challenges for Team 8 and 7

Team 8	Team 8 SSER	Team 7 SSER	Team 8 Challenges	Team 7 Challenges	Team 8 Proportions[1]	Team 7 Proportions
Interview	78	13	47	184	1.66	.07
Interactions	219	20	21	18	10.43	1.11
Total	297	33	68	202	4.37	.16

[1] Proportions indicate the SSER to Challenge ratios for each team.

Now that different challenge categories and SSER strategies have been identified, we turn to the third research question to examine whether there is a quantitatively significant relationship between the application of SSER strategies during teamwork and: (a) the level of mutual trust between members of a team, and also (b) the extent of shared mental models within team members.

Research Question 3: Is There a Relationship Between Applying SSER and Building Team Coordination Mechanisms Within Socially-Challenging Learning Teams?

Preliminary Analysis

Preliminary analyses were run to determine whether differences in team composition were statistically significant or not. Nonsignificant team composition would enable valid between-team comparisons on the research variables which examine whether there is a relationship between *SSER* and *shared mental models*, and *SSER* and *mutual trust.* Any significant differences in team composition would count as study covariates, and would need to be controlled for in the main analyses. Based on previous literature, potential significance in differences of team compositions might be due to:

- Mixed gender vs. male only teams (see for example: Schrock & Knop, 2014 studying emotions and gender differences).
- Team size ranging from two to five members (e.g., Amason & Sapienza, 1997 identifying the impact of team size in teamwork).
- Average prior programming expertise with three levels of low, moderate or high (e.g., Rentsch, & Klimoski, 2001 identifying positive relations between team experience levels and team effectiveness).
- Members' prior familiarity with each other (e.g., Huckman, Staats, & Upton, 2009 describing the positive effects of prior familiarity on team performance).

Some studies have shown that age differences might impact teamwork, however they have situated age within different developmental stages of the lifespan (e.g., Wegge et al., 2012). In the current study, all of the current study participants were within one developmental stage (early adulthood), and descriptive statistics indicated that there was little difference in mean age

in teams with low standard deviation and skewness (M = 21.92, SD = 2.14, skewness = .16). Therefore, age was not considered as a potential covariate.

The five SSER categories, four mutual trust categories, and three shared mental model categories resulted in 12 dependent variables (DVs). To test significance in team differences based on gender, an independent samples *t*-test was conducted between mixed-gender teams vs. male-only teams (see Table 11). Based on the *t*-test *p*-values, no significant differences in SSER, mutual trust or shared mental models were attributed to differences in gender composition (mixed vs. male-only teams). Therefore, gender was removed from the list of potential covariates.

Table 11

Preliminary Analysis: Examining Significance between Study Variables and Potential Study Covariate: Team Gender (Mixed vs. Male only)

Measures	*n*		*M*		*SD*		*t*
	Male-only	Mixed	Male-only	Mixed	Male-only	Mixed	
SSER1: Situation selection	9	20	3.22	3.20	1.39	1.51	0.38
SSER2: Situation modification	9	22	3.29	2.69	0.70	0.86	1.87
SSER3: Attention deployment	9	20	1.67	2.60	1.50	1.64	-1.46
SSER4: Cognitive change	9	22	2.97	2.87	0.84	0.74	0.51
SSER5: Response modulation	9	20	1.67	2.15	1.00	1.27	-1.01
Trust 1: Propensity to trust	13	24	6.09	5.58	0.76	0.99	1.63
Trust 2: Perceived trustworthiness	13	24	5.97	5.37	0.87	0.89	1.98
Trust 3: Cooperative behaviors	13	23	6.04	5.64	0.73	0.89	1.39
Trust 4: Monitoring behaviors	13	23	4.74	4.57	1.27	1.46	0.37
S1: Task & Team knowledge	13	26	4.14	3.87	0.68	0.57	1.35
S2 : Task & Communication Skills	13	26	4.00	3.83	0.80	0.57	0.74
S3: Team Dynamics & Interaction	13	25	4.20	3.97	0.69	0.56	1.13

To assess significance in team differences based on *programming expertise levels, prior familiarity, and team size*, one-way ANOVAs were run. One-way ANOVAs were chosen for each analysis as there was one dependent variable (DV) and one independent variable (IV) with multiple levels. Based on participants' self-reports, programming expertise had three levels (low, medium, high expertise levels) and prior familiarity also had three levels (no, partial, full familiarity). Also, team size (via counting the number of participants in each team) had four levels (two, three, four, or five members). Based on the number of DVs, a total of 12 separate one-way ANOVAs were run. Tables 12 through 14 provide a summary of the analyses with significant relationships ($p < .05$) marked with an asterisk (*). Individual ANOVAs were run for each factor and are provided in rows below.

Table 12

Preliminary Analysis: ANOVA Results for Team Programming Expertise (Low, Moderate, High)

Items	*df*		*F*	*p*
	Between	Within		
SSER1: situation selection	2	26	0.51	.606
SSER2: situation modification	2	28	2.60	.089
SSER3: attention deployment	2	26	2.14	.137
SSER4: cognitive change	2	28	0.61	.545
SSER5: response modulation	2	26	0.06	.941
Trust 1: propensity to trust	2	34	0.06	.938
Trust 2: perceived trustworthiness	2	34	0.51	.612
Trust 3: cooperative behaviors	2	33	0.47	.623
Trust 4: monitoring behaviors	2	33	0.26	.779
S1: task & team knowledge	2	36	1.00	.381
S2 : task & communication skills	2	36	1.29	.290
S3: team dynamics & interaction	2	35	0.12	.892

Based on the *p*-values provided in Table 13, no significant differences in SSER, trust or shared mental models were attributed to differences in programming levels (low, moderate, high expertise). Therefore, programming expertise was removed from the list of potential covariates.

Table 13

Preliminary Analysis: ANOVA Results for Prior Familiarity (No, Partial, & Full)

Measures	*df*		*F*	*p*
	Between	Within		
SSER1: Situation Selection	2	26	0.14	.871
SSER2: Situation Modification	2	28	5.61*	.012
SSER3: Attention Deployment	2	26	2.26	.128
SSER4: Cognitive Change	2	28	1.52	.239
SSER5: Response Modulation	2	26	0.47	.653
Trust 1: Propensity to Trust	2	34	1.54	.228
Trust 2: Perceived Trustworthiness	2	34	0.02	.981
Trust 3: Cooperative Behaviors	2	33	1.75	.185
Trust 4: Monitoring Behaviors	2	33	1.99	.147
S1: Task & Team Knowledge	2	36	2.11	.143
S2 : Task & Communication Skills	2	36	3.01	.061
S3: Team Dynamics & Interaction	2	35	1.02	.374

*$p < .05$.

As indicated in Table 13, differences in prior familiarity (comparing teams of none, partial, or full familiarity) were significantly meaningful only for SSER2 ($F(2,28) = 5.608$, $p = .009$). Cohen's $\underline{d}$ was calculated to be lower than .5 ($\eta = .26$), revealing a small effect size (Cohen, 1988). Therefore, familiarity was not included as a covariate either.

Table 14

Preliminary Analysis: ANOVA Results for Team Size (2, 3, 4, & 5 Members)

Measures	*df*		*F*	*p*
	Between	Within		
SSER1: Situation Selection	3	25	0.41	.751
SSER2: Situation Modification	3	27	0.56	.654
SSER3: Attention Deployment	3	25	4.53*	.012
SSER4: Cognitive Change	3	27	0.36	.779
SSER5: Response Modulation	3	25	2.82	.064
Trust 1: Propensity to Trust	3	33	1.33	.278
Trust 2: Perceived Trustworthiness	3	33	4.47*	.013
Trust 3: Cooperative Behaviors	3	32	0.83	.491
Trust 4: Monitoring Behaviors	3	32	2.23	.103
S1: Task & Team Knowledge	3	35	0.79	.512
S2 : Task & Communication Skills	3	35	0.68	.569
S3: Team Dynamics & Interaction	3	34	0.77	.522

*$p < .05$.

Based on results of Table 14, variance in team size (comparing teams of 2, 3, 4 or 5 members) was significant for two out of the 12 items: SSER3 ($F(3,25) = 4.534$, $p = .011$) and Trust 2 ($F(3,33) = 4.471$, $p = .010$). Cohen's *d* was calculated for each of the significant factors ($\eta = .35$ and $\eta = .29$ respectively) which again revealed a small effect size (Cohen, 1988). Thus team size was not included as a covariate.

In sum, although pre-existing literature has shown relationships between teamwork and gender, team size, prior familiarity and expertise levels, such relationships were not found to be strong in the current study. For our additional confidence, each of the four afore-mentioned factors were individually included as co-variates in the correlations, however, the directionality

of the relationships remained unchanged. Therefore, gender, team size, prior familiarity, and expertise levels were finally not included as covariates.

Main Analysis

Correlation analyses were conducted to identify possible relationships between shared emotion regulation strategies and the two coordination mechanisms (shared mental models and mutual trust). A summary of the analyses are provided in Table 15 (mutual trust: T and shared mental models: S). As can be seen, there is a significant correlation between (a) SSER2 and Trust 2, (b) SSER2 and S2, (c) SSER2 and S3, (d) SSER4 and Trust 2, (e) SSER5 and Trust 3, and (f) SSER5 and Trust 4. All other correlations are insignificant. The insignificance of other relations may be due to the small sample size. Significant correlations are discussed in detail in the Discussion chapter.

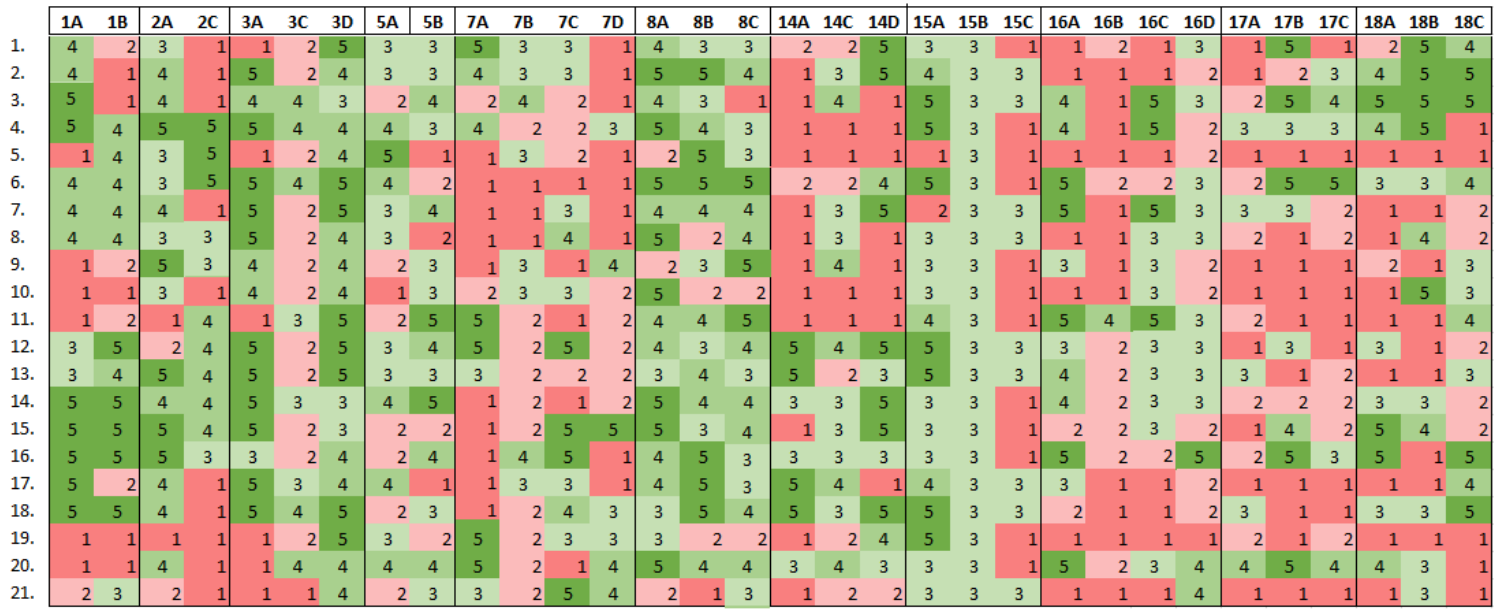
Table 15
Correlations Among Continuous Study Variables

Measure	1	2	3	4	5	6	7	8	9	10	11
1. SSER1: Situation Selection	-										
2. SSER2: Situation Modification	.22	-									
3. SSER3: Attention Deployment	.20	.08	-								
4. SSER4: Cognitive Change	.28	.77**	.19	-							
5. SSER5: Response Modulation	.06	.34	.18	.43*	-						
6. Trust 1: Propensity to Trust	-.02	.37	-.07	.27	-.08	-					
7. Trust 2: Perceived Trustworthiness	-.04	.45*	-.15	.45*	-.15	.62**	-				
8. Trust 3: Cooperative Behaviors	-.01	.13	.10	.26	-.48*	.58**	.65**	-			
9. Trust 4: Monitoring Behaviors	.12	-1.3	-.10	.13	-.43*	.08	.05	.27	-		
10. S1: Task & Team Knowledge	-.06	.31	-.05	.09	-.13	.55**	.60**	.42*	-.33*	-	
11. S2: Task & Communication Skills	-.06	.39*	.07	.11	.05	.45**	.42*	.27	-.46**	.86**	-
12. S3: Team Dynamics & Interaction	.08	.47*	-.03	.16	.05	.64**	.56**	.33	-.28	.73**	.77**

Note. SSER = Socially-shared Emotion Regulation, Trust = Mutual Trust, S = Shared Mental Models.
* $p < .05$. ** $p < .01$.

Multicollinearity was observed between situation modification and cognitive change as indicated by a strong correlation ($F(31) = .77$, $p < .01$). Although in some subscales

multicollinearity was observed, the items are conceptually different and in the questionnaires the phrasing of the questions was in a manner that multi-collinear constructs were disparate with no overlaps. Since cognitive change and situation modification are both adaptive strategies, it might be that students who frequently used one adaptive strategy also used another adaptive strategy frequently. For other cases of multicollinearity, the items were reviewed and considered conceptually different. Heat map representations are provided along with their legends in Figures 14 to 16, presenting an overview of the results of questionnaires that students filled in for the study variables (i.e., SSER, mutual trust, and shared mental models). Questionnaire items measured students' perceptions about their team in terms of their application of different SSER strategies, perceived mutual trust within the team, and strength of shared mental model bonds among members. Darker red cells indicate less occurrence of SSER, lower frequency of mutual trust and lower shared mental model bonds among members. As an example, Team 7 (a low performing team) exerted low levels of SSER strategies, had instances of mistrust and low shared mental models within the team.



	1A	1B	2A	2C	3A	3C	3D	5A	5B	7A	7B	7C	7D	8A	8B	8C	14A	14C	14D	15A	15B	15C	16A	16B	16C	16D	17A	17B	17C	18A	18B	18C
1.	4	2	3	1	1	2	5	3	3	5	3	3	1	4	3	3	2	2	5	3	3	1	1	2	1	3	1	5	1	2	5	4
2.	4	1	4	1	5	2	4	3	3	4	3	3	1	5	5	4	1	3	5	4	3	3	1	1	1	2	1	2	3	4	5	5
3.	5	1	4	1	4	4	3	2	4	2	4	2	1	4	3	1	1	4	1	5	3	3	4	1	5	3	2	5	4	5	5	5
4.	5	4	5	5	5	4	4	4	3	4	2	2	3	5	4	3	1	1	1	5	3	1	4	1	5	2	3	3	3	4	5	1
5.	1	4	3	5	1	2	4	5	1	1	3	2	1	2	5	3	1	1	1	1	3	1	1	1	1	2	1	1	1	1	1	1
6.	4	4	3	5	5	4	5	4	2	1	1	1	1	5	5	5	2	2	4	5	3	1	5	2	2	3	2	5	5	3	3	4
7.	4	4	4	1	5	2	5	3	4	1	1	3	1	4	4	4	1	3	5	2	3	3	5	1	5	3	3	3	2	1	1	2
8.	4	4	3	3	5	2	4	3	2	1	1	4	1	5	2	4	1	3	1	3	3	3	1	1	3	3	2	1	2	1	4	2
9.	1	2	5	3	4	2	4	2	3	1	3	1	4	2	3	5	1	4	1	3	3	1	3	1	3	2	1	1	1	2	1	3
10.	1	1	3	1	4	2	4	1	3	2	3	3	2	5	2	2	1	1	1	3	3	1	1	1	3	2	1	1	1	1	5	3
11.	1	2	1	4	1	3	5	2	5	5	2	1	2	4	4	5	1	1	1	4	3	1	5	4	5	3	2	1	1	1	1	4
12.	3	5	2	4	5	2	5	3	4	5	2	5	2	4	3	4	5	4	5	5	3	3	3	2	3	3	1	3	1	3	1	2
13.	3	4	5	4	5	2	5	3	3	3	2	2	2	3	4	3	5	2	3	5	3	3	4	2	3	3	3	1	2	1	1	3
14.	5	5	4	4	5	3	3	4	5	1	2	1	2	5	4	4	3	3	5	3	3	1	4	2	3	3	2	2	2	3	3	2
15.	5	5	5	4	5	2	3	2	2	1	2	5	5	5	3	4	1	3	5	3	3	1	2	2	3	2	1	4	2	5	4	2
16.	5	5	5	3	3	2	4	2	4	1	4	5	1	4	5	3	3	3	3	3	3	1	5	2	2	5	2	5	3	5	1	5
17.	5	2	4	1	5	3	4	4	1	1	3	3	1	4	5	3	5	4	1	4	3	3	3	1	1	2	1	1	1	1	1	4
18.	5	5	4	1	5	4	5	2	3	1	2	4	3	3	5	4	5	3	5	5	3	3	2	1	1	2	3	1	1	3	3	5
19.	1	1	1	1	1	2	5	3	2	5	2	3	3	3	2	2	1	2	4	5	3	1	1	1	1	1	2	1	2	1	1	1
20.	1	1	4	1	1	4	4	4	4	5	2	1	4	5	4	4	3	4	3	3	3	1	5	2	3	4	4	5	4	4	3	1
21.	2	3	2	1	1	1	4	2	3	3	2	5	4	2	1	3	1	2	2	3	3	3	1	1	1	4	1	1	1	1	3	1

1. We understood that we have to reconcile our goals closer to one another.
2. We decided that we had to work out the situation together in order to carry on working.
3. We considered each other's feelings when criticizing each other's work.
4. To resolve conflict we needed to keep open-minded and learn from one another.
5. We reminded each other that our discussions should be friendly and polite.
6. We incorporated everyone's ideas.
7. By not making a mountain out of a molehill we continued on our work.
8. We reminded ourselves that frustration wouldn't help solve our problem.
9. When conflict arose, we talked it out and/or shared our feelings.
10. We told each other to take arguments positively and not personally.
11. When challenges arose we discussed off-task topics.
12. When someone didn't do their share of the work, more competent team members put more effort.
13. We focused more on accomplished tasks rather than uncompleted tasks.
14. We reassured ourselves that we will do the best we can do.
15. We optimistically justified that external constraints were the cause of a member's shortcomings not his/her irresponsibility.
16. We told ourselves that winning isn't as important as learning.
17. After finding causes of our team shortcomings, we set rules to reach our top goals.
18. We sought help from mentors to possibly overcome our weaknesses.
19. We focused on our competing teams' shortcomings to relieve ourselves.
20. We took a break and went away to eat.
21. We didn't manage our team challenges well.

5. happened a lot
4. happened often
3. Sometimes Happened
2. Less happened
1. Didn't Happen

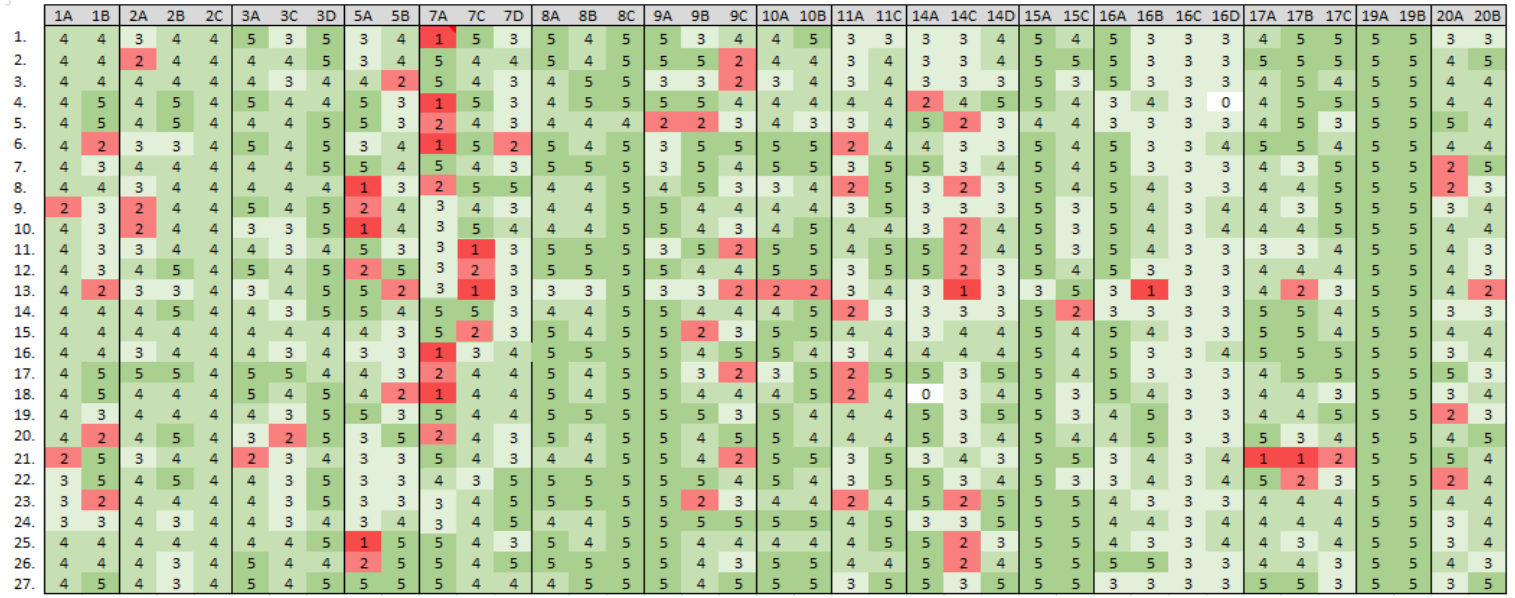
Figure 14. Heat map representation of SSER among team members for all teams.

	1A	1B	2A	2B	2C	3A	3C	3D	5A	5B	7A	7C	7D	8A	8B	8C	9A	9B	9C	10A	10B	11A	11C	14A	14C	14D	15A	15B	15C	16A	16B	16C	16D	19A	19B	20A	20B
1.	6	5	4	6	6	7	5	6		7	7	7	4	7	7	7	7	7	7	7	6	5	6	7	7	6	5	7	7	4	6	7	6	7	7	5	6
2.	6	5	6	5	6	7	6	6	3	6	7	7	5	7	6	7	7	6	7	7	7	5	6	7	7	5	7	7	7	7	6	7	6	7	7	6	7
3.	3	3	5	5	6	6	4	5	6	6	7	3	6	7	6	4	7	6	7	6	5	4	6	4	7	5	6	7	7	4	5	4	4	7	7	3	7
4.	2	4	7	4	6	7	5	6	1	5	7	5	3	6	5	7	6	5	7	6	7	4	6	4	4	6	7	7	6	2	4	4	5	7	7	5	5
5.	6	5	7	5	6	6	4	6	3	5	7	6	4	7	7	7	7	4	7	7	6	5	6	7	4	4	7	7	6	6	4	7	5	7	7	5	5
6.	6	6	6	7	4	7	5	6	2	6	7	7	5	7	7	7	7	3	6	4	5	3	6	7	7	3	7	7	6	6	3	4	4	7	7	7	7
7.	6	7	6	6	4	7	5	7	2	6	7	5	5	6	6	7	7	5	6	7	7	4	6	7	4	5	7	7	6	6	5	7	4	7	7	6	7
8.	6	7	4	5	4	6	5	7	6	6	5	6	5	7	6	7	7	4	5	7	7	3	6	4	4	5	7	7	5	3	4	7	4	7	7	6	7
9.	6	5	6	5	4	6	5	7	3	6	3	5	7	7	6	7	7	6	6	7	5	4	6	1	4	6	7	7	6	4	4	4	5	7	7	6	7
10.	2	5	1	2	5	2	2	6	3	2	7	6	7	1	1	3	1	1	1	1	5	2	1	7	1	1	2	1	3	2	3	1	3	1	2	2	1
11.	6	3	6	5	5	6	5	7	6	5	7	5	4	6	6	6	6	4	5	7	7	4	4	7	5	6	6	7	5	5	5	1	5	7	7	5	6
12.	6	5	7	6	5	6	4	6	7	5	7	7	4	7	7	7	7	6	6	7	7	4	6	7	6	4	7	7	5	7	6	7	4	7	7	5	7
13.	6	4	6	7	5	7	4	6	1	5	7	6	4	7	7	7	7	7	7	7	7	3	6	7	6	5	7	7	7	7	5	7	3	7	7	5	7
14.	6	4	6	6	3	6	3	7	5	7	7	6	5	7	7	7	7	6	5	7	6	6	7	7	5	6	7	7	7	7	5	7	5	7	7	5	6
15.	2	1	2	3	4	1	2	5	4	1	4	6	4	1	1	1	1	2	2	1	2	1	1	1	1	1	2	1	2	1	3	1	2	1	1	2	1
16.	2	1	3	2	5	1	1	5	5	2	7	6	7	3	2	3	7	2	4	1	2	7	3	7	2	7	6	1	5	2	2	1	3	2	1	3	3
17.	7	7	6	6	4	6	6	6	6	6	7	6	5	6	6	7	7	6	7	6	6	5	5	7	6	6	7	7	6	7	6	7	6	7	7	6	6
18.	6	7	2	5	4	3	2	3	5	4	7	6	4	3	3	7	1	3	2	3	2	3	2	1	3	2	6	1	3	4	4	1	5	4	4	7	3
19.	2	1	3	5	4	4	1	3	6	4	4	6	4	1	3	7	4	3	1	3	2	2	2	1	3	5	4	1	2	1	2	1	4	4	5	2	2
20.	2	1	1	6	2	2	4	3	5	2	7	6	5	4	3	7	4	2	1	2	2	2	2	1	1	2	4	1	4	3	2	1	4	7	4	6	1

1. My team members do not hesitate to help each other if they can
2. We speak out for what we believe is a good strategy
3. We stand behind our opinions
4. We are sincerely concerned about challenges any of us faces
5. We act as much as helpful to each other when needed
6. We usually tell each other the truth, even if we know were better off by lying
7. We can rely on one another
8. We have complete confidence in each other`s ability to perform tasks
9. We do as we have promised
10. *Some of us have often tried to get out of previous commitments**
11. We try to address each other`s interests as much as possible
12. We work in a climate of cooperation
13. We discuss with issues and problems openly
14. While taking a decision, we take each other`s opinions into consideration
15. *Some of us have tried to hold back relevant information**
16. *We have minimized what we tell each other about our personal life**
17. We are mostly open to advice and help from others
18. *In our team people watch each other very closely**
19. *Our team keeps checking whether we have kept our promises**
20. *Most of us have tended to keep each other`s work under surveillance**

Direct items	Reverse Items
1. Completely Disagree	1. Completely Agree
2. Highly Disagree	2. Highly Agree
3. Quite Disagree	3. Quite Agree
4. Slightly Agree	4. Slightly Disagree
5. Quite Agree	5. Quite Disagree
6. Highly Agree	6. Highly Disagree
7. Completely Agree	7. Completely Disagree

Figure 15. Heat map representation of mutual trust within teams for all teams. Reverse items are italicized and marked with an asterisk, however heat maps represent trust directly (not reversely).



	1A	1B	2A	2B	2C	3A	3C	3D	5A	5B	7A	7C	7D	8A	8B	8C	9A	9B	9C	10A	10B	11A	11C	14A	14C	14D	15A	15C	16A	16B	16C	16D	17A	17B	17C	19A	19B	20A	20B
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3.	4	4	4	4	4	4	3	4	4	2	5	4	3	4	5	5	3	3	2	3	4	3	4	3	3	3	5	3	5	3	3	3	4	5	4	5	5	4	4
4.	4	5	4	5	4	5	4	4	5	3	1	5	3	4	5	5	5	5	4	4	4	4	4	2	4	5	5	4	3	4	3	0	4	5	5	5	5	4	4
5.	4	5	4	5	4	4	4	5	5	3	2	4	3	4	4	4	2	2	3	4	3	3	4	5	2	3	4	4	3	3	3	3	4	5	3	5	5	5	4
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7.	4	3	4	4	4	4	4	5	5	4	5	4	3	5	5	5	3	5	4	5	5	3	5	5	3	4	5	4	5	3	3	3	4	3	5	5	5	2	5
8.	4	4	3	4	4	4	4	4	1	3	2	5	5	4	4	5	4	5	3	3	4	2	5	3	2	3	5	4	5	4	3	3	4	4	5	5	5	2	3
9.	2	3	2	4	4	5	4	5	2	4	3	4	3	4	4	5	5	4	4	4	4	3	5	3	3	3	5	3	5	4	3	4	4	3	5	5	5	3	4
10.	4	3	2	4	4	3	3	5	1	4	3	5	4	4	4	5	5	4	3	4	5	4	4	3	2	4	5	3	5	4	3	4	4	4	5	5	5	4	4
11.	4	3	3	4	4	4	3	4	5	3	3	1	3	5	5	5	3	5	2	5	5	4	5	5	2	4	5	3	5	4	3	3	3	3	4	5	5	4	3
12.	4	3	4	5	4	5	4	5	2	5	3	2	3	5	5	5	5	4	4	5	5	3	5	5	2	3	5	4	5	3	3	3	4	4	4	5	5	4	3
13.	4	2	3	3	4	3	4	5	5	2	3	1	3	3	3	5	3	3	2	2	2	3	4	3	1	3	3	5	3	1	3	3	4	2	3	5	5	4	2
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17.	4	5	5	5	4	5	5	4	4	3	2	4	4	5	4	5	5	3	2	3	5	2	5	5	3	5	5	4	5	3	3	3	4	5	5	5	5	5	3
18.	4	5	4	4	4	5	4	5	4	2	1	4	4	5	4	5	5	4	4	4	5	2	4	0	3	4	5	3	5	4	3	3	4	4	3	5	5	3	4
19.	4	3	4	4	4	4	3	5	5	3	5	4	4	5	5	5	5	5	3	5	4	4	4	5	3	5	5	3	4	5	3	3	4	4	5	5	5	2	3
20.	4	2	4	5	4	3	2	5	3	5	2	4	3	5	4	5	5	4	5	5	4	4	4	5	3	4	5	4	4	5	3	3	5	3	4	5	5	4	5
21.	2	5	3	4	4	2	3	4	3	3	5	4	3	4	4	5	5	4	2	5	5	3	5	3	4	3	5	5	3	4	3	4	1	1	2	5	5	5	4
22.	3	5	4	5	4	4	3	5	3	3	4	3	5	5	5	5	5	5	4	5	4	3	5	5	3	4	5	3	4	3	4	4	5	2	3	5	5	2	4
23.	3	2	4	4	4	4	3	5	3	3	3	4	5	5	5	5	5	2	3	4	4	2	4	5	2	5	5	5	4	3	3	3	4	4	4	5	5	4	4
24.	3	3	4	3	4	4	3	4	3	4	3	4	5	4	4	5	5	5	5	5	5	4	5	3	3	5	5	5	4	4	3	4	4	4	4	5	5	3	4
25.	4	4	4	4	4	4	4	5	1	5	5	4	3	5	4	5	5	4	4	4	4	4	5	5	2	3	5	5	4	3	3	4	4	3	4	5	5	3	4
26.	4	4	4	3	4	5	4	4	2	5	5	4	5	5	5	5	5	4	3	5	5	4	4	5	2	4	5	5	5	5	3	3	4	4	3	5	5	4	3
27.	4	5	4	3	4	5	4	5	5	5	5	4	4	4	5	5	5	4	5	5	5	3	5	5	3	5	5	5	3	3	3	3	5	5	3	5	5	3	5

1. My team have general ideas of how to proceed
2. My teammates do what they are assigned to do
3. My team knows how they are going to consolidate members' contributions
4. My team looks for different interpretations of a problem when seeking a solution to various task issues
5. My team evaluates their limitations while performing their project
6. My team has a shared goal for various project tasks
7. My team discusses its goal and attains the agreement of teammates
8. My team knows specific strategies for completing their various tasks
9. My team knows the general process involved in conducting a given task
10. My team understands that they have the skills necessary for doing various tasks
11. My team communicates effectively with other teammates while performing tasks
12. My team supports personal and team-level skill improvement
13. My team defines its communication style at the beginning of their work
14. My team uses a common vocabulary in task discussions
15. My team members effectively listen to each other's suggestions
16. My team understands their roles and responsibilities for doing various team tasks
17. My team understands where/from whom they can get information for doing their tasks
18. My team understands their interaction patterns
19. My team informs each other about different work issues
20. My team is likely to make a decision together
21. My team can flexibly adapt to any role within the team for carrying out various team tasks
22. My team undertakes interdependent tasks
23. My team understands how they can exchange information for doing various team tasks
24. My team solves problems that occur while doing various team tasks
25. My team acknowledges and rewards behaviours that contribute to an open team climate
26. My team encourages each other's work in order to improve outcomes
27. My team is committed to the team goal

5. Strongly Agree
4. Average agree
3. Moderately Agree
2. Disagree
1. Strongly Disagree

Figure 16. Heat map representation of shared mental models in teams for all teams.

Summary

In summary, the analyses presented to address Research Question 1 identified 16 different types of challenges that teams faced during the hackathon. These challenges were categorized into seven macro-level themes including cognitive, motivational, emotional, behavioral challenges, cognitive/behavioral, general, and external challenges. Excerpts from the data were provided to better elaborate on the identified categories. Frequency counts of student perceptions from team interaction transcripts, questionanires, and interviews revealed the challenges that most hampered team shared mental models and were more detrimental to mutual trust in teams.

Research Question 2 focused on the SSER strategies that teams apply to manage coordination breakdown. SSER strategies (N = 29) were categorized based on Gross' (1998) original process model, and the individual emotion regulation model was extended into a team emotion regulation model. Excerpts from team interaction and interview data were provided to better elaborate on the identified categories. A case study of two extreme teams (a winning and a losing team) was provided to contextualize findings based on the dataset and shed light on the negative relationship between SSER and the challenges teams face.

Finally, Research Question 3 quantitatively analyzed the relationship between SSER and mutual trust, and SSER and shared mental models. Analyses revealed six significant correlations between study variables (SSER2 and Trust 2, SSER2 and SMM2, SSER3 and S3, SSER4 and Trust 2, SSER5 and Trust 3, and SSER5 and Trust 4). In addition heat maps were created to provide an overview of individual team members' perceptions of their teams' SSER strategy application, mutual trust within the team, and strength of shared mental model bonds among team members. Interpretations of the results will be provided in the next section.

CHAPTER 5

DISCUSSION

The purpose of this dissertation was to understand the challenges teams experience during teamwork, and whether and how they use socially-shared emotion regulation strategies (SSER) to move beyond such challenges (Isohätälä et al., 2017). Specifically, we explored how teams performed in a competitive hackathon and examined the types of SSER they used when they encountered challenges. We also explored the relationship between SSER and two key team coordination mechanisms, namely shared mental models and mutual trust between team members.

Multimodal data (team interaction videos, interview data, and questionnaires) were collected to identify the challenges teams faced as well as the SSER strategies they applied during the competition. Seven macro-level types of challenges were identified: cognitive, motivational, emotional, and behavioral, cognitive/behavioral, general and external challenges. SSER strategies were coded and analyzed using a newly developed model of team emotion regulation that was created by extending Gross' process model of emotion regulation. Results demonstrated that SSER strategy application was strongly correlated with higher levels of mutual trust, and shared mental models at challenging moments. This chapter contextualizes these results within the current literature in the domains of shared emotion regulation and organizational psychology, discusses implications for future research and practice, and acknowledges the study's limitations.

Challenges Impeding the Development of Shared Mental Models and Mutual Trust in Socio-Emotionally Challenging Team Contexts

The hackathon examined in this research is an authentic collaborative context that is competitive and time-limited in nature which makes it an excellent setting to study challenges that can arise during teamwork. To address the types of challenges experienced in this particular setting, an analysis of multiple sources of data was conducted including data generated in team interactions, and from interviews and questionnaires. 16 types of challenges were identified, the most prevalent being: low shared mental models (cognitive), low team cohesion (general), being idealistic (cognitive), being off-track (cognitive), unequal contributions (cognitive/behavioral), high task difficulty (external), and having unreliable members (emotional). Although predominant challenges may change based on the context of the collaborative situation, we argue that types of challenges are similar regardless of the context, and can be generalizable to other settings (Salas et al., 2018). Examples include health care (O'Malley, Gourevitch, Draper, Bond, & Tirodkar, 2015), sports (McEwan & Beauchamp, 2014), or military teams (Salas, Milham, & Bowers, 2003). In a further examination, we identified challenges that hampered shared mental models and mutual trust among members. These challenges are described briefly in the following section.

Challenges that Hamper Shared Mental Models

Team members rated the following as factors decreasing their levels of shared mental models (as opposed to trust impairment): dominating, low communication, incompatible working styles, being idealistic, and being off track. Most of the afore-mentioned challenges have a cognitive component and therefore facing these challenges may lead to poorer levels of shared mental models:

Dominating. Dominating refers to not allowing others to contribute to the shared project as much as oneself. When a member dominates, he/she may put less effort to acknowledge others' contributions, does not communicate his/her chain of thoughts to other members, nor implements their ideas for further actions making individual decisions. Therefore domination weakens shared mental models among members. A brief example of dominating extracted from the study (Participant 1B) is: "Because he is so individualistic, I find I am less aware of team tasks. I think it would have been much better to decide together instead of deciding individually about our next steps." Six teams in the hackathon reported/showed having dominant members, and almost the same teams reported having less common understanding of the tasks to be done. This finding is also in line with previous literature indicating that dominating members negatively influence the development of shared understandings among members and harm team performance (e.g., Citera, 1998).

Low communication. In Chapter 2 we saw that communication is key to the development of shared mental models, through a two-step process of "accepting ideas that are shared." Literature has shown that low communication constrains externalization of individual mental models (Järvenoja et al., 2013). An brief example of low communication from Participant 17C was "We had difficulty understanding each other, so we didn't communicate much." In line with the extant literature, students in the present study also reported that low or inefficient communication led to poorer shared mental models among their team and lower team performance. Research on team breakdown has explored types of communication failure that decrease team shared mental models (e.g., Wilson et al., 2007). Such failures include the lack of sufficient information exchange, correct phraseology, and closed-loop communication. This

study also provides examples to illustrate how these three factors can lead to inefficient communication.

Incompatible working styles. This type of challenge refers to differences in members approaches to working; for example, one member may choose to brainstorm ideas but one may want to start working right away. In such situations, members have less opportunity to discuss their mental models with each other, therefore in line with participant reporting, this challenge hinders the development of shared mental models within a team. An example of this challenge from the data was when Participant 16C said: "There was one person who did most of the work. Well I guess it's just hard to be productive. and I didn't have matlab, so I kind of worked just on my own thing." As these differences become habitual, members may see their peer as "different" from themselves, and this may lead to lower team cohesion, less team satisfaction and decreased team performance.

Being idealistic. This challenge refers to unrealistic expectations of team capabilities. As mentioned in Chapter 2, trust violation is a consequence of expectation violation. Therefore, high expectations may unfavorably decrease trust among members. Prior to blaming a trustee, a trustor needs to verify whether his/her expectations were accurate or not. Therefore, contrary to the study participant ratings, previous literature has suggested that this challenge primarily decreases trust levels between members (Jones & George, 1998). It may be that members who were idealistic, put less effort to update others or discuss their ideas with them, as they assumed others would disagree with them. Likewise, other team members who viewed one member as idealistic, might not have communicated their ideas with him/her, since they thought their ideas might get rejected. An example of this was when Participant 7C said: "I was personally trying to do something more simple, and they wanted to make it more better, you know those kinds of

things, more cosmetic things. I was like okay you guys can do that if you want and I can help if you guys have a real idea that I think is doable, but until then I'm just going to keep working on this."

Being off track. This challenge was also reported as a factor that led to decreasing shared mental models. When members are lost and do not know what to do, they cannot engage in building shared mental models and instead spend their time untangling the complexities of the problem they are facing. Therefore being lost decreases opportunities to co-construct knowledge and enhance shared mental models. One example from the data was when Participant 7A reported: "Like they don't know about the equation and I don't know how to code in javascript. so I learnt in like this 24 hours. Our time passed for just learning javascript and equations, we couldn't do more."

Challenges that Hamper Mutual Trust

Hackathon participants reported the following factors (in descending order) as leading to lower mutual trust among members: unreliable members, low self-efficacy, unequal contributions, different priorities, and being biased. The relationship between these challenges and trust impairment is explained as follows:

Unreliable members. Having unreliable members decreases mutual trust among a team. Members cannot trust whether their peers will perform their responsibilities or not, and they cannot further delegate tasks to each other, therefore the team may become polarized between those who contribute and those who do not contribute. Unreliable team members significantly decrease team cohesion, whereby the team may suffer from internal challenges rather than collaborating with full energy towards a high-standard goal. This finding was evidenced by the analysis of Team 7 (a low performing team) where members could not rely on each other and

their prospective actions were not taken seriously. Established research has shown reliability among members as a fundamental factor to the development of mutual trust (McAllister, 1995).

Low self-efficacy. Students reported low self-efficacy as the second major challenge to trust violation. Self-efficacy is defined as how much one believes he or she is competent in a specific area. Those who express low self-efficacy reveal signs of being unreliable, and therefore become less trustworthy (e.g., Hsu, Ju, Yen, & Chang, 2007). An example of this challenge from the data negatively influencing team trust was stated by Participant 16D that: "I guess people who feel they are less skilled do something else. And it reduced trust, just because of what I mentioned. Like you might ask someone to do something but you might think they are not able to do that and they might take either a really long time and not communicate that they were going to take a long time."

Unequal contributions. This challenge was the next reported challenge damaging mutual trust. Members of a team have different responsibilities and contribute to different parts of a project. Some tasks may be easy and some tasks may be hard. Similarly, some members may be competent while others may be novices. Depending on the context of a team, these differences may be natural. In a healthy team, novice members may realize they are not contributing much, therefore they choose to work harder to compensate for their deficiencies. However, challenges arise when a competent member does not put much effort, or when a novice does not try hard enough. An example from the data was when 5A stated that "I knew that [5B] really wanted to like do it himself, he's a guy that normally works alone, but I was just supporting him all weekend", while 5B (her team member) mentioned that: "I just was disappointed that we could not easily work equally on the project". Social loafing is a well-

known example of unequal contributions, leading to lower trust between members (e.g., Jassawalla, Sashittal, & Sashittal, 2009).

Different priorities. This challenge is another key challenge to trust violation, especially if differences are significant. For example, it may happen that one member targets winning or outperforming other teams, while another member participates to have fun. The following excerpt from the data provides an example of members with different priorities: "I don't care about actual winning but I just want to, whatever I do, I just want to make the best out of it… and I was like, "oh this is going great, we're making great progress", until they left at 11 PM yesterday". If members cannot balance their goals to a similar level, they may not trust each other and work in a climate of satisfactory relations (Järvenoja & Järvelä, 2009). For example, the member who wants to win does not assign tasks to the member who wants to have fun, and the member who wants to have fun distances him or herself from the hard worker.

Being biased. This challenge was reported as another factor to trust impairment. Being biased refers to negative pre-conceptions about another member, the task or the event from the past that influence current perceptions. As trust is built on a history of expectation fulfillments, negative past experiences influence beliefs of trustworthiness towards the other(s), the task or the event (Jones & George, 1998). Therefore, negative biases build a strong dam against trust building. An example of this challenge from the data was "My sister and I have a very long history of conflicts…My sister took a more dominant role, I let her kind of make final decisions on things some of which I disagreed with later because it made things harder for me".

A Challenge Hampering Shared Mental Models as well as Mutual Trust: Low Cohesion

Low cohesion was reported as a challenge that impaired both mutual trust and shared mental models. Team cohesion is a fundamental factor in team performance (Bell, Brown,

Colaneri, & Outland, 2018) and our findings showed that lack thereof may result in cognitive, motivational, emotional, and/or behavioral challenges. Signs of team cohesion include exhibiting strong bonds and desires to remain united in pursuit of shared goals in face of conflicts, and feeling less stressed when part of the team, as opposed to when working alone (Wilson, Salas, Priest, & Andrews; 2007). These signs were detected through analysis of team interactions and upon interview reflections of members about their team interactions. In the context of this study, lack of team cohesion was reported as a prevalent challenge, and several teams reported low team cohesion as a challenge (Teams 7, 9, 14, 16, and 18). Excerpts of data from such teams have evidenced how lack of team cohesion raised new challenges. However, caution should be taken that the desire for harmony and cohesion between team members does not result in suppression of alternative viewpoints and loss of individual creativity (i.e., yielding to a mal-functioning situation of *groupthink* within team decision making; Golembiewski, 2018).

Points to Consider in Analyzing Team Challenges

In analyzing team challenges some points should be considered. First, it is important to know that a challenge might be perceived by only one member, and others may not perceive or report it (e.g., a team might be composed of two members where one is free-riding, and thus feels happy; while the other contributes to most of the workload and as a result becomes disappointed and stressed). Second, challenges have different depths and impact; some are more fundamental and deep-rooted (e.g., low team cohesion, inefficient communication), others are more surface-layered (e.g., getting lost). Fundamental challenges have a deeper impact and, if possible, need to be resolved primarily.

Third, some challenges are beyond team capabilities to be modified (e.g., limited time). Such challenges should not be overlooked and rather need to be acknowledged so that the team

can plan accordingly; for example, “Well the, like the most, the biggest challenge that our team had was that we took very long to figure out what we wanted to do. So we didn’t figure out what we wanted to do until like 5 o'clock yesterday so then we got started so like that’s the problem causing a lot of confusion and so like and our ideas kept like bouncing off because we had like different new ideas” (Participant 7A). Fourth, team members should become aware that their thoughts, emotions and/or behavior may turn into team challenges if they are maladaptive for team performance. More importantly, they should be aware (i.e., metacognition; Flavell, 1979), and admit such behavior, otherwise their maladaptive reactions, if not accepted, become an even deeper layer of challenge that can be harder to resolve. For example, a member may not realize they are dominating and discouraging others to contribute. Other members may become less motivated and express signs of dissatisfaction (Chanel, Avry, Molinari, Bétrancourt, Pun, 2017). If not realized, the dominant member may deepen such a challenge.

Fifth, in extreme situations (Driskell et al., 2018) and in the current study context, at final moments of the competition deadline, where time pressure becomes stronger, shared mental models and mutual trust become key in helping a team proceed (see research on action teams and implicit communication; for example Wildman et al., 2012). If members have high shared mental models, they can better anticipate how to help each other, with minimal communication (Cannon-Bowers et al., 1993). Also, with high mutual trust, members can delegate tasks to each other with confidence that the tasks will successfully be accomplished. Teams of high mutual trust will perform better at such stress situations, as they believe in each other and do not question why something should be done or not (Baker, Day, & Salas, 2006). However as seen in the current study, it may happen that upon submitting, teams may fail in trusting each other or lack sufficient levels of shared mental models. At this time, the power of emotion regulation

becomes clearly visible. Our analyses from high performing teams showed that through the application of regulatory strategies, a team can develop trust and shared mental models especially during moments of high pressure. The example below shows using decreasing standards as an emotion regulation strategy as Team 8 approached the deadline:

> "Because we really had no time to waste, time was the money here and I felt that maybe I was right but only if we had more time. For the time being, his solution was correct. I would rather step on my ego than make everybody fail" (Participant 8A).

A Model of Team-Related Challenges

This research extends the literature of challenges and conflicts experienced in teamwork (refer back to Figure 5), by differentiating between the types of internal and external challenges that teams face Internal challenges may be motivational, emotional, cognitive, or behavioral. They may also be cognitive/behavioral (like low communication) or encompass all of the four afore-mentioned factors (i.e., low team cohesion). In addition, teams may face external challenges such as time or task pressure (see Figure 17).

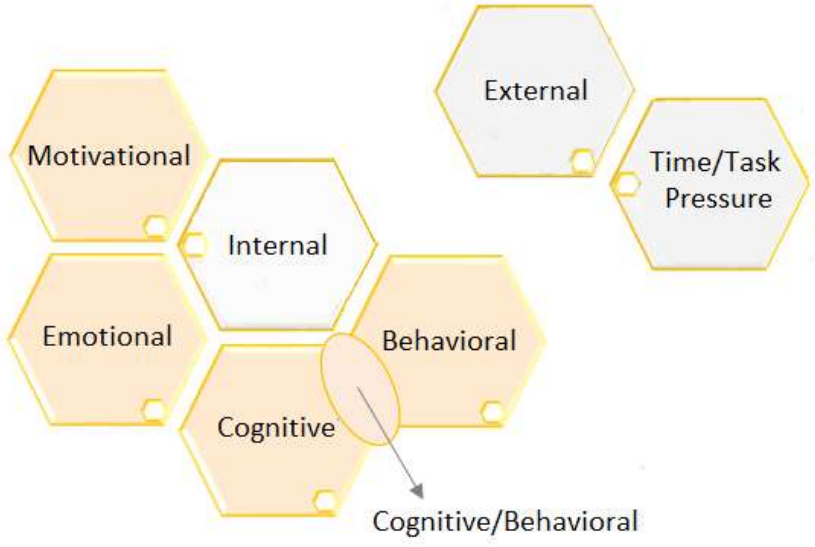

Figure 17. Extension of the challenges model illustrated in Figure 5 (Chapter 2) adding cognitive, motivational, emotional and behavioral challenges

The Influence of SSER Strategies in Managing Emerging Team Challenges: The Team Emotion Regulation Model

Challenging learning environments stimulate emotional arousal and the need to regulate emotions. When these challenges occur in a team setting, shared emotion regulation opportunities are created (Hadwin, Järvelä, & Miller, 2017). In other words, socio-emotionally difficult situations open a need for SSER: the stronger the challenges are experienced, the higher there is a need for SSER. In this study, we looked at whether and how teams applied emotion regulation strategies (either consciously or unconsciously) in the face of the challenges they experienced.

Using a top-down/bottom-up approach (previous literature as well as the multimodal hackathon data; Sabatier, 1986), we identified SSER strategies teams used during the competition. Through several iterations of data analysis, a final comprehensive list of 29 SSER strategies was created. In a second stage, the list was divided into five main categories of emotion regulation, originally identified by Gross (1998, 2015) for individual emotion regulation. This newly-developed framework is labelled as the "team emotion regulation model" with SSER subcategories that can be applicable in general collaborative settings, irrespective of the context they occur in.

As theoretically stated in Chapter 2 (Panadero et al., 2015), our findings evidenced that SSER strategies originate from individual emotion regulation. For example, reappraisal as a cognitive change strategy has been described as a strategy to self-regulate emotions (e.g., Gross & John, 2002), and such a strategy has also been observed in students' SSER attempts in the hackathon. Other studies have also shown that shared emotion regulation strategies stem from individual emotion regulation (e.g., Naykki et al., 2014; Jiang et al., 2013; Williams, 2007).

In the context of the physics hackathon, we found several micro level strategies used frequently across teams. These strategies include: (a) collaborative problem solving, (b) adapting to increased workload, (c) help seeking/giving behavior, (d) decreasing standards, (e) contribution encouragement, (f) concentration, and (g) being open minded. Several of these strategies (a, b, c, and e) fall under situation modification. The next most prevalent challenges fall under cognitive change, and the remaining under response modulation, attention deployment and finally situation selection. In some instances students did not explicitly refer to an SSER strategy, but such SSER strategies were inferred as we noticed a self-regulatory strategy following the occurrence of a challenge. These inferences were further validated with triangulation of other data (e.g., multiple members' interview perspectives, team interactions, and/or questionnaire responses). For example, a student said: "I know I have some difficulties in teamwork in general. It's not that I want to be mean or something, it's just I have difficulty coordinating things." And in a parallel interview his team member said: "My peer really wanted to do the project himself, he's a guy that normally works alone, but we think that's because our project didn't divide itself much." Therefore "working alone" was coded as a challenge, and "the project being hard to divide" was coded as an SSER emotion regulation strategy falling under cognitive change. The predominant strategies and their relation to challenge management will be explained below:

Collaborative problem solving. When members got lost they would usually reconnect with their team to brainstorm and negotiate best further approaches. In teams of low cohesion, there were fewer instances of collaborative problem-solving as members were not united and preferred to proceed on their own. An example of collaborative problem solving is "both of us pitched ideas all the weakend" (Participant 7A).

Adapting to increased workload. When a member would (or could) not work on their assigned task, other members might experience tension and stress. In order to reach the desired goal, the team can compensate on that member's behalf and finish the incomplete task. Through dynamic adaptation to changes in teamwork, the team can survive and continue to proceed further. An excerpt in this regard from the data was "for the most part they understood that we were going out of our way… [I would] get my work done and then do theirs I guess."

Help seeking/help giving behavior. As mentioned earlier, this category refers to actively solving a shared problem. At times when working on the project became complicated, or members would get lost, their first response would be to reach out to each other and ask for help. Whoever who had a suggestion would step in and propose a new solution (give help). In teams with high trust and psychological safety (Ilgen et al., 2005; Reynolds & Lewis, 2018), the new solution would be considered and the team would either resolve their issue and move a step ahead, or realize that the proposed solution was not correct and brainstorm again. This strategy was mostly used when students referred to task complexity or being off-track. An example is when Participant 8A mentioned: "I didn't feel pressured, it made me feel like I was there to do my job and that they were there to help me if I needed to".

Decreasing standards. This is a cognitive change strategy where members downgrade their expectations (e.g., learning instead of winning the competition). When a goal is hard to reach even with effort, anxiety may occur (see articles on perfectionism and depression; e.g., Smith, Sherry, McLarnon, Flett, Hewitt, & Etherson, 2018). When they accurately realize their capabilities and affordances, and downgrade to a more doable target, they feel more competent. Based on the self-determination theory (Ryan & Deci, 2000), members will experience more positive emotions when they feel they are more competent. This strategy is in response to being

idealistic as a frequent challenge in the hackathon teamwork experiences. An example from the data includes: “so we changed our topic and we went for a middle ground which seems to work” (Participant 8A).

Contribution encouragement. This is a situation modification strategy where members encourage each other to contribute by using positive adjectives such as “excellent,” “great idea,” “wow,” etc. This strategy enhances team cohesion and students’ self-efficacy beliefs about their competence, and motivates them to get more involved. An example from Team 9 interaction data is when 9A says: “Haha I think that for the hackathon anyway that works is a great way!!” and 9C replies: “That’s true, you are right. Let me just…ugh yeah sure”.

Concentration. is an attention deployment strategy used to focus on parts of the project that are complicated. The reverse may occur when students distract their attention away from a complexity/challenge. These strategies (concentration or distraction) may be favorable depending on the situation. As an example: “If we get stuck we will try this over and over again until it’s resolved.” In this case concentration is an adaptive SSER strategy used to resolve the problem, and positively influences team emotions. This strategy has mainly been reported in response to the challenge of high task difficulty. An example of concentration when facing challenges from the data is “(I knew this would work at the end). Just trying again and again until it works” (Participant 5B).

Being open minded. Finally, being open minded was reported as a predominant cognitive change strategy. Being open minded and unbiased is important in teamwork, especially in teams of diversity and heterogeneity. Heterogeneity in the context of the hackathon teams might be in terms of different academic backgrounds, age levels, gender differences, competencies, or cultures. Being unbiased is also important if members may have had negative

past experiences. Being open minded will enable members to “hear” and “see” what others are suggesting and apply their suggestions if logical. This strategy along with “perceptivity taking” (a cognitive change strategy) has been used in opposition to the challenge of “having unreliable members.” Literature has also shown the power of open mindedness in emotion regulation (Kashima et al., 2017).

Points to Consider in SSER Analysis

First, based on the procedure provided by Järvenoja et al. (2013), SSER was usually coded following the occurrence of a challenge. For example 5A mentioned that: “At one point I really had difficulty doing the network [coded as a challenge – task difficulty] but he helped me and we figured out a new algorithm more easier to code and yeah so we worked together to do this [SSER – collaborative problem solving]”. Second, in the context of this study coding was based on meaning units rather than words per se. For example, when 7C said: "I’m not super competitive anyway like by nature, so it’s not highly important for me to win," this instance could not be coded as downgrading from winning to learning as no attempt to emotion regulation (e.g., downgrading) was detected. Third, emotion regulation can be shared across members or targeted to regulate one’s own emotions. In analyzing the data, we coded an emotion regulation strategy as *SSER* when the challenge and the regulation of the challenge were felt by more than one member.

Fourth, in our analyses we realized several instances of recursive emotion regulation (refer to the extended model of emotion regulation; Gross, 2015); for example:

> "I felt like we lacked communication [Challenge: low communication]. It wasn’t really frustrating, I just tried to talk more and like communicate more [SSER: increase communication], but it kind of didn’t work [Challenge: low communication, ER failure],

but it was fine. I wasn't frustrated or anything because I knew he was doing his job and he does it right, he works more than I do, so I trust him [SSER: Cognitive change]" (Participant 1B).

Fifth, it should be noted that SSER is not always beneficial and may sometimes be maladaptive towards team goals. For example, if a team has not come up with a project idea after several hours from the start of the competition, and members are still doubtful, yet changing their minds; this situation may be coded as *flexibility* but it should not be counted as an adaptive strategy towards reaching the overall team goals. In such cases, coders can divide SSER codes into adaptive or maladaptive. Sixth, it is important to note that sometimes an emotion regulation attempt may be a maladaptive self-regulation strategy, but the same strategy may be adaptive for the overall team goals. For example, empirical literature has consistently shown that suppression of negative emotions is an inappropriate strategy for individual well-being (e.g., Gross & John, 2002), however within a team emotions (positive or negative) are contagious and consequently self-suppression of negative emotions may be favorable to promote a better team experience. Seventh, like many other procedures, emotion regulation (self, co- or shared) is only good when applied at an intermediate level. Too much emotion regulation may not be adaptive for a team in the long-term; for example too much help seeking behavior may be interpreted by peers as intrusive. Finally, although generally negative emotions require SSER, there may be instances that SSER can enhance team coordination by maintaining and increasing positive emotions within the team environment. Some empirical evidence from the current research as well as previous literature (e.g., Lajoie et al., 2015; Rogat & Linnenbrink-Garcia, 2011) that can enhance trust and shared mental models include: (a) showing interpersonal sensitivity and caring, (b) using humor, (c) extending mutual respect, (d) active listening, (e) encouraging participants'

contributions by appreciation and expressions of agreement, and (f) using inclusive pronouns to convey team cohesion.

In summary, the multiple afore-mentioned points should be considered in labelling a regulatory attempt as an SSER strategy. These eight points were identified during different iterations of data coding and categorization, and helped identify when an attempt reflected self-regulation of emotions, or extended to the team and reflected the broader SSER strategies. Of the other highlights were that only during coding in context could one claim whether an SSER attempt was adaptive or maladaptive for the team.

Comparison Between a Low and a High Performing Team: A Case Study Approach

Our findings revealed a major difference between a high and a low performing team (Bakhtiar, Webster, & Hadwin; 2018) in terms of challenges they experienced: the low performing team had high percentages of *internal* challenges. In particular they experienced (a) different working styles, (b) unequal contributions, and (c) low shared mental models which led to low team cohesion and labelling each other as unreliable and untrustworthy. The low performing team experienced the most challenge because they could not downgrade their self-set goals even after a long period of team discussion, leading to a polarized group each working separately.

On the other hand, the high performing team had few challenges, which were mainly external (i.e., being off track and experiencing time pressure) that were successfully managed with shared emotion regulation strategies such as (a) collaborative problem solving, (b) down grading, (c) contribution encouragement, and (d) expressing adaptive emotions. Generally, the high performing team showed high involvement, helpfulness, and responsibility taking, encouraged each other's contributions with strong welcoming words, downgraded from idealistic

ideas in a timely manner, and also apologized when they realized they had made mistakes. Figure 18 provides a visualization of external challenges teams faced at the start of their team experience within the socio-emotionally challenging context of a hackathon, and the different approaches they applied in face of those challenges. With high application of SSER, internal challenges were less observed and the team could pass the ups and downs of the session more smoothly. However, with low application of SSER, not only did the external challenges not fade away, but internal challenges arouse as well and the situation became more complex.

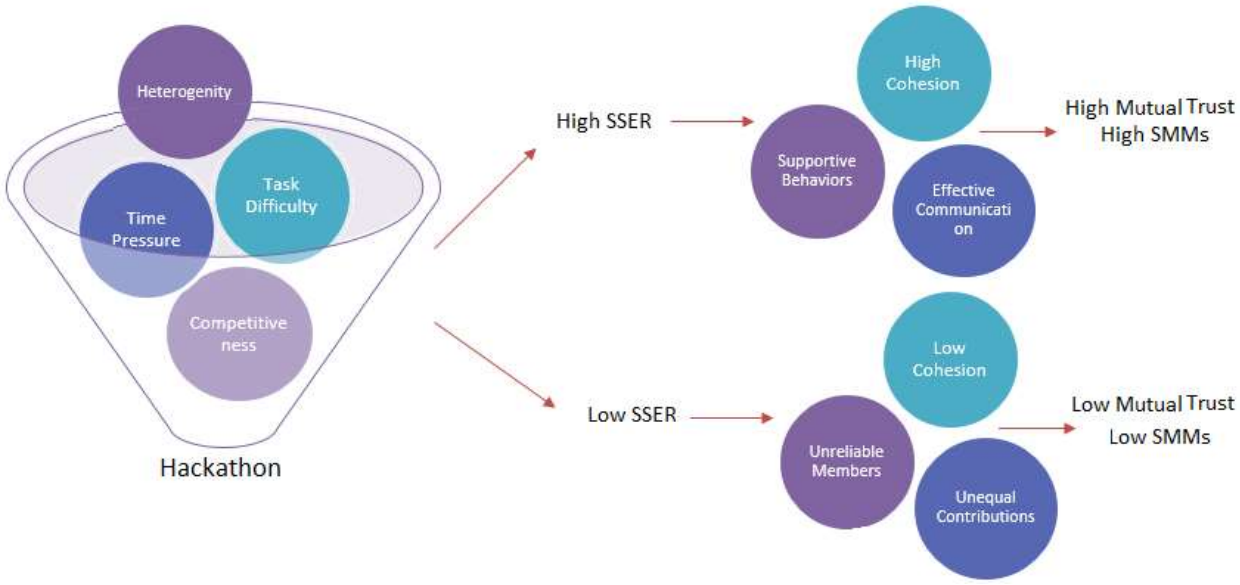

Figure 18. The hackathon presents some external challenges (see funnel) but teams can use SSER to overcome challenges (upper right circles) or they may not use SSER to their benefit since they have not addressed internal challenges (lower right circles).

When members apply SSER strategies, they build a cohesive atmosphere and synergistic team relationships that enable them to build strong ambitions to contribute to the overall team goals. SSER will facilitate the development of mutual trust between members, and enhance constructs such as psychological safety within the team so that members can externalize their mental models, by communicating their thoughts, developing shared understandings of the procedures and tasks, and progressing towards reaching team goals.

A Visual Model of SSER in Teamwork

As mentioned earlier in Chapter 2, emotion regulation in the social context spans over a continuum from self-regulation of emotions to co-regulation of emotions, and finally to socially-shared emotion regulation. Considering these findings we modify Figure 3 and consider how members join each other within a collaborative context while they may have different levels of emotional arousal (compare the base line levels of adaptive emotional states for Person 1, 2 and 3 in Figure 19). The SSER strategies that a team applies following a challenge, influences different members to different extents. Different reactions to an SSER strtaegy may depend on differences in members' perceptions of the challenge (whether they see it as a strongly or moderately destructive challenge), personality styles (whether they are emotional in nature), gender, etc. (see the upper blue spheres rising to different levels from the lower blue spheres).

Therefore, a team should acknowledge that members do not change similarly with a specific SSER attempt. This was evident in our research, generally we found that some members in a team experienced deeper challenges and emotions, and some experienced less (refer back to the challenges heat map in Figure 10). Also, some members reacted more to SSER strategies applied in their team, showing higher influence than others (refer back to the SSER heat map in Figure 14). It should also be noted that the SSER arrow (represented at the right of Figure 19) does not simply change from a lower to a higher emotion state, rather it is on a continuous spectrum ranging according to the intensity of an emotion (e.g., gradual change from high anxiety towards calmness).

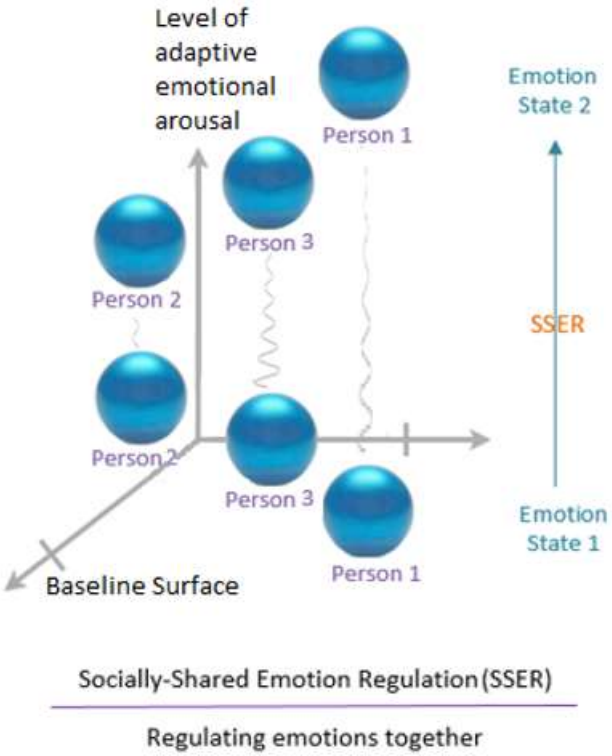

Figure 19. The SSER model: Different people change differently with the application of SSER in their team.

Statistical Relationship Between SSER and Shared Mental Models and Mutual Trust

The final research question focused on the relationship between SSER and shared mental models, and between SSER and mutual trust. The relations are described individually below.

SSER and Shared Mental Models

Previous literature has focused on the indirect relation between SSER and shared mental models through the management of challenges and conflicts teams face. To our knowledge, the direct link between emotion regulation (specifically SSER) and shared mental models has not yet been explored. The general trend so far has been to investigate two independent relationships: (a) the negative relationship between emotion regulation and challenges (that may result in conflicts), and the number of challenges and shared mental models. A few studies have considered both relationships and focused on managing conflict as a key emotionally challenging

hindrance to the development of shared mental models (e.g., Hamilton, Shih, Tesler, & Mohammed, 2014). To address this gap, the third research question examined whether there is a direct relation between SSER and shared mental models (upper image in Figure 20 shows the indirect relation between SSER and shared mental models through the management of conflicts; while the lower image refers to the direct relationship between SSER and shared mental models).

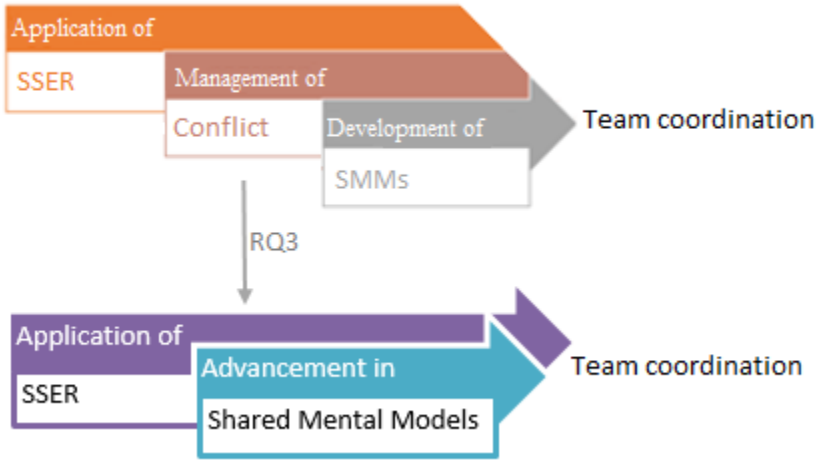

Figure 20. Research Question 3 examining the direct relationship between SSER and shared mental models.

Our analyses found that there was a significant direct relationship between: (a) "SSER situation modification" and "shared mental model: task and communication skills," and (b) "SSER situation modification" and "shared mental model: team dynamics and interaction." We will describe these significant relationships hereafter:

SSER2 (situation modification) and S2 (task and communication skills). Looking at items describing task and communication skills, we can see that there is high correspondence between such skills and situation modification. Specific skills such as effective communication, supporting continuous improvements of members and the team, using a common vocabulary in task discussions, and consistently demonstrating effective listening skills are positivcly

associated with the situation modification strategy. SSER situation modification items that are associated with with the shared mental model category include contribution encouragement, increasing communication, being open minded and unbiased. The strong positive correlations between the two aforementioned factors suggests that the more members of a team apply SSER situation modification, the more they can advance their task and communication skills. Our analyses comparing the low and high performing teams demonstrated that a lack of such skills can weaken teamwork and lead to poor team performance.

SSER2 (situation modification) and S3 (team dynamics and interaction). Items that describe team dynamics and interactions include understanding roles and responsibilities, updating each other about different work issues, collaborative decision making, flexibly adapting to roles within the team to carry out various tasks, knowing where to get information, and solving problems that occur during teamwork. Several such items have been addressed in SSER situation modification. Again, some of the SSER situation modification items are collaborative problem solving, adapting to increased workload, increasing communication, and help seeking and help giving behavior. Thus items of SSER situation modification and items of shared mental models, team dynamics, and interactions are in correspondence to each other. Positive correlations between there is a strong correlation between the two aforementioned factors. As a next step, regression analyzes can inform the direction or bidirectionlity of this relationship, i.e. determine whether the more members of a team apply SSER situation modification, the more they can enhance their team dynamics and interaction skills. Our analyses comparing the low and high performing teams showed how lack of such skills can weaken teamwork and lead to the failure. The correspondence between SSER situation modification and shared mental model items in the two aforementioned factors is provided in Table 16. Higher frequencies in the

situation modification category are associated with higher frequencies in two specific categories of shared mental models

Table 16

Correspondence Between Situation Modification and Two Shared Mental Model Factors

SSER2 (situation modification)	S2 (task & communication skills)	S3 (team dynamics & interactions)
Collaborative problem-solving		Collaborative decision making Solving problems that occur while doing various tasks
Contribution encouragement	Supporting personal and team improvements	
Adapting to increased workload		Flexibly adapting to roles in the team Taking interdependent tasks
Help seeking/ help giving behavior	Knowing the team has skills for doing various tasks	Knowing where to get information from
Increasing effective communication	Communicating tasks with team mates Using a common vocabulary defining communication channels at the start	Knowing how to exchange information Knowing about roles and responsibilities
Being open-minded and unbiased	Demonstrating effective listening skills	

SSER and Mutual Trust

The second hypothesis in Research Question 3 was that SSER has a positive relationship to mutual trust between members of a team. Our analyses revealed significant relationships between: (a) SSER situation modification and perceived trustworthiness, (b) SSER cognitive change and perceived trustworthiness, (c) SSER response modulation and cooperative behaviors, and (d) SSER response modulation and monitoring behaviors. We will describe these significant relations hereafter:

SSER2 (situation modification) and Trust2 (perceived trustworthiness). Items that describe perceived trustworthiness refer to the level of reliability of members (Costa, Roe, & Taillieu, 2001). These include members having complete confidence in each other's' ability to perform tasks, keeping their word and staying committed, and looking for each other's interests honestly. These items are coherent with the second category of SSER (situation modification strategies): the more members show collaborative problem solving behaviors, convey help giving behaviors, adapt to increased workload, provide constructive criticisms, be open-minded and unbiased, and have efficient communication and time management skills; the more they become reliable and signal their responsibility taking and commitment to the overall project goals. This is also in line with previous literature describing reliability and trustworthiness of members collaborating in a team (e.g., Cogliser, Gardner, Gavin, & Broberg, 2012), identifying high commitment levels as strong predictors of being reliable.

SSER4 (cognitive change) and Trust2 (perceived trustworthiness). An interesting and novel finding from this research was the strong correlation between cognitive change as an SSER strategy and perceived trustworthiness. This previously unexplored relation indicates the power of changing original thoughts about other members towards more positive thoughts on how much others can be perceived trustworthy. Cognitive change items include optimism, putting into perspective, problem shrinkage, decreasing standards, and decreasing expectations. As mentioned earlier, cognitive strategies can significantly influence trust repair since expectations and violation of expectations have a thick cognitive dimension (Jones & George, 1998). Therefore changing thoughts through decreasing high expectations or seeing violations of expectations as minor can help the trustor forgive more easily and maintain mutual trust.

As mentioned earlier in Chapter 2, there are several points in the trust dissolution path where SSER can intervene. One main point is around expectations, another is around violations of these expectations, and a third is around emotional reactions. The first two points are before emotions are elicited, but the third is after emotion elicitation (see Figure 21). Through cognitive reappraisal of a team's expectations of a trustee's responsibilities, violation criteria of these expectations, and emotional reactions to violations can help maintain or restore trust in the team atmosphere. Examples include: (a) is our expectation reasonable; (b) is our perception of violation accurate; and (c) are we overreacting? These questions and considerations help change thoughts when trust is at risk of dissolution.

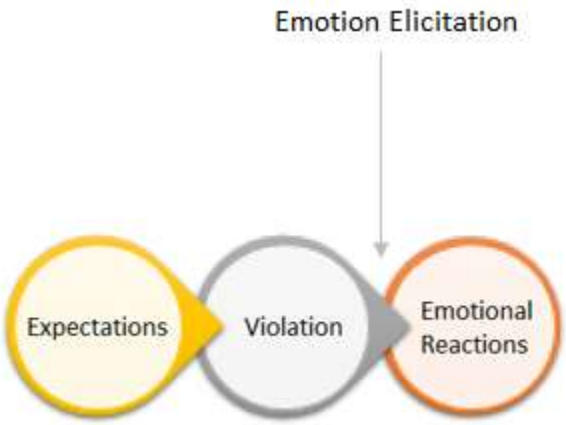

Figure 21. Trust dissolution path: Three points where SSER can intervene through cognitive change.

SSER5 (response modulation) and Trust3 (cooperative behaviors). The third trust category refers to working in a climate of cooperation and openness. The significant negative relationship between response modulation and this trust category can be explained through the categories of this SSER strategy; like suppressing maladaptive emotions and resisting maladaptive emotional contagion. Previous literature has proven the maladaptive nature of suppression of emotions for the wellbeing of the self (Gross & John, 2002). It may be the case

that suppression or resisting the contagion of negative emotions of the self within a team has similar negative effects, and other members may possibly perceive that the suppressing member does not discuss and deal with issues openly and prefers to hold back relevant information (reverse items of the trust questionnaire on cooperative behaviors). Research in this regard (English & John, 2013) has shown that the link between suppression of emotions and poor collaborative performance is mediated by inauthenticity (Lehman, O'Connor, Kovacs, & Newman, 2018), or the incongruence between the inner-self and outer-behavior. Likewise, in this research we can infer that suppressing negative emotions and resisting contagion of maladaptive emotions may have negative effects on trust between members. Members should either target the four former SSER strategies prior to emotion elicitation (Gross, 1998), or openly express their negative emotions in order to maintain high levels of mutual trust with each other.

SSER5 (response modulation) and Trust4 (monitoring behaviors). The fourth significant relationship between SSER and mutual trust refers to the negative significant correlation between SSER response modulation and monitoring behaviors. This relationship indicates that the more members suppress their negative emotions and resist contagion of maladaptive emotions, the less they show monitoring behaviors. This may be because efforts to hide negative emotions, and attentional resources required to suppress negative emotions may decrease opportunities to attend to others or put them under surveillance. As we saw in the data provided in this dissertation, it may be very common that teams face anxiety and moments of stress. When members experience such emotions, their attention to hide such emotions in favor of the overall team goals, may remove much of their attention to others (Sänger, Bechtold, Schoofs, Blaszkewicz, & Wascher, 2014). Therefore response modulation may have advantages as well as disadvantages. One of the disadvantages is not connecting well with others, and one of

the advantages may be that those members have less chances to check others work and keep other's work under surveillance.

The Trust Model

In the Literature Review section we presented a conceptual model of trust (refer back to Figure 2). This model presented the dynamic evolution of trust from distrust to unconditional trust through ongoing expectation fulfillments signaled by positive emotions. Minor expectation violations (lapses) would result in minor levels of negative emotional arousal and would not affect mutual trust between members as much, however major violations would lead to major lapses, strong negative emotional arousal, and trust would spiral downward to lower levels. The findings of this study support such a conceptualization and show that negative emotions signal lapses in trust, pushing it towards distrust, and positive emotions signal strengthened trust bonds. Specifically in challenging moments, SSER helped manage emotions and therefore maintain mutual trust. For example, close to the competition deadline (extreme situation; Driskell et al., 2018), members of Team 3 (third ranked winners) realized that one of the members had made a mistake in a part of the program and because of this, the project would not run (a major lapse). Using SSER cognitive change (problem shrinkage), response modulation (telling each other to chill down) and SSER situation modification (encouraging each other to continue) they managed to work around the obstacle in time, express signs of joy and happiness. Based on their trust questionnaire, they also reported having strong trust in each other. These findings provide empirical support to the conceptual model of trust evolution (see Figure 22).

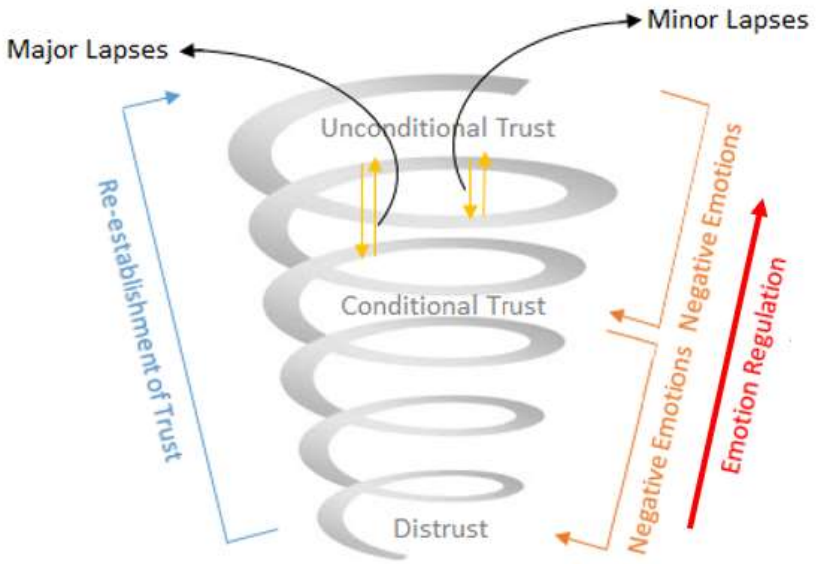

Figure 22. Emotion regulation facilitating the maintenance of mutual trust during violation lapses.

Contributions to the Literature

The wealth of team-related research in the organizational psychology literature is yet neglected in educational contexts. The current research provides new insights in this area by linking theoretical paradigms used in both domains of organizational psychology and emotion regulation. In doing so, this research provides a better understanding of team effectiveness by examining the components that underlie team coordination, namely shared mental models and mutual trust, and the relationship that emotion regulation plays when inevitable challenges occur during teamwork.

In this research, teamwork was examined in the context of an international hackathon that provided an excellent opportunity to observe the natural but complex behavior of students in the process of knowledge co-construction with their peers. This novel face-to-face CSCL context provided a unique opportunity to study teamwork in a competitive but motivating setting where students enhanced their learning while working collaboratively on projects using technology tools to create sophisticated solutions to real-world phenomenon.

This research contributes to the theoretical literature by extending our understanding of socially shared emotion regulation. In particular, socially-shared emotion regulation was explored to understand how it manifests in socio-emotionally challenging team settings, and how it contributes to building trusting teams with convergent mental models. Several graphical visualizations were created to illustrate the complex nature of socially shared emotion regulation and how it was different from other types of emotion regulation (self- and co-regulation). Visual representations were also created to demonstrate the developmental spiral of trust from distrust to unconditional trust; and a visual model was created to present team-related challenges.

Using a top-down/bottom-up approach (previous literature as well as the multimodal hackathon data; Sabatier, 1986), this research identified SSER strategies that teams used during the competition. Through several iterations of data analysis, a final comprehensive list of 29 SSER strategies was created and further categorized into five main categories of emotion regulation, originally identified by Gross (1998, 2015) for individual emotion regulation. This newly-developed framework is labelled as the "team emotion regulation model" with SSER subcategories that may be extended to other collaborative settings. Additionally, an SSER questionnaire was developed that can serve as the basis for developing a validated team emotion regulation questionnaire in the future.

Previous theoretical literature (Panadero et al., 2015) has declared that SSER originates from individual emotion regulation and is therefore isomorphic to individual emotion regulation in its effects. This research expanded our understanding of socially-shared emotion regulation, and provided evidence that although SSER and individual ER have similar origins, SSER is not necessarily isomorphic to individual emotion regulation "in its effects". As an example, sometimes an emotion regulation attempt may be maladaptive for the self, but the same strategy

may be adaptive for the overall team goals (effects being different). For example, empirical literature has consistently shown that suppression of negative emotions is an inappropriate strategy for individual well-being (e.g., Gross & John, 2003), however within a team emotions (positive or negative) are contagious and consequently self-suppression of negative emotions may be favorable to promote a better team experience.

A comprehensive list of challenges experienced in teams (16 in total) was identified, and was categorized into seven major themes including cognitive, motivational, emotional, behavioral, and a blend of such challenges. The identification and categorization of team challenges provided a first step in improving team effectiveness since resolving such challenges can assist in the development of shared mental models and mutual trust. These challenge-categories can be used to examine teams in other contexts beyond academia, and may ultimately lead to empirical research that examines whether team performance gains can occur when teams are taught effective socially-shared emotion regulation strategies.

From a methodological standpoint, the dissertation presented a critical review of the literature of how socially shared emotion regulation, shared mental models and mutual trust have been assessed in collaborative settings. This review led to the selection of multimodal data to answer the research questions using several data channels (questionnaires, in-session audio/video records of team interactions, and post-competition interviews) to identify the challenges teams faced and the SSER strategies applied during the competition. Multimodal data were triangulated to enhance the validity of research findings. Mutual trust and shared mental models were examined using thematic analysis and deductive coding (Flick, 2014) to identify the predominant emergent themes derived from the afore-mentioned sources of data. Two coding schemes were created that provide *observable markers* of mutual trust and shared mental models in teamwork.

These coding schemes can be replicated by other researchers interested in understanding team performance.

Another contribution of this research was that we found members who were more affected by challenges, tended to use more maldaptive self-, co or socially-shared emotion regulation strategies in efforts to overcome their challenges. This finding shows the importance of advising all team members to be consciously sensitive to each other, specifically at times of challenge, in order to co-regulate those who get more affected by challenges. In addition to the amount of pressure team members experienced individual member goals are an important factor in choosing which types of emotion regulation strategies they might prefer to apply at different time points during their collaboration. Our empirical analyzes showed that members' emotion regulation strategies may be convergent with each other and collectively yield a superior SSER strategy towards advancing the team move over roadblocks. On the other hand, team member ER strategies may be divergent from each other and not only block the team from moving forward, but intensify or add new challenges to the team. The SSER strategies that a team applies following a challenge, influences different members to different extents. Different reactions to an SSER strategy may depend on differences in members' perceptions of the challenge (whether they see it as a strongly or moderately destructive challenge), personality styles (whether they are emotional in nature), and gender, etc. (refer back to Figure). Therefore, a team should acknowledge that members do not change equally with a specific SSER attempt.

The empirical findings revealed how SSER strategies could be used to overcome team challenges, leading to higher levels of mutual trust and shared mental models. A case study of two extreme teams (a winning and a losing team) was provided to contextualize findings based on the dataset and shed light on the negative relationship between SSER and the challenges

teams face. Findings revealed that teams whose members applied more SSER strategies demonstrated higher levels of mutual trust, and shared mental models at challenging moments.

These findings have implications for enhancing team performance in teams with coordination breakdowns within challenging settings. Intervention programs can be aimed at facilitating SSER in collaborative learning and achievement contexts. Workshops can be designed to simulate challenging team contexts, and teams can be guided to practice applying SSER strategies to adaptively manage the challenges and proceed forward. A current intervention strategy can be to develop mobile apps to help each member of the team apply adaptive individual emotion regulation strategies using self-report or physiological data. The same apps can be designed to incorporate data from all members of a team in order to detect and/or promote adaptive SSER strategy application. Other methods include mere presentation and discussion regarding possible challenges within teamwork (especially in tense settings), and the myriads of methods to apply SSER strategies to manage such challenges. Raising team awareness of the natural challenges of teamwork (occurring even in best teams) and the relative power and types of SSER strategies teams can apply in encountering such challenges, can help enhance team coordination. While more research is necessary to fully understand the influence of SSER on team coordination mechanisms, this research provides important steps toward helping learners adaptively manage challenging learning situations that require collaborative learning.

Study Limitations

There were several limitations in this study that can be addressed in future research. Although we recruited a high percentage of Hackathon participants, the sample is still small and decreased the power of our statistical analyses. However, this authentic competition did provide

us with a window onto how teams meet challenges and how SSER can lead to better shared mental models, mutual trust and better team performance.

The context of the study provided an authentic and exciting new venue for data collection on collaborative learning. However, as teams were working together in one open auditorium, background noise was high and recorded voices were hard to transcribe. Future research may slightly modify the data collection setting by using partitions or by positioning teams as remote to each other as possible. We also had limited cameras and audio recorders and could not record all teams simultaneously. Our study was limited to the analysis of verbal data and questionnaires, and partial nonverbal behaviors of team interactions (see section on "Video/audio data of teams" in Methods for a sample transcription). Future research can consider a broader range of nonverbal behavior as a mode of communication towards building shared mental models. Examples include posture (nodding, shaking heads, thumbs up, tapping over the shoulder of a peer; see Bousmalis et al., 2009); vocal characteristics (Kazemitabar et al., 2019), and facial expressions (Hall, Horgan, & Murphy, 2019).

This research only focused on the SSER strategies students applied. However, as self-regulation of emotions and perhaps co-regulation of emotions can co-occur during collaborations, future studies might consider the three different modes of regulation simultaneously. It should however be noted that self-report data (including interviews and questionnaires) of high performing teams applying adaptive ER strategies revealed that at times when a challenge was felt by everyone and an SSER opportunity was created, collective attempts to manage the situation were reported more than individual attempts targeting the regulation of oneself. It might be that students consciously applied SSER strategies, while simultaneously although unconsciously applying self-regulation strategies. Thus, in their self-report they mainly

discussed shared ER strategies. Future research can examine the potential benefit of conducting physiological measures of emotion regulation to better analyze the *co-existence of emotion regulation modes* when one (e.g., SSER) is consciously being applied while others (e.g., self-regulation of emotions) are unconsciously active.

Future analyses can also consider the influence of negative SSER (where members reported a lack of SSER). Future analyses can consider application and lack thereof SSER in coding the data. Hadwin, Jarvella, and Miller (2017) state that without knowledge of students' intent, inferences about observed emotion regulation are limited at best. Although in this study, we used post-reflection interview data from participants as well as questionnaire data as channels to students' intent, this data did not cover all team interactions and in some cases, inferences were made.

Future Directions

Study Sample and Context

Future research can further strengthen the findings of the present study by including a larger population. As literature has identified effects of culture on emotion regulation, future studies can also identify the impact of culture on SSER. Also, longitudinal data gatherings can provide more insight into the development or impairment of trust relationships between members as challenges emerge during teams' ongoing activities. In this research we only focused on two cases, representing as high and low performers where they had respectively shown high and low SSER strategies within their teams. Future research may explore if there are teams of high SSER application but low performance, and reversely whether there are teams of low SSER application but high performance.

Instruments, Scales and Equipment

As there are no questionnaires developed to capture students perceptions of their team's SSER attempts, the SSER questionnaire developed by the current study can be used as a basis to develop a validated SSER instrument. In addition, our research identified a gap in the current literature in that there were no questionniares to examine emotions within a team. This limitation highlights the need to develop a comprehensive emotion questionnaire for collecting individual's emotions within a team, that could be labelled as the *team emotions questionnaire*.

In the future multi-modal data can be used to provide more context to the influence of emotions on team performance. For example, it would be interesting to extend the study of team emotions by using physiological data, using electrodermal bracelets, to understand whether co-occurrences of emotional arousal between members can be an indication of team cohesion (see Malmberg et al., 2019; Järvelä, Hadwin, Malmberg, & Miller, 2018). Also, supplementary information from eye tracking data of a team of individuals could enhance the validity and richness of team cognition measures. Future research can investigate the feasibility of including eye tracking (eye gaze and eye fixation rates) as well as other objective cognitive measures (e.g., EEG, skin conductivity) into team cognition research, and what the potential value of these objective cognitive measurements might be in understanding and validating shared mental models. For example, while members collaborate with each other, there are different events taking place; like thinking and discussing. During thinking members may have less common points of interest (POIs), however while discussing and negotiating they may gaze more at the face of others in order to detect signals of agreement or disagreement. Combining information from multiple nonverbal resources such as facial expressions, and head and hand gestures can better signal evidence of shared mental models in a team.

Likewise, although nonverbal behavior has shown to provide a rich data source to individual emotion regulation (Bousmalis et al., 2009), to our knowledge there have been no reported studies that have analyzed SSER through observational mechanisms. One approach might be to analyze emotional contagion and see whether this may be a source to observe SSER. For example, a team member's smile in a stressful occasion may transmit to others in the team a certain message and decrease the overall level of team anxiety. Based on studies that have looked at individual emotion regulation through physiological signals of the human body, another future direction may be to determine SSER in a learning team through processing co-occurrences of physiological data channels of the team members (see Haataja, Malmberg, & Järvelä, 2018 for examining co-occurrences of physiological signals in collaborative learning that may be expanded to SSER research). We hope that through such techniques a wider lens can be provided to less subjective approaches of understanding SSER within learning teams. Finally, future research can use data mining software to identify and count numbers of positive, neutral, negative sentiments and examine whether teams of high SSER have a higher overall number of positive sentiments, and whether positive sentiments can represent high satisfaction in teamwork.

Variables of Focus

Emotion regulation in the social context is especially important since individual emotions can strongly be influenced by the social setting and intensify into more positive or more negative emotions (Barsade & Gibson, 1998). Future research can examine the effects of emotional contagion on SSER and team performance. Further research can expand the team emotion regulation model to include both positive and negative SSER strategies. Research can also identify which challenges were stronger in coordination breakdown, and which challenges required more SSER attempts. Also, the relative power of different SSER strategies in resolving

challenges can be examined, and further research can explore how teams can apply more adaptive SSER strategies (as opposed to maladaptive strategies). Although not examined in this paper, future longitudinal studies can examine whether the relation between SSER and shared mental models is reciprocal, implying that SSER can facilitate the development of shared mental models, and in turn advanced shared mental model bonds can ease application of further SSER strategies. Likewise, future longitudinal research can examine the bi-directionality between SSER and mutual trust between members.

The difference in members' arousal levels by a challenge, and differences in influences of SSER on different members may also be examined in future studies through consideration of personality traits, gender and emotional capacity. Also, given the cognitive as well as affective elements of trust, further research can identify the relative power of cognitive reappraisal as a SSER strategy in ameliorating trust in comparison to other strategies directly targeting affect regulation (e.g., response modulation).

Further studies need to understand the effect of SSER on moving from conditional trust to unconditional trust. Our data did not allow us to examine unconditional trust even within high performing teams. Future research can explore tangible cues that infer unconditional trust within a team. Also, future research can compare teams where members resist expressing negative emotions (in favor of their team) with teams whose members express their feelings openly in order to examine which teams perform better. In trust examination, future studies can investigate what types of lapses move trust downward in the evolution spiral, and which lapses have higher emotional load, more strongly impacting trust violation, and consequently in need of stronger emotion regulation. Finally, despite the theoretical emphasis on the power of the leader's emotions on team behavior, empirical research in this area has received minimal attention

(Eberly & Fong, 2013). The leadership literature has only a thin connection with research on emotions, emotion regulation, and SSER. Future research can examine the relative power of leader emotions on followers and can examine how different hierarchies of members may differently impact overall team emotions.

Concluding Remarks

This dissertation has implications for assisting teams in challenging learning environments, including face to face CSCL settings. Raising team awareness of the natural challenges of teamwork (occurring even in best teams) and the relative power and types of SSER strategies teams can apply in encountering such challenges, can help enhance team coordination. While more research is necessary to fully understand the influence of SSER on team coordination mechanisms, this research provides an important first step toward helping learners adaptively manage challenging learning situations that require collaborative learning.

All teams are not created equal, each having its own dynamics and outcomes, but sometimes teams performing in different contexts are more similar than different (Salas et al., 2018). This research provided a new lens to study teams by looking at emotions in teamwork and how their management can help teams move beyond challenges and achieve successes. Our findings showed that shared emotion regulation is a critical mechanism in the face of teamwork challenges, and it can serve as a powerful mechanism to resolve conflicts, build cohesion, and advance performance. In conclusion, “It is the law of nature that trees with the sweetest fruits are those that have had less water” (Imam Ali, 601 AD). This quote reminds us that challenges can be viewed helpful if we are strong enough to deal with them efficiently and, more importantly, together!

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Appendices

Appendix A

Definitions of teamwork factors (adapted from Salas et al., 2005, p. 560-561)

Factors	Definition
Team Leadership	Ability to direct and coordinate the activities of other team members, assess team performance, assign tasks, develop team knowledge, skills, and abilities, motivate team members, plan and organize, and establish a positive atmosphere.
Mutual Performance Monitoring	The ability to develop common understandings of the team environment and apply appropriate task strategies to accurately monitor teammate performance.
Backup Behavior	Ability to anticipate other team members' needs through accurate knowledge about their responsibilities. This includes the ability to shift workload among members to achieve balance during high periods of workload or pressure.
Adaptability	Ability to adjust strategies based on information gathered from the environment through the use of backup behavior and reallocation of intra-team resources. Altering a course of action or team repertoire in response to changing conditions (internal or external).
Team orientation	Propensity to take other's behavior into account during group interaction and the belief in the importance of team goal's over individual members' goals.

Appendix B

Consent Form

Title of study: Examining the Effects of Shared Emotion Regulation on Students' Team Coordination

Investigator: Maedeh Sadat Kazemitabar, PhD Candidate at the Department of Educational and Counselling Psychology, McGill University, Email: maedeh.kazemi@mail.mcgill.ca, Phone: 514-(398) 8867.

This research is conducted under the supervision of Dr. Susanne P. Lajoie (Professor and Canadian Research Chair Tier 1 at the Department of Educational and Counselling Psychology, McGill University), Email: susanne.lajoie@mcgill.ca, Phone: 514-(398) 3429.

Purpose of the study: The primary purpose of this research is to identify strategies that team members apply in managing teamwork effectively, and explore how these strategies may influence team knowledge development and team trust towards reaching common learning goals. By conducting research on this topic we can determine the effectiveness of models that could become available for students to support their team learning activities. Your participation will contribute towards furthering our understanding of these factors in order to inform instructional support offered to student teams within competitive settings.

Compensation: We will offer participating students entry into a lottery of 10 gift cards each valuing $40.

What is involved in participating: You will be asked to fill in a set of questionnaires including those that cover basic demographic characteristics such as your age, gender, and degree; and how much you value the hackathon (taking approximately 5 minutes). You will be asked to report your emotions at various points throughout the hackathon that pertain to your teamwork (taking approximately 5 minutes). Audio and video recordings will be collected for the purpose of understanding how teams function. On day 1, you will be asked to complete two questionnaires (approximately 15 minutes). These questionnaires refer to the trust level you perceive in your team, and the extent to which you share common knowledge or mental models. On day 2, you will be asked to fill in a second set of questionnaires that refer to challenges you may have encountered during collaborative programming and how you and your team managed to deal with the challenges (10 minutes). At the end of the session, you may be interviewed by the principal investigator or one of her lab researchers regarding your teamwork experience (for approximately 15 minutes).

Benefits of Participation: Participation in this study will help to set the groundwork for developing emotion regulation models that can benefit high-level teamwork through enabling students to overcome teamwork challenges via shared emotion regulation strategies. This project is independent of the hackathon and your willingness to engage in this research will not impact your performance ranking or your academic standing. Your participation is independent to your peers' participation and you are free to refuse participation in the study without fear of any negative consequences and are free to withdraw your

involvement in the study at any time. At the end of the study, you can inquire about the findings by contacting the principal investigator by email (maedeh.kazemi@mail.mcgill.ca).

Risks of Participation: This study includes minimal risk. It is possible that you might experience mild unpleasant emotions that may be associated with completing a questionnaire on emotion-related topics.

Confidentiality: Confidentiality will be guaranteed by the following means: you will be assigned a code number by the principal investigator at McGill University in order to ensure that no personally identifying information will ever be mentioned in any publication or dissemination of the research data and/or results to other researchers. In order to publish and/or disclose the data outside McGill University, only the data and information for which you have given authorization will be used. The videos and audiotapes that you have provided authorization may be played at academic conferences or for teaching purposes. All data from this study will be kept confidential and will be used strictly for research purposes. The principal investigator and her lab researchers will have access to identifiable survey, and audio and video data gathered in this study. This data will only be accessed for research purposes to conduct analyses. All identifiable materials will be kept in a locked facility at McGill University and electronic data will be kept in a password-protected file. All identifying information will be destroyed after the study has been completed.

This research will be a thesis-based dissemination to the academic research community. The principal researcher aims to publish findings in recognized journals and conferences.

Signatures and Consent

You are free to refuse to participate in the study without fear of any negative consequences and are free to withdraw your consent and discontinue your involvement in the study at any time.

Please see the agreements below and circle Yes or No to indicate acceptance or not to each item:

Yes/No I consent to have my audio-records gathered during this study used during dissemination of the results of this study at conferences and other venues (academic journals and educational sessions). My name will not be used in any dissemination.

Yes/No I consent to have my video-records gathered during this study used during dissemination of the results of this study at conferences and other venues (academic journals and educational sessions). My name will not be used in any dissemination.

Your signature below indicates your agreement to participate in this study.

Print name	Signature	Date

If you have any questions or concerns regarding your rights or welfare as a participant in this research study please contact the McGill Research Ethics Officer at 514-398-6831 or lynda.mcneil@mcgill.ca.

Appendix C

Study Measures

A. Demographic Information

Please fill in the following:

Name .....

Team Name .....

Programming experience ...High...Moderate...Low.....

Past experience with team members .....Yes...No.....

School/College/University .....

Program & Year of Study.....

Current GPA .....

Email address .....

Gender .....

Age .....

Ethnicity .....

B. Value Questionnaire

(Adapted from the AIRE instrument; Järvenoja et al., 2013)

1. What was your major goal in becoming involved at the McGill Physics Hackathon?

   .....

2. Please fill the table below regarding other reasons that have been important to you in this hackathon:

Goal	**Importance**				
	Not very important for me	Slightly important for me	Moderately important for me	Highly important for me	A top priority for me
Win first place	○	○	○	○	○
Learn as much as possible	○	○	○	○	○
Get new ideas from the team	○	○	○	○	○
Practice my leadership skills	○	○	○	○	○
Not let my team down	○	○	○	○	○
Avoid looking incompetent	○	○	○	○	○
Have a good time, enjoy the experience	○	○	○	○	○
Make new friends, socialize with other students	○	○	○	○	○
Take personal responsibility for the project	○	○	○	○	○
Make sure everyone in my team will contribute equally	○	○	○	○	○

3. Please **<u>rank</u>** which of the above goals (indicated by you or based on the table) have been the most important to you in this hackathon:

   a. The first most important ……

   b. The second most important ……

   c. The least important …….

C. Challenges

(AIRE instrument; Järvenoja et al., 2013)

Below is a list of situations that you may or may not have encountered in your team and if so they would have triggered strong feelings among (some) team members. Please indicate for each of them, whether you experienced this in your team or not. If it happened, specify how big the challenge was, in your opinion. Please note that having to work through a challenge is not necessarily a negative experience. It may have turned into a positive experience and a successful outcome in the end.

Our team experienced a situation which triggered emotions where…

1. Our goals for the competition were different.

For example - one/some people wanted to rank high and others were just happy to participate

It did not happen	*It was a small challenge*			*It was a big challenge*
0	1	2	3	4
☐	☐	☐	☐	☐

Our team experienced a situation which triggered emotions where…

2. We had different priorities.

For example - Some people were more interested in socializing than getting on with the case.
- For some people, it was so important to have a pleasant atmosphere and friendly interactions that they were not prepared to question each other's views when discussing the task.

It did not happen	*It was a small challenge*			*It was a big challenge*
0	1	2	3	4
☐	☐	☐	☐	☐

Our team experienced a situation which triggered emotions where…

3. We seemed to have incompatible styles of working.

For example - One/some people wanted to start working right away while others wanted to plan first and start to work after that.
- Some needed breaks too often.

It did not happen	*It was a small challenge*			*It was a big challenge*
0	1	2	3	4
☐	☐	☐	☐	☐

Our team experienced a situation which triggered emotions where…

4. We seemed to have different styles of interacting.

For example - one/some people were used to telling others (or others telling them) directly if they disagreed but others found this style of interaction confrontational
-one/some people were rather shy and others very outspoken
- two were competing to lead the team.

It did not happen	*It was a small challenge*			*It was a big challenge*
0	1	2	3	4
☐	☐	☐	☐	☐

Our team experienced a situation which triggered emotions where…

5. People in our team did not connect very well with one another.

For example - we found it very difficult to create a team atmosphere

It did not happen	*It was a small challenge*			*It was a big challenge*
0	1	2	3	4
☐	☐	☐	☐	☐

Our team experienced a situation which triggered emotions where…

6. **People had very different standards of work.**

For example - they said they could not find the information
- the quality of their work was unacceptable

It did not happen	*It was a small challenge*			*It was a big challenge*
0	1	2	3	4
☐	☐	☐	☐	☐

Our team experienced a situation which triggered emotions where…

7. **Team members were not equal.**

For example - Some tended to dominate, trying to impose their ideas, while others' didn't get a chance to contribute
- Some people's opinions were not taken into account

It did not happen	*It was a small challenge*			*It was a big challenge*
0	1	2	3	4
☐	☐	☐	☐	☐

Our team experienced a situation which triggered emotions where…

8. Some people were easily distracted.

For example - they were interrupted by committee organizers easily
- they couldn't do two things at the same time (eat and work)

It did not happen	*It was a small challenge*			*It was a big challenge*
0	1	2	3	4
☐	☐	☐	☐	☐

Our team experienced a situation which triggered emotions where…

9. Our ideas about what we should do were not the same.

For example - One/some people had strong opinions of how we should proceed but others thought they were wrong.

It did not happen	*It was a small challenge*			*It was a big challenge*
0	1	2	3	4
☐	☐	☐	☐	☐

Our team experienced a situation which triggered emotions where…

10. We differed in our understanding of the concepts/task.

For example - we were sometimes talking about different things even though we used the same words
- we had problems agreeing on what content to cover
- our views were very different

It did not happen	*It was a small challenge*			*It was a big challenge*
0	1	2	3	4
☐	☐	☐	☐	☐

******

a. *Did any of the above challenges (1 to 10) weaken your <u>trust to your team members</u>?*

(Please indicate by number) .....

b. Did any of the challenges weaken your <u>common understanding of team tasks and member roles</u>?

(Please indicate by number) .....

D. Trust Questionnaire

(Adapted from Costa & Andersen, 2011)

Item	Team Trust Level						
	Completely Disagree			Agree			Completely Agree
	1	2	3	4	5	6	7
1. My team members do not hesitate to help each other if they can	○	○	○	○	○	○	○
2. We speak out for what we believe is a good strategy	○	○	○	○	○	○	○
3. We stand behind our opinions	○	○	○	○	○	○	○
4. We are sincerely concerned about challenges any of us faces	○	○	○	○	○	○	○
5. We act as much as helpful to each other when needed	○	○	○	○	○	○	○
6. We usually tell each other the truth, even if we know were better off by lying	○	○	○	○	○	○	○
7. We can rely on one another	○	○	○	○	○	○	○
8. We have complete confidence in each other`s ability to perform tasks	○	○	○	○	○	○	○
9. We do as we have promised	○	○	○	○	○	○	○
10. Some of us have often tried to get out of previous commitments	○	○	○	○	○	○	○
11. We try to address each other`s interests as much as possible	○	○	○	○	○	○	○
12. We work in a climate of cooperation	○	○	○	○	○	○	○
13. We discuss with issues and problems openly	○	○	○	○	○	○	○
14. While taking a decision, we take each other`s opinions into consideration	○	○	○	○	○	○	○
15. Some of us have tried to hold back relevant information	○	○	○	○	○	○	○
16. We have minimized what we tell each other about our personal life	○	○	○	○	○	○	○
17. We are mostly open to advice and help from others	○	○	○	○	○	○	○
18. In our team people watch each other very closely	○	○	○	○	○	○	○
19. Our team keeps checking whether we have kept our promises	○	○	○	○	○	○	○
20. Most of us have tended to keep each other`s work under surveillance	○	○	○	○	○	○	○

Shared Mental Models
(Adapted from Johnson et al., 2007)

Please read the items below and rate how much you agree this item is true in your team:

Item	Intensity of Shared Mental Models				
	Strongly Agree		Moderately Agree		Strongly Disagree
	5	4	3	2	1
1. My team have general ideas of how to proceed	○	○	○	○	○
2. My teammates do what they are assigned to do	○	○	○	○	○
3. My team knows how they are going to consolidate members' contributions	○	○	○	○	○
4. My team looks for different interpretations of a problem when seeking a solution to various task issues	○	○	○	○	○
5. My team evaluates their limitations while performing their project	○	○	○	○	○
6. My team has a shared goal for various project tasks	○	○	○	○	○
7. My team discusses its goal and attains the agreement of teammates	○	○	○	○	○
8. My team knows specific strategies for completing their various tasks	○	○	○	○	○
9. My team knows the general process involved in conducting a given task	○	○	○	○	○
10. My team understands that they have the skills necessary for doing various tasks	○	○	○	○	○
11. My team communicates effectively with other teammates while performing tasks	○	○	○	○	○
12. My team supports personal and team-level skill improvement	○	○	○	○	○
13. My team defines its communication style at the beginning of their work	○	○	○	○	○
14. My team uses a common vocabulary in task discussions	○	○	○	○	○
15. My team members effectively listen to each other's suggestions	○	○	○	○	○
16. My team understands their roles and responsibilities for doing various team tasks	○	○	○	○	○
17. My team understands where/from whom they can get information for doing their tasks	○	○	○	○	○
18. My team understands their interaction patterns	○	○	○	○	○

19. My team informs each other about different work issues	○	○	○	○	○
20. My team is likely to make a decision together	○	○	○	○	○
21. My team can flexibly adapt to any role within the team for carrying out various team tasks	○	○	○	○	○
22. My team undertakes interdependent tasks	○	○	○	○	○
23. My team understands how they can exchange information for doing various team tasks	○	○	○	○	○
24. My team solves problems that occur while doing various team tasks	○	○	○	○	○
25. My team acknowledges and rewards behaviors that contribute to an open team climate	○	○	○	○	○
26. My team encourages each other's work in order to improve outcomes	○	○	○	○	○
27. My team is committed to the team goal	○	○	○	○	○

E. Socially-Shared Emotion Regulation

(Developped based on the AIRE instrument; Järvenoja et al., 2013)

In light of the challenges you dealt, did you or your team do any of following in order to deal with your experienced emotions and re-engage in building common knowledge of team tasks and member roles or mutual trust? Please indicate and rate.

Shared Emotion Regulation Strategies	**T/ K** (TRUST or Knowledge)	Didn't happen 1	2	Sometimes Happened 3	4	Happened a lot 5
1. We understood that we have to reconcile our goals closer to one another.		○	○	○	○	○
2. We decided that we had to work out the situation together in order to carry on working.		○	○	○	○	○
3. We considered each other's feelings when criticizing each other's work.		○	○	○	○	○
4. To resolve conflict we needed to keep open-minded and learn from one another.		○	○	○	○	○
5. We reminded each other that our discussions should be friendly and polite.		○	○	○	○	○
6. We incorporated everyone's ideas.		○	○	○	○	○
7. By not making a mountain out of a molehill we continued on our work.		○	○	○	○	○
8. We reminded ourselves that frustration wouldn't help solve our problem.		○	○	○	○	○
9. When conflict arose, we talked it out and/or shared our feelings.		○	○	○	○	○
10. We told each other to take arguments positively and not personally.		○	○	○	○	○
11. When challenges arose we discussed off-task topics.		○	○	○	○	○
12. When someone didn't do their share of the work, more competent team members put more effort.		○	○	○	○	○

13. We focused more on accomplished tasks rather than uncompleted tasks.		○	○	○	○	○
14. We reassured ourselves that we will do the best we can do.		○	○	○	○	○
15. We optimistically justified that external constraints were the cause of a member's shortcomings not his/her irresponsibility.		○	○	○	○	○
16. We told ourselves that winning isn't as important as learning.		○	○	○	○	○
17. After finding causes of our team shortcomings, we set rules to reach our top goals.		○	○	○	○	○
18. We sought help from mentors to possibly overcome our weaknesses.		○	○	○	○	○
19. We focused on our competing teams' shortcomings to relieve ourselves.		○	○	○	○	○
20. We took a break and went away to eat.		○	○	○	○	○
21. We didn't manage our team challenges well.		○	○	○	○	○

4.2. Is there anything else that you or the team did to address challenges you faced?

……

……

Appendix D

Interview Questions

[Set 1]

1. Who was the team leader?

2. What was the hardest part in team coordination?

[Set 2]:

3. Let's see...these are the challenges you reported [refer to challenges]: Ok, which was a bit frustrating?

4. The challenge that you identified here [point to challenge questionnaire]: How does this challenge impact your (a) performance, (b) your trust to each other, or (c) the team's shared understanding of the task? What was its influence on the team environment? Can you elaborate on it?

5. Were there any instances where you thought that you don't have a common understanding of the task, together as a team? And whether you got confused about you're next steps?

[Set 3]:

6. If you had any emotions which weren't really as you wanted them to be, could you manage your emotions? Can you elaborate how?

6. How do you feel now that you have submitted your project?

7. Is there anything you want to add about your experience?