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Emotion regulation in teamwork during a challenging hackathon: Comparison of best and worst teams

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Abstract

Research has demonstrated the power of emotion regulation in managing challenges students face in different learning contexts. However, emotion research in team-learning where challenges become more evident is yet in its infancy. The current study examines case studies of two teams (high and low performing) in a hackathon where the task involved building a novel computer program to demonstrate a physics phenomenon; and explores how shared emotion regulation impacts teamwork and the types of challenges teams face (e.g., different goals/priorities; unreliable members; emotional imbalance; being off track, inefficient communication). Using a mixed-methods approach, we analyze team interactions in terms of emotion regulation strategies student teams apply and the challenge types/levels they encounter. Comparative excerpts as well as descriptive statistics based on video data of student interactions, interview inputs, and responses to several questionnaires are provided to show differences among the cases. The team with higher shared emotional regulation mainly had external challenges that were less frustrating and demanding than relational challenges, while the team with lower shared regulation had internal challenges as well as external challenges and thus performed poorly. Our findings showed that when team members apply shared emotion regulation strategies, they build a cohesive atmosphere and synergistic team relationships that enable them to contribute to the overall team goals. This study also has implications for assisting educational teams in challenging environments. We hope that our paper will generate new ways of understanding and seeing shared emotion regulation in team settings.

Keywords Hackathons · Computer programming competitions · Emotion regulation · Collaborative learning · Teamwork · Socially shared emotion regulation

This article is based on a doctoral dissertation (Kazemitabar, 2019) conducted by the first author at McGill University. Accessible via: https://www.proquest.com/docview/2515016557.

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Introduction

Teamwork has become essential in all facets of life, even post-pandemic across various domains and contexts (O'Neill & Salas, 2018). Indeed, teamwork is an important competency (Planas-Lladó et al., 2020) with research suggesting its positive association with advanced productivity and enhanced performance (McEwan, Ruissen, Eys, Zumbo, & Beauchamp, 2017; Schmutz, Meier, & Manser, 2019). Past research has shown that coordination is crucial for teamwork (Salas et al., 2005), yet, both research and anecdotal evidence have highlighted that successful team coordination can be difficult to achieve.

Empirical literature has shown that collaborative learning teams face challenges and conflicts that may hinder their coordinating attempts and decrease team performance and overall learning gains (Järvelä et al., 2010). Unproductive conflict decreases learner satisfaction, raises negative emotions within the team, and interferes with effective team working. Thus, unresolved challenges within teams lead to team emotional imbalance, which could lead to losing opportunities, missing deadlines, and providing low-quality results (Isohätälä, J., Järvenoja, H., & Järvelä, S. 2017).

In examining the prerequisites to effective team coordination, we note the role of socially shared emotion regulation (SSER; Järvelä & Hadwin, 2013) in the management of challenges that hinder the development of coordination mechanisms in teams. SSER encompasses shared and interactive regulatory processes that team members can apply to manage shared challenges together (Ujitani & Volet, 2008). In collaborative learning, Järvenoja et al. (2020) argue that "a substantial portion of the challenges learners face is related to cognitive hurdles that have socioemotional and motivational origins" (p. 2). Thus, and in order to deal with team challenges, team members need to apply effective interpersonal skills such as SSER (Gross, 2002; Järvenoja & Järvelä, 2009; Järvenoja et al., 2013; Thompson & Fine, 1999; Ujitani & Volet, 2008). However, until today, scarce empirical investigations have examined consequences of student teams' SSER decisions and efforts on team coordination within socio-emotionally challenging academic settings.

In examining this relationship, we used a unique research context. A challenging hackathon was purposefully selected as an authentic collaborative context, presenting an emotionally tense atmosphere, perfect for addressing the research objectives. Hackathons or programming competitions, are "time-bounded events where participants gather in teams to develop projects that interest them" (p. 50, Angarita & Nolte, 2020). By their nature (Falk Olesen & Halskov, 2020), hackathons require teamwork and rely on effective communication skills, highly convergent shared mental models, and mutual trust levels (Salas et al., 2005) for participants to tackle problems together and accomplish their goals and complete projects. However, although hackathons provide an innovative and exciting way to engage students to learn collaboratively (Mtsweni & Abdullah, 2015), to date negligible empirical research has analyzed the richness of such contexts in addressing collaborative research.

Purpose of the study

This paper aims to uncover the power of SSER in managing challenges that occur in complex teamwork—which refers to teamwork settings where problems and difficulties are likely to arise (Carroll et al., 2006). This study addresses the following overarching research question: What is the role of SSER in team challenges? The current paper focuses on two extreme cases (i.e., the best and worst teams) to shed light on the role of SSER in team challenges. Thus, two extreme cases were chosen for case analysis, a losing team that faced multiple challenges and a winning team that faced few challenges. Our intention was to explore whether SSER had any impact on how these two teams performed.

Literature review

Effective team performance requires team members to hold shared understanding of the team missions, role responsibilities, available resources, and appropriate procedures (Denzau & North, 1994; Mathieu, Heffner, Goodwin, Salas, & Cannon-Bowers, 2000). At the same time, despite the benefits of coordinated teamwork, we know that successful coordination does not always occur. This necessitates the need to examine the prerequisites for effective coordination. Extant research (e.g., Panadero et al., 2015) has highlighted 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). Research has also highlighted the role of emotions in influencing coordinating strategies such as shared mental models and mutual trust within learning teams (e.g., Panadero & Järvellä, 2015). Along with understanding team challenges, team members also need to develop and apply effective regulatory strategies to manage such challenges.

To sum, from the literature, we know that emotion regulation in the social context is crucial. Specifically, positive emotions can motivate team members toward higher team coordination and team performance, and conversely more negative emotions can have a converse effect (Rafaeli & Cheshin, 2009).

Socially shared emotion regulation in teams

In the social context, emotion regulation ranges over a continuum: (1) self-regulation of emotions (ER); (2) co-regulation of emotions (Co-ER); and (3) socially shared emotion regulation (SSER). We have developed a graphical model comparing the three types of emotion regulation (Fig. 1). In this figure, the left model represents an individual regulating their own emotions (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). Moving on to the middle, this model represents co-regulation of emotions, that is, an

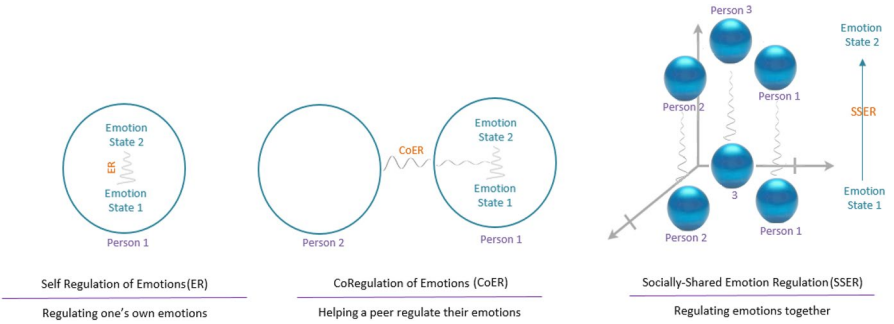

Fig. 1 A model of three emotion regulation mechanisms present in teams (respectively ER, Co-ER, and SSER from left to right)

individual helping another regulate their emotions (otherwise known as *extrinsic* emotion regulation; Gross, 2008); e.g., "I reassured him that he was almost there" (Järvenoja et al., 2013, p. 57). The remaining right part of the model represents socially shared emotion regulation (SSER), that is, 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). An example of SSER is: "We accepted that different members have different goals, and we need to organize our work according to that" (Järvenoja et al., 2013, p. 57). Whereas each form of regulation focuses on a different target (self, others, and the team), these regulatory processes are interdependent and can coexist simultaneously (Grau & Whitebread, 2012).

There is a dearth of work on the link between SSER and the development of shared mental models in learning teams. The effect of SSER on managing emergent conflicts within teams to sustain the development of shared mental models (SMMs) is depicted in Fig. 2.

Antecedents to conflict are many (e.g., Brett et al., 2014; Gelfand et al., 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 Fig. 3).

From the literature, we note the saliency 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.

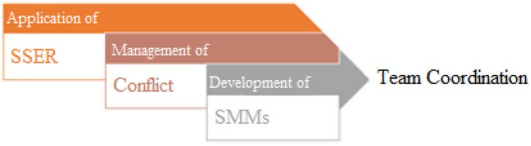

Fig. 2 The indirect relation between SSER and the development of shared mental models in the literature

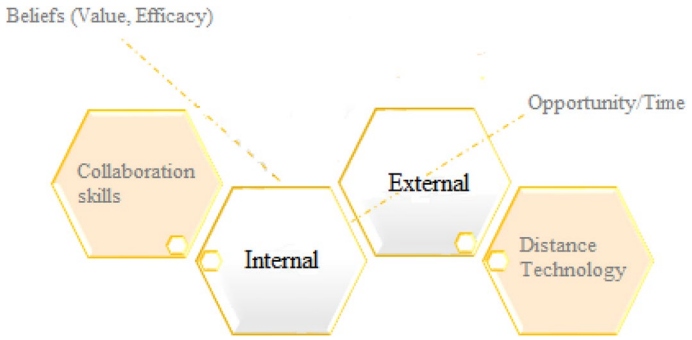

Fig. 3 Factors that contribute to conflict within a team

Methods

Participants

As mentioned earlier, the data for the present study were gathered at a hackathon. This hackathon was a 2-day Physics programming competition organized by a North American university's Physics department. In advance of the hackathon, participants were introduced to the present study via emails sent by the organizers of the hackathon. In addition, during the introductory session of the hackathon, the principal investigator of the research informed potential participants about the study through a presentation. There were 59 participants in the hackathon from which 53 students volunteered to participate in the study. From this sample, five participants had to be excluded: 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. Therefore, the final sample of the study included 48 participants (71% male, mean age = 22 years, SD = 3.28). The study participants were undergraduate or graduate students; with backgrounds in Physics (42%), software engineering and computer science (19%), and electrical, mechanical, and civil engineering fields (31%). Student participants' average GPA was 3.87/4.3 (SD = 1.18) and their ethnicity was 31% Asian, 21% Middle Eastern, and 48% Caucasian. The study was approved by the institutional review board of the principal investigator's university. All student participants signed the consent form. and were eligible to win one of the ten $40 gift cards on top of the hackathon awards due to participating in the study.

Team formation

The participants were offered the choice to form their own teams using an online platform in advance of the event. There were 16 teams of 2 to 5 participants (see Table 1 for basic team information). Teams included students of different expertise backgrounds (programmer, physicist or a designer) and programming levels (novice,

Table 1 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-labeled 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

intermediate, expert). Teams were given the liberty to select the roles of each team member.

Task

The task involved building a novel computer program to demonstrate a physics phenomenon of their choice artistically. To inspire creativity, project guidelines offered minimal rules. However, to scaffold struggling teams, the organizing committee had prepared several ideas in advance (including Kinematics, Metaphysics, nuclear

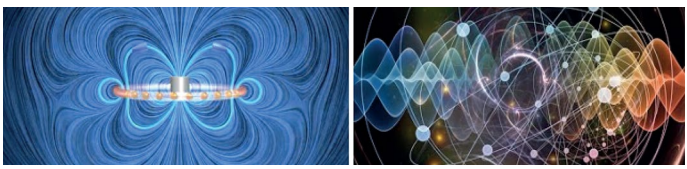

Fig. 4 Examples of physics project ideas that students could choose to program artistically

magnetic resonance, Quantum theory, etc.) (see Fig. 4 as some examples of physics phenomena).

Mentors, judges, and judging criteria

Mentors were available in the venue and online via a private platform named Slack chatroom where student participants could interact with mentors (computer science graduate students) in the venue and through a private Slack chatroom for support on programming issues.

At the end of the competition, teams were ranked by a team of four expert judges: a physics professor, a Microsoft technologist, a Nexalogy technologist, and a Lenovo salesman. A holistic coding scheme was used to rank the team projects: (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). Prizes were given to the top three teams. The judging criteria focused on the team project not the performance of the members. Therefore, winners picked by the judges were not necessarily high performing teams (i.e., consisted of only one expert member who worked on most of the project solely), and teams with high performance (very novice in terms of reaching the targets set by the judges) did not necessarily win.

Context

The event included two spaces: (1) a hall with twenty "team pods" where team members were stationed with laptops and (2) a dome with 360 degrees projection where presenters could project their work to the audience (Fig. 5).

Schedule of the event

During the opening ceremony, the investigator of the current study briefly introduced the research and explained what participation in the study would entail. The programming competition officially started at 12:00 pm on Day 1 and continued until 12:00 P.M. on Day 2 for a consecutive 24-h period. At the conclusion of day two, each team presented their project to the judges. The judges rated teams based on the judging criteria and selected three teams as winners during the awards ceremony. 10 study participants were also randomly chosen for study gift cards.

Procedure of data gathering

Setup

During the event, cameras were placed beside team pods, and audio recorders were placed on tables (where all members had provided consent for audio/video

Fig. 5 Location of the event: the hack hall (left upper image), a team pod (right upper image), and the presentation dome (two lower images)

recording). Video recorders captured who was talking with whom and students' postural behavior while working in their team, and audio recorders captured team dialog.

Data

The following 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. Because of limited audio and video equipment, in-session team interaction data were only recorded from some of the teams. Based on what teams reported in the questionnaires, teams of interest (reporting stronger positive or negative emotions, and fewer/more challenges) were identified and were later purposefully recorded (Teams 3, 7, 8, 9, 14, and 16). Team selection was also approved by the hackathon mentors and director.

Data collection timeline

Time points for data collection included: beginning, midpoint, directly before submitting projects, and directly after submitting projects (see Fig. 6).

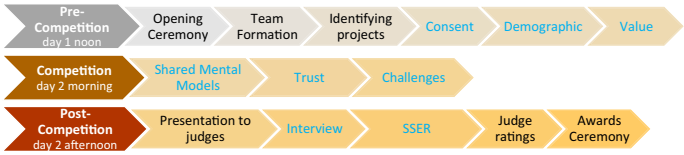

Fig. 6 Data collection schedule pre-, during, and post-competition (blue wordings represent data collection steps, whereas black wordings represent hackathon events)

Data used in the present study

Codebooks were 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). We coded student interactions based on video data and interview inputs. Interview transcriptions, as well as team interaction transcriptions, were coded from the perspective of socially shared emotion regulation (SSER). We also examined individual inputs reporting their general demographic information and responses to several questionnaires:

Challenges Questionnaire, including 10 items from the AIRE instrument (Järvenoja et al., 2013; e.g., "Our goals for the competition were difference") measured using a scale from 0 (it did not happen) to 4 (it was a big challenge).

SSER (a comprehensive list of strategies adapted from Järvenoja et al., 2013) including 5 subcategories (SSER1: Situation Selection, SSER2: Situation Modification, SSER3: Attention Deployment, SSER4: Cognitive Change, and SSER5: Response Modulation), e.g., "We considered each other's feelings when criticizing each other's work." Sample items are presented in Appendix A. See Kazemitabar, Lajoie, and Doleck (2022) for a complete list of strategies.

Analyses and findings

A multiple case study analysis of two teams is presented that provides an 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) and a winning team that faced few challenges (Team 8).

Comparative excerpts as well as descriptive statistics are provided to show differences among the cases. 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. In regard to challenges encountered, the following classification of challenges was provided by Kazemitabar et al. (2022): Different goals/priorities; Unreliable members; Emotional

imbalance; Negative attitudes; Low SMMs; Being off track; Being idealistic; Low self-efficacy; Being biased; Incompatible working styles; Dominating; Inefficient communication; Unequal contributions; Low team cohesion; High task difficulty; Limited time.

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 is 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, and one (pseudo-named Daniel) 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.

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, Daniel 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 Daniel 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".

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".

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 for.

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 are 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 2. 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.

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

Table 2 Team 7 data (number of SSER strategies and number of challenges)

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

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

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!"

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."

They created a positive team atmosphere and encouraged themselves with every little success. This preventive SSER strategy was very helpful for them in progressing toward 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!"

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	8B: You are a true king!
[All laughing]	
8A	8A: It's perfect
8B	8B: it's beautiful! [Laughing]

Their project, the magnetic pendulum simulator, won first prize and they all reported having a very enjoyable teamwork experience in their interviews. Figure 7 provides a snapshot of the magnetic pendulum simulation.

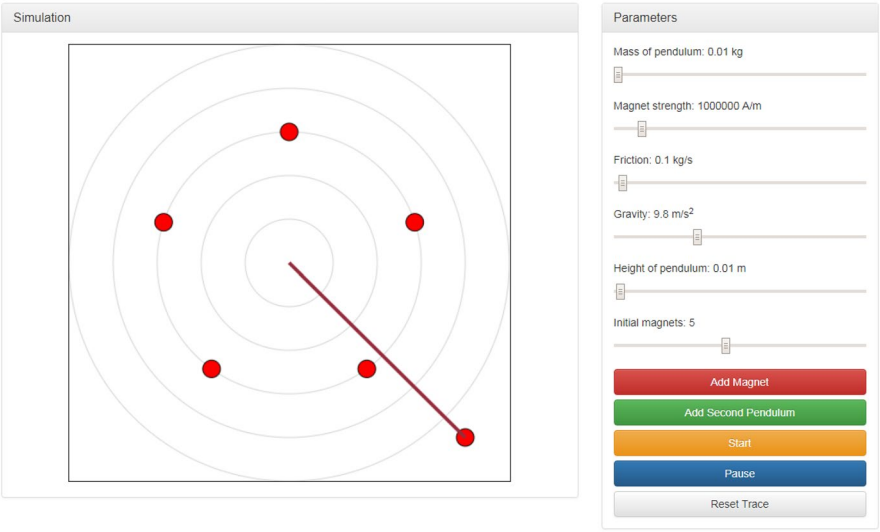

Fig. 7 The winning project: Magnetic Pendulum Simulator, copied with permission

Table 3 Team 8 data (number of SSER strategies and number of challenges)

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

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

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 3.

To compare the high vs. low performing team, data from Tables 2 and 3 are aggregated into Table 4. As can be seen, the high performing team (team 8) reported more SSER strategies and less challenges than the low performing team (team 7). Chi-square analyses revealed that the values are significantly different: $X(4) = 6.0$ $p = 0.199$ indicating that the high performers had a significantly higher value of SSER vs. Challenges ratio compared to the low performers.

Discussion

Comparison between a low and a high performing team: A case study approach

We found performance differences between a high and a low performing team in terms of challenges they experienced: the low performing teams had high percentages of internal challenges. In particular, they experienced (a) different working styles;

Table 4 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[a]	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

[a]Proportions indicate the SSER to challenge ratios for each team

(b) unequal contributions; and (c) low shared mental models which led to low team cohesion and labeling each other as unreliable. 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 teams 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-others' contributions with strong welcoming words, downgraded from idealistic ideas in a timely manner, and apologized when they realized they had made mistakes.

Figure 8 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.

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, develop shared understandings of the procedures and tasks, and progress toward reaching team goals.

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

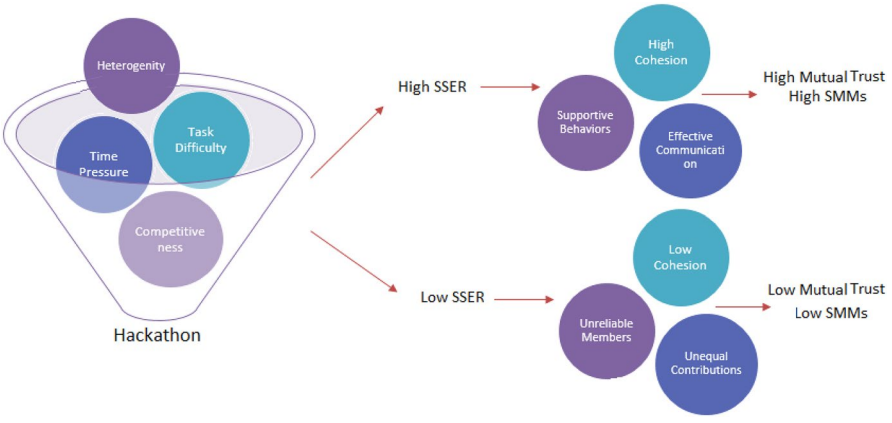

Fig. 8 The hackathon presents some external challenges (see funnel) but teams can use SSER to overcome challenges (upper right circles) or they may not use SSER to their benefit since they have not addressed internal challenges (lower right circles)

encountering such challenges, and 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 teams adaptively manage challenging situations that require collaborative work.

Limitations and future directions

The present study is not without limitations. The limitations provide several directions for future research. The sample size in the present study is a concern, yet we note that this authentic context, that is, a hackathon, provided us a lens into how teams meet challenges and how SSER can lead to better shared mental models, mutual trust, and better team performance. Future work can consider working with larger number of study participants. Our work was constrained to the analysis of verbal data and questionnaires and partial nonverbal behaviors of team interactions. Future work could investigate ways to improve data collection by considering a broader range of nonverbal behavior. Another point is that 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. Another limitation concerns participants' self-reports. There are also opportunities for further work in relation to data collection methods. For example, consider 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. Finally, it would be interesting to consider new alternate forms of hackathons, such as virtual hackathons (Wang, Yeoh, Ren, & Lee, 2021). The COVID-19 pandemic has accelerated the trend of the rise of virtual hackathons. As such, future work in this space warrants attention.

Concluding remarks

Given the lack of insights in examining the nature of team experiences during a hackathon, a case study of two extreme teams (a winning and a losing team) was conducted. 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 labeling 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. 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 and the relationship that emotion

regulation plays when inevitable challenges occur during teamwork. In sum, the present study contributes to the nascent research examining emotions in team-learning where challenges become more evident.

Appendix A

Socially shared emotion regulation (Developed 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				

Data availability Data are available on request due to privacy or other restrictions.

Declarations

Conflict of interest The authors have no relevant financial or nonfinancial interests to disclose. This article is based on a doctoral dissertation (Kazemitabar, 2019) conducted by the first author at McGill University.

Ethics statement The study was approved by the institution's Research Ethics Board.

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