Role of Socio-Emotional Interactions on Mutual Trust and Shared Mental Models in a Case Study of Programming Teams

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Abstract: This exploratory study examines international physics teams that competed in a two-day challenging hackathon (computer programming competition). Through case study analysis of three representative teams, we examined team interactions in terms of socio-emotional interactions, trust and shared mental models (SMMs). High and low performing teams were identified based on number of social challenges experienced by the team. Challenges and goals were measured using a modified version of AIRE (Järvenoja, Volet, & Järvelä, 2013). Using a mixed methods exploratory approach, preliminary results showed that teams whose members (a) interacted with more positive social-emotional interactions (b) reported more team-oriented goals, and (c) had prior familiarity with each other, reached higher levels of mutual trust and shared mental models. Specifically, findings highlight the role of socio-emotional interactions in enhancing mutual trust and shared mental models, and have implications for teams composed of learners with heterogeneous expertise in CSCL environments.

Objectives and significance

Physics teams were examined in the context of a challenging computer-supported hackathon. A hackathon is defined as a programming competition where several programming teams compete to program an innovative idea (i.e., a physics phenomenon in this study) within a specific timeline. Although emerging rapidly into the educational domain, such a CSCL context is less studied both empirically and theoretically. In the context of this study, teams were examined to see types of challenges they faced during their interactions, and whether positive socio-emotional interactions helped them overcome the challenges, build mutual trust and regain strong bonds of shared mental models between members.

Theoretical framework

Collaborative team-based learning situations are powerful learning experiences, but may face potential challenges, such as different levels of expertise, engagement and commitment (Järvenoja et al., 2013), especially if they are from heterogeneous backgrounds. Previous literature has shown that such challenges can hamper (a) mutual trust, and (b) shared mental models (SMMs) between team members, two mechanisms that are significant for team effectiveness (Salas, Burke & Sims, 2005). Mutual trust is defined as the "shared belief that team members will perform their tasks and protect the interests of other team members" (Salas et al., 2005, p. 561), and SMMs refer to "knowledge structures held commonly 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 the demands of the task and other team members" (Cannon-Bowers et al., 1993, p. 228).

Dealing with the possible challenges that emerge in team tasks requires applying effective interpersonal skills. Previous research has found co-regulation, metacognition and socio-emotional interactions as factors of effective collaboration (Lajoie et al., 2015). For the purpose of this paper we examine socio-emotional interactions experienced in teams with the goal of identifying whether positive interactions lead to fewer challenges, more trust and higher SMM bonds in this complex, competitive, and time-limited social learning context (i.e., hackathon). Our premise is that positive socio-emotional interactions can mitigate challenging team moments and help maintain high levels of SMMs and mutual trust between team members. Furthermore, teams who possess individuals with more team-oriented goals than individual-based goals create a stronger team atmosphere and work collaboratively with a higher sense of unity. Thus, based on these factors we hypothesize that teams with more positive socio-emotional strategies and team-oriented goals will have less team challenges (or deal with challenges more effectively), high levels of mutual trust and stronger SMMs between team members, hence leading to enhanced team effectiveness.

Methods

Participants

17 international teams of 2, 3, 4, or 5 participants (N= 48 students; Average age= 22 years; 73% male) invited from around the globe participated in a two-day Physics Programming competition held in a North American University. Students ranged in expertise from Software Engineering to Math and Physics, and teams were composed of members with varied levels of programming expertise. Teams were formed based on students' individual interests and were then asked to collaboratively build a novel computer program that could demonstrate a physics phenomenon of their choice artistically. Teams were audio and video recorded at different time points during the competition (i.e., beginning, midpoint, and before submitting their projects). Individuals were asked to report general demographic information and fill in several questionnaires based on the AIRE instrument (Järvenoja, Volet, & Järvelä, 2013), an instrument designed to capture the nature of socio-emotional regulation processes that students employ during collaborative learning. AIRE was used to capture students' goals for participating in the hackathon (administered at beginning of competition), as well as the challenges they reported (administered at the end of the competition). Teams were judged and ranked by a group of expert judges at the end of the competition, and winners were awarded valuable prizes.

Design

A case study analysis of three representative teams was conducted using a mixed methods approach to analyze factors of team effectiveness during the physics competition. These teams represented teams who: (a) ranked high (in terms of team productivity), reported low levels of challenges (representative team labelled *Team A*), (b) ranked high, reported high levels of challenges (representative team labelled *Team A*), and, (c) ranked low, reported high level of challenges (representative team labelled *Team C*). Each of these teams were composed of three multicultural international members.

Data analysis

Audio and video data were transcribed verbatim. Two raters segmented, and coded the transcriptions based on socio-emotional interaction codes (derived from Garrisson, Andeson & Archer, 2001) including affective, intearctive and cohesive social presence (see Table 1 for some examples) to identify levels of socio-emotional interaction competency in students' teamwork. Pearson's percentage of agreement was calculated as 74%. Apart from demographic data, answers to the goal questionanire derived from the AIRE instrument, Trust questionnaire (Costa & Anderson, 2011) and SMMs questionnaire (Johnson et al., 2007) were also analyzed quantitatively.

Table 1: Examples of socio-emotional codes (refer to Lajoie et al., 2015 for the complete codebook)

Valence	Social Presence	Subcategories	Descriptions
Positive Socio-Emotional Interactions [P]	1. Affective Social Presence	1.1. Use of humor	Explaining in funny sentences to provide laughter
		1.2. Mutual Respect	Showing respect or polite disagreement
		1.3. Interpersonal sensitivity	Showing caring and understanding
	2. Interactive Social Presence	2.1. Continuing a thread	Adding to someone else's discussion
		2.2. Expressing appreciation, encouraging contributions	Attempting to encourage the sustained involvement and contributions of other group members.
	3. Cohesive Social Presence	3.1. Using inclusive pronouns	Addressing or referring to the group using plural pronouns; e.g. we, our, us.
		3.2. Phatic, Salutations	Greetings / general utterances in social interactions
Negative Socio-Emotional Interactions [N]	Internal	1. Negative criticism	Undermining a group members' task by negatively criticizing their work
		2. Discouraging others' participation	Not assigning tasks to someone, ignoring one's participation
		3. Passive listening	Not listening actively, showing distractive behaviors.
	External	4. Task difficulty (technological issues)	Task difficulty posing stress on the team.

Results

Although teams were ranked on their programming outcomes rather than their collaboration skills, we found effective collaboration was associated with fewer team-based challenges. Thus we refer to an effective team as a team with less team-based challenges. Based on the AIRE instrument, low number of challenges were encountered in Team A but high frequency of challenges in team B and C. Table 2 demonstrates team differences in terms of challenges encountered.

Table 2: Heat map of challenges reported by students in each team (derived from the AIRE instrument). Darker cells indicate more occurrences of challenges

	Team 1 participants			Team 2 participants				Team 3 participants			
1. Our goals for the competition were different.	1	1	0	0	3	2	3	4	4	2	3
2. We had different priorities.	2	0	0	0	3	2	3	4	3	3	3
3. We seemed to have incompatible styles of working.	1	0	1	1	2	1	2	4	3	3	2
4. We seemed to have different styles of interacting.	1	0	0	0	1	1	3	2	2	1	2
5. People in our team did not connect very well with one another.	0	0	0	0	1	2	2	2	2	2	1
6. People had very different standards of work.	2	1	1	1	1	3	0	2	3	3	2
7. Team members were not equal.	0	0	0	1	3	1	2	0	4	4	1
8. Some people were easily distracted.	2	2	0	1	2	2	2	3	4	0	2
9. Our ideas about what we should do were not the same.	3	1	0	0	2	3	3	4	4	4	2
10. We differed in our understanding of the concepts/task.	2	1	1	0	2	1	2	4	4	4	2

The transcripts and AIRE data indicate differences in effective collaboration. Team A and B showed high positive and low negative socio-emotional interactions, whereas Team C showed low positive and high negative socio-emotional interactions. An analysis of the AIRE goal statements demonstrated that team-oriented goals were more prevalent for team A and B than C. Excerpts of socio-emotional interactions, and examples of goals for each team are presented in Table 3. One antecedent to Team A's productive collaboration is that they had past experience working together which increased the speed at which trust was established. High levels of trust enabled them to direct their attention rapidly towards the main task from the beginning hours of the competition.

Table 3: Excerpts indicating coded positive/negative socio-emotional interactions within team interactions

Examples of Reported goals	Prior Familiarity	Excerpts demonstrating social –emotional interactions	Ranking
Not let my team down (team-based) Win first place (team-based)	Team members knew each other from before	But the radius of the circle is exactly this [N3] -Oh yeah you're right [P2], my apologies [P1], Okay now I understand your equation [P2] -Does it work? [P2] -See when I click on it, it tells me which bracket [P2] -Yess! [P2] And if you click outside? [P2] -You are a true king! [P1] -it's beautiful! Hahaa!! [P1][P2]	Team A (Winner) **High** positive socio-emotional interactions
Not let my team down (team-based) Learn as much as possible (individual-based)	No prior familiarity	- Our angular momentum is still off a bit. [P2] - It has to be to the power of 12, yeah? [P2] - Well, our eccentricity should be 0.05 [P2] - What's that range in the bottom? [P2] - Hold on a second, I'm just going to do this [P2] - Our eccentricity, there you go! [P2] - I just solved the memory leak! [P2]	Team B (Winner) **High** positive socio-emotional interactions
Make sure all members contribute equally (individual-based) Have a good time and enjoy the experience (individual-based)	No prior familiarity	-Why didn't we do that earlier? [P2] -No, you don't understand [N3] we have that! [P2] -Okay where do we insert it? [P2] -Oh my goodness! [N3] it's in the description!! [N1] Girl continues to text in Facebook without involving herself much in the project. [N4][N2]	Team C (Loser) **Low** positive socio-emotional interactions

Teams A and B who demonstrated high positive socio-emotional interactions, had more strong levels of trust and SMMs, whereas team C who had lower levels of positive socio-emotional interactions revealed weaker trust and less strong SMM bonds (refer to Tables 4 and 5 respectively).

Table 4: Sample items for measuring trust in team members (dark cells indicate high levels of distrust)

	Team a			Team b			Team c		
9. We do as we have promised	7	6	7	6	5	7	3	5	7
10. Some of us have often tried to get out of previous commitments	1	1	3	2	2	6	7	6	7
11. We try to address each other`s interests as much as possible	6	6	6	6	5	7	7	5	4
12. We work in a climate of cooperation	7	7	7	6	4	6	7	7	4
13. We discuss with issues and problems openly	7	7	7	7	4	6	7	6	4
14. While taking a decision, we take each other`s opinions into conside	7	7	7	6	3	7	7	6	5
15. Some of us have tried to hold back relevant information	1	1	1	1	2	5	4	6	4
16. We have minimized what we tell each other about our personal life	3	2	5	1	1	5	7	6	7

Table 5: Sample items for SMMs between team members (dark cells indicate low levels of SMMs)

	Team a			Team b			Team c		
7. My team discusses its goal and attains the agreement of teammates	5	4	5	5	4	5	5	5	2
8. My team knows specific strategies for completing their various tasks	5	5	5	4	4	5	5	4	3
9. My team knows the general process involved in conducting a given task	4	4	5	4	4	4	5	5	5
10. My team understands that they have the skills necessary for doing various tasks	4	4	5	5	4	5	5	2	3
11. My team communicates effectively with other teammates while performing tasks	4	4	5	3	3	5	1	5	4
12. My team supports personal and team-level skill improvement	5	5	5	4	3	4	5	4	3
13. My team defines its communication style at the beginning of their work	5	5	5	5	4	5	5	5	3
	3	3	5	3	4	5	5	4	3
	4	4	5	4	3	5	2	5	3

Conclusions and implications

As guided by the literature, results of this study revealed that effective team collaboration is based on building positive socio-emotional interactions and also team-oriented goals. Results also showed that prior familiarity with members can lead to higher trust levels. We contend that these factors should be examined simultaneously rather than in isolation; i.e., focusing on only one factor is not sufficient for guaranteeing high or low team effectiveness. However, the relative influence of each of the three afore-mentioned factors should be considered. Our preliminary findings suggest that the role of positive socio-emotional interactions was more significant than the other two factors (team-oriented goals and prior familiarity) in determining team effectiveness. For example, winning team B faced high challenges and had no prior familiarity with each other, but demonstrated high positive socio-emotional interactions, high trust levels and strong SMM bonds. Although effective in describing the three teams and how challenges were mitigated by positive socio-emotional interactions, these findings are not yet generalizable. In a larger examination of all of the teams, we aim to further explore the validity of this and examine the relative power of positive socio-emotional interactions in determining team effectiveness. This study has implications for heterogeneous CSCL teams with different levels of expertise, communication methods or commitment levels; in that such teams need to raise their awareness of the relative power of socio-emotional interactions, and how their interactions can significantly influence the team climate, in a positive or negative direction. Teams can also benefit from seeing whether each member values the task at hand, so that student members can work closely based on their shared goals. Furthermore, ice-breakers can be used to increase familiarity of members who have not worked together prior to the team event and facilitate building trust bonds between each other.

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