Investigating teams' Socially Shared Metacognitive Regulation (SSMR) and transactivity in project-based computer supported collaborative learning environment

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ABSTRACT

In collaborative project-based learning environments, students handle ill-structured challenges and practice socially shared metacognitive regulation (SSMR). Transactivity refers to the degree to which students demonstrate a shared engagement and build on each other's knowledge contributions. Prior research has highlighted the need to investigate SSMR and transactivity systematically. Putting learners in a team and assigning project does not guarantee the success of the collaboration. Collaborating team members may face cognitive and metacognitive issues due to different levels of metacognitive capabilities. To support SSMR and to have teams with a high level of transactivity, we need to understand the shared regulation behavior of team members. Interestingly, the lack of studies in this domain directed us to understand the shared regulation behavior of team members and their transactive interactions. We have conducted two studies which are primarily focusing on qualitative data. To validate and triangulate the claims using another mode of data, we are proposing an additional mode of data i.e. system interaction data. Based on our understanding, further in our research goals, we are proposing a computer-supported learning environment to foster SSMR and a higher level of transactivity. We will try to achieve this through metacognitive prompts as scaffolds for team members. We present the initial work done in this direction and we proposed one additional mode of data. Currently, most of the learning environments are focusing on individual learners, so we are trying to bridge this gap through the proposed system, supporting SSMR & transactivity in a project-based CSCL context. We intend to seek advice on the validity and reliability of our approach to understand SSMR & transactivity and further measure its impact on collaborating teams.

Keywords

Socially shared regulation of learning (SSRL), Socially shared metacognitive regulation (SSMR), Transactivity, CSCL, Project-based learning, open-ended problem, collaborative problem solving (CPS).

1. INTRODUCTION

Computer-supported collaborative learning environments (CSCL) facilitate interactions among learners to acquire knowledge, skills, and attitudes [2, 7, 8]. As learners are coming from diverse socio-cultural backgrounds, they bring diverse goals, approaches, attitudes, and experiences which become an important and dynamic element in collaborative learning environments. Handling the dynamic nature of the team and simultaneously achieving progress in a given task needs many socially shared regulation strategies amongst the collaborating members [6]. While collaborative learning looks attractive for facilitating collective knowledge construction, it's not easy to orchestrate [10]. While working collaboratively on the set of tasks, some cognitive and metacognitive issues may arise due to differences in task and content understanding or different interpretations of the task by different learners [5].

To ensure the success of collaboration, learners must develop a shared mental model and a collective scheme of cognitive interdependence for communication and coordination to derive the high-quality participation of each team member in the shared task [6]. Metacognition plays a vital role in collaboration to make members aware of the challenges and need for regulation. Socially shared metacognitive regulation (SSMR) is an important process in collaborative learning which refers to participants' goal-directed, consensual, egalitarian, and complementary regulation of joint cognitive processes in the collaborative learning context [3, 4]. SSMR ensures the appropriate direction of the groups' cognitive activity using constant monitoring and controlling of the cognitive process.

A recent study illuminates that SSMR has some relation with idea of transactivity which refers to reciprocity and interdependence in the transactions between learning partners and between those partners and the task [1].Transactive discussion refers to a type of verbal interaction in which each learner uses own conversational turn to operate on the reasoning of the partner or to clarify his or her own ideas [12]. The scale of transactivity comprises different social modes of co-construction and represents different degrees of transactivity. On this scale, externalization and quick consensus building is regarded as the least transactive social mode, whereas conflict-oriented consensus building is the most transactive social mode [12].

In the interconnected and interdisciplinary knowledge-driven professional environment, the ability to work collaboratively on ill-structured long-term project goals (e.g Global Goals - https://www.globalgoals.org/) and engaging in socially shared regulated learning throughout the process have become vital skills. In this context, we explore project-based learning for fostering such socially shared regulation of learning (SSRL). Project-based learning pedagogy has six features - (a) learning goals, (b) collaboration, (c) focus question, (d) engagement in scientific practice, (e) scaffolding with learning technology, and (f) creation

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of tangible solutions useful for addressing real-world problems [9]. In project-based learning, learners engage with the problem, learn by doing, discussing, applying ideas and try to solve the problem given to them, which increases learners' engagement and helps them to develop a deeper understanding of important ideas by facilitating them opportunities for problem-solving, decision-making, and explaining their ideas [9].

To ensure success of project-based learning in the CSCL environment, we are focusing on with socially shared regulation for team members while working collaboratively. Team members use cognitive and metacognitive strategies while working, so we have investigated their SSRL & SSMR strategy application and level of transactivity in two studies. Understanding the shared regulation processes is important in order to support their regulation in the context of project-based learning in the CSCL environment. Following are our research goals (RGs)

•RG1: Conduct studies to understand learners' socially shared regulation behavior in project-based CSCL environments.

•RG2: Design and develop a learning environment to foster socially shared metacognitive regulation (SSMR) using metacognitive prompts in a project-based learning context.

•RG3: Measure and validate the impact of metacognitive prompts given in the learning environment to foster SSMR and transactivity in a project-based CSCL

2. RESEARCH PROGRESS

The research progress till now is given in this section. We have explained each research progress with respect to each research goal as follows:

RG 1: Conduct studies to understand learners' socially shared regulation behavior in project-based CSCL environments.

In order to address this research goal, we conducted two research studies as detailed below.

Study 1: The objective of this study was to understand the Socially shared regulation of learning (SSRL) strategy application by teams. In the first study, the differences in application of SSRL strategies were studied for high and low performing teams in project-based learning settings having open-ended problems (tasks). We have found considerable differences in the application of SSRL strategies between high and low-scoring teams, those differences were represented by using quantitative and thematic representations. For analyzing the data, we have used the framework given by [10].

Study 2: The first objective of this study was to understand the socially shared metacognitive regulation (SSMR) which is a subcomponent of SSRL and one type of regulation learners use in SSRL context. The second objective of this study was to understand the relation between SSMR & transactivity. We found a considerable difference in application of SSMR strategies by teams, which highlight some important aspects of the relationship between SSMR and transactivity. Findings about this dynamic relationship are reported through quantitative and thematic representations. To analyze the SSMR strategy, we have used the framework given by [4] and for analyzing the transactivity externalized through verbalized interactions, we have used the frame-work given by [12]. Two Studies were conducted as part of 12 weeks of a graduate-level face-to-face semester-long course having an open-ended problem statement. Participants were divided into teams consisting of 4 members each; each team consisted of Master's, Ph.D., and Bachelor's level learners. The course followed a project-based learning approach and was divided into major milestones leading to the final solution. For each week, learners were given one hour for teaching by an instructor and two hrs for teamwork. At the start of each milestone, each team collectively responded to the OurPlanner tool and at the end of each milestone, each team collectively responded to the OurEvaluator tool. At the end of each milestone, teams were asked to present their team progress to the entire class. Teams were instructed to log their progress in shared group journals asynchronously. Group interactions were video recorded. To investigate the SSMR and degree of transactivity in those contrasting teams, we analyzed the video data (15 hours) from a synchronous face-to-face classroom. The content analysis approach was followed to analyze students' verbalized interactions in high and low-performing teams to see emergent relationship between SSMR and transactivity. The team's performance was evaluated by a predefined rubric. The video was segmented into episodes that map to multiple conversational turns by multiple students while they were working on various topics. Those episodes were considered SSMR episodes if verbalizations were referred to as monitoring and controlling cognitive processes [1].

In both studies, we tried to investigate the SSRL & SSMR strategy applications of learners from high and low performing teams. Along with that we have investigated the relationship between SSMR & transactivity of teams while working in project-based learning settings having open-ended problems (tasks). In proposed research, three major parameters of SSMR are considered to quantify the SSMR episodes. a) Metacognitive regulation skill used in SSMR episode (orienting, planning, monitoring, reflection), b) Focus of SSMR episode (Fundamental, organizational, surface level), c) function of SSMR episode (Facilitate or inhibit the current metacognitive activity). The data from both the studies were mostly qualitative in nature and were analyzed by manual method (ground root) using established frameworks. We have reported the differences between teams using Quantitative and thematic representations.

So far the modes of data we have collected were a) video & audio data of teams while working collaboratively b) Self-reported data by team members, and c) performance of teams. The evidence we have collected to support the claims were based on these data sources. As per the existing literature, most of the studies have investigated SSMR for mathematics domain, so they have used mathematics word problem specific parameters while investigating SSMR. Some studies have collected gesture and GSR data to investigate, but these methods are mostly used in small duration studies. As proposed study was face-to-face and longitudinal in nature hence it was not feasible to use these data modes because learners were supposed to move physically and interact with other participants. The proposed study design intends to investigate SSMR for collaborative programming tasks (using open-ended project based learning pedagogy) using verbal interaction data and some extent of self-report data such as surveys and interviews. Hence as of now verbal interaction data and self-report data are two most feasible modes available for investigating SSMR for collaborative programming tasks.

The existing study design followed for above two studies is represented in the fig 1 which shows different data modes. For the teams working in project-based learning settings and having open-ended problems (tasks), we have derived understanding about the teams' SSMR strategy application and level of transactivity teams

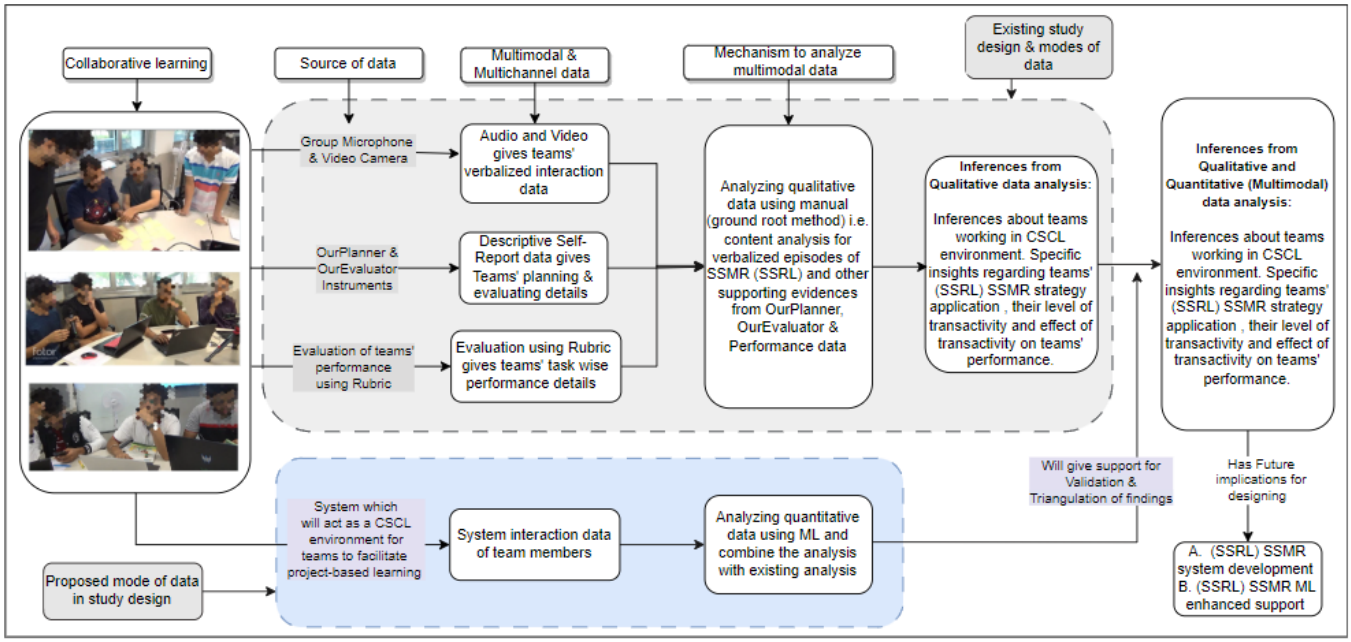

Figure 1. Existing study design with proposed mode of data

attain. The proposed project is intended to model the SSMR behavior of team members while working on open-ended collaborative programming projects. The SSMR model will inform collaborative system developers for programming tasks and teachers who use project based learning pedagogy in programming projects in course. On the basis of the understanding, we are proposing a framework of learning environment.

RG2: Design and develop a learning environment to foster socially shared metacognitive regulation (SSMR) using metacognitive prompts in a project-based learning context.

To provide a prompt as a scaffold for a learner (based on what we learned from above 2 studies), we searched for existing learning environments which provide prompts as scaffold for learners in project-based CSCL context. Since there is not much extensive research available on such learning environments to foster learners' SSMR, we propose to design and develop a learning environment. The proposed learning environments will also try to overcome the limitation of not having multiple modes of data. Currently the data source is mainly video and audio collected through manual way.

In order to validate our findings from research studies we propose to collect data from the learning environment and triangulate the findings. The data collected from the learning environments will be used to support our claims regarding teams while they are applying SSMR strategies. In our learning environment, we will record the learners' interaction data generated from click-stream. So while team members will be working collaboratively on open-ended problems in project based learning, they will be contributing to the shared goal from their own system. The learning environment will help us in collecting multimodal data in addition with the video and audio data. We plan to develop a system that

captures the learners' interaction behavior. The learners actions along with timestamp will be analyzed to understand the SSMR. We propose to use Process mining tools like ProM to analyze the data. In order to support the SSMR in collaborative learning environment, we are willing to use ML algorithms to detect the place in SSMR to provide scaffold. We are trying to achieve triangulation while establishing our claims through multiple modes of data. The proposed mode of data is also highlighted in fig 1.

RG3: Measure and validate the impact of metacognitive prompts given in the learning environment to foster SSMR and transactivity in a project-based CSCL context.

This is the final research goal after conducting studies with a learning environment. The major focus here will be to measure and validate the impact of metacognitive prompts given in the learning environment to foster SSMR and transactivity in a project-based CSCL context.

3. ADVICE SOUGHT

Question 1: Is the study design with proposed mode of data capable/suitable for validation/triangulation of research claims?

Question 2: Is the proposed mode of data (system interaction) aligned with existing modes of data? If not what are the ways to make it aligned for given research goals?

Question 3: How to handle overlapping areas of two different modes of data (i.e. audio-video and system interaction)?

4. CONCLUSION

On the basis of understanding about SSRL, SSMR and transactivity of teams while working in project-based learning in CSCL context, we intend to add one more mode of data channel (i.e. System interaction data from proposed learning environment). This will help us to validate and triangulate our claims with evidence from multiple modes. In order to make collaborative project-based learning successful, we need to understand the (SSRL) SSMR process and teams' transactivity in detail using data from multiple channels. Here, we are proposing that we need a learning environment to collect multi modal data to understand teams' regulation behavior and ultimately to support collaborating teams with metacognitive prompts. As there is not much intensive research that has happened on supporting teams' regulation while working in project-based CSCL environments, our proposed learning environment may help teams to regulate better and have a

high level of transactivity. Because we have understood from our studies, applying maximum (SSRL) SSMR strategies and attaining a high degree of transactivity have high correlation with high performance.

Though we have some understanding from previous studies, it's based on some assumptions like, a) team members may have externalized their potential metacognitive strategy application capability while working collaboratively, b) team members may have worked on problem statements in project-based learning in class, when data was collected etc. Considering the assumptions, those are limitations for this research. We feel that this research process is at the defining moment of its journey and seeking some advice for the future discourse with respect to some challenges. We request feedback from experts in this community to overcome/handle challenges so that the proposed learning environment can be developed and impact the teams' (SSRL) SSMR and transactivity in an effective way.

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