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Interaction and Monitoring Matter: Comparison of High and Low-performing Groups in CSCL

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Abstract: This study explores students' interaction patterns and how monitoring influenced students' interactions when they were engaged in computer-supported collaborative learning (CSCL) activities. A comparison analysis was conducted between two groups of students (one high-performing group and one low-performing group) from a secondary school in Singapore. Content analysis was performed to compare the quality of student-generated artifacts between the two groups. Social network analysis (SNA) and lag-sequential analysis (LSA) were employed to analyze the interactive processes of the students. The results identified three differences in the ways the two groups engaged in collaborative argumentation: (1) quantity of social interaction, (2) diversity of interactive patterns (3) sequence of contributing to group work and seeking input. The findings reveal the possible interaction patterns which promote or constrain the development of collaboration argumentation. The implications on how teachers design and implement small group computer-supported collaborative learning is discussed.

Keywords: Interaction, computer-supported collaborative argumentation

1. Introduction

Collaborative competency is increasingly important in the workplace and life. Learners should learn how to collaborate effectively in classrooms (French & Kottke, 2013). How to promote meaningful group interactions and improve learning performance in computer supported collaborative learning (CSCL) have attracted much attention from researchers and educators in in recent years. One way to design and implement effective collaborative learning is to foster good quality interactions among students. Research studies showed that learning in groups can be more effective than learning alone (Furberg & Ludvigsen, 2008). Dillenbourg and Schneider (1995) defined collaborative learning as two or more subjects build synchronously and interactively a joint solution to solve a problem. The definition infers that the extent and the quality of the exchanges that occur within groups of students in collaborative environments is important (Curtis & Lawson, 2001). Assessment of CSCL should go beyond the learning outcomes; the quality of the collaborative learning processes is also important (Strijbos, 2010). This study explores how students in high-performing and low-performing groups engaged in collaborative argumentation in a CSCL environment to learn by interacting with one another, and to identify interaction behaviors that led to desired learning outcomes.

2. Literature Review

Researchers have been interested in argumentation and how students can benefit from it in CSCL (Stegmann et al., 2007). "Collaborative argumentation" has been important because students can learn critical thinking, elaboration, and reasoning from it (Andriessen, 2006). In argumentative dialogue, learners are expected to put forward suggestions for the analysis and solution of the problem, challenge their proposals, back them up with theories, rebut opposing views on theoretical grounds, and weigh the available theoretical evidence that favors or disfavors possible solutions (Resnick et al., 1993).

Effective collaborative learning requires mutual engagement of learners constructing knowledge and solving problems with joint effort (Dillenbourg, 1999). In collaborative learning activities, students need to actively make sense of the subject matter by articulating relevant concepts, considering multiple perspectives, and discussing alternative solutions to the problem (Slof et al., 2010). Interactions within the group help the group move towards or away from its goal, or maintain its status quo (Kapur et al., 2011).

Researchers have also found that the groups with students monitoring their own and their peers' learning and thinking processes seem to have an advantage over groups without doing it (Lee et al., 2015). The fact that different groups showed different interaction patterns in collaborative learning was more often group-related than task-related (Vuopala et al., 2016). High-performing groups focused on regulating the cognitive and social aspects of their collaboration, which was not the case with the low-performing groups. The low-performing student groups did not activate the socially shared regulation (Malmberg et al., 2015). A comprehensive understanding of students' collaborative learning requires analysis of both learning process and outcomes (Tan & Chen, 2022). However, the interaction patterns of higher and lower performing groups in collaborative argumentation remain underexplored.

This study examines how students from high- and low-performing groups interact within group in computer-supported collaborative argumentation (CSCA). The objectives of this study are to investigate the high- and low-performing groups interactive network and the behavioral characteristics of students in online collaborative learning activities. Two research questions are specified as follows:

1. What are the differences in terms of interaction network between the high- and low-performing groups in CSCA?
2. What are the differences in terms of behavioral characteristics between the high- and low-performing groups in CSCA?

3. Method

This study employed the exploratory case study method. It examined the collaborative argumentation process of two groups of students (N=9) from an English language class of a secondary school in Singapore.

3.1 Participants

There were ten groups of three to five Secondary-3 students (aged around 15 years old) in the class participating in computer-supported collaborative argumentation. Content analysis was conducted to assess the high- and low-performing groups based on students' written arguments at the end of the activity. The groups with the highest quality argumentation and lowest quality argumentation were included in the data analysis for this study.

3.2 CSCA environment

The CSCA activities were conducted in an online collaborative learning environment named AppleTree (Chen et al., 2021; Chen et al., 2019), a graph-oriented, computer-assisted application to support students' collaborative argumentation. The process of participants interacted in a intra-group synergy phase was analysed. During the intra-group synergy phase, the participants were asked to deliberate and integrate group members' ideas in order to be able to present quality argumenation via a group mind map. Figure 1 shows the screen capture of one group of students working on CSCA in AppleTree.

Instead of the traditional teacher-centered instructional approach, the CSCA approach was adopted. In this study, students in groups co-constructed argumentation in the form of an argumentation graph with claim, evidence, and reasoning. During collaborative argumentation in the English language lesson focused on argumentation, students sat in groups and worked on an online collaborative argumentation platform, Appletree. They brainstormed and put forth their opinions to the question "Technology is the solution to climate change. Do you agree?" in the AppleTree system. At the end of collaborative argumentation task, each student completed an argumentation writing for 30 minutes.

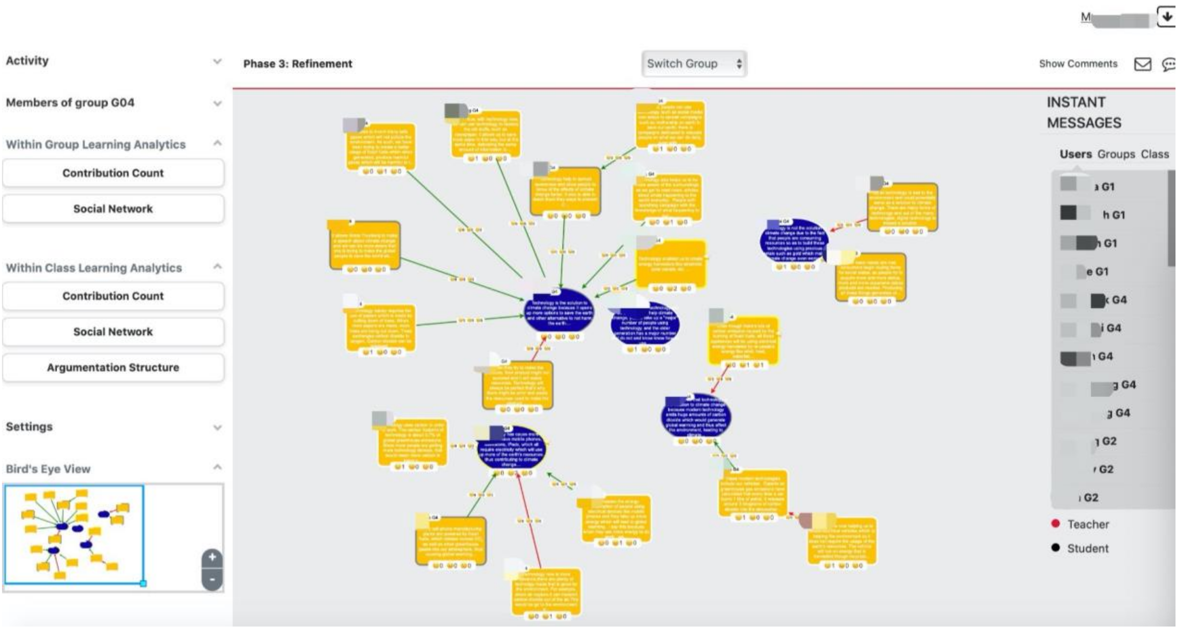

Figure 1. The screen capture of one group's argumentation in Appletree System with Learning analytics on the left and chat function on the right side

3.3 Data Collection and Instrument

The students' online interaction data during the activities and individual argumentative writing pieces at the end of the activities were collected. When students co-constructed arguments on the Appletree system, all the online interaction data were stored automatically in the Appletree System. Figure 2 shows the online artefacts generated by the two groups. The sequence of the online interactive behavioral were captured by the backend of the system. The two groups of students' online behaviors were screen recorded and transcribed.

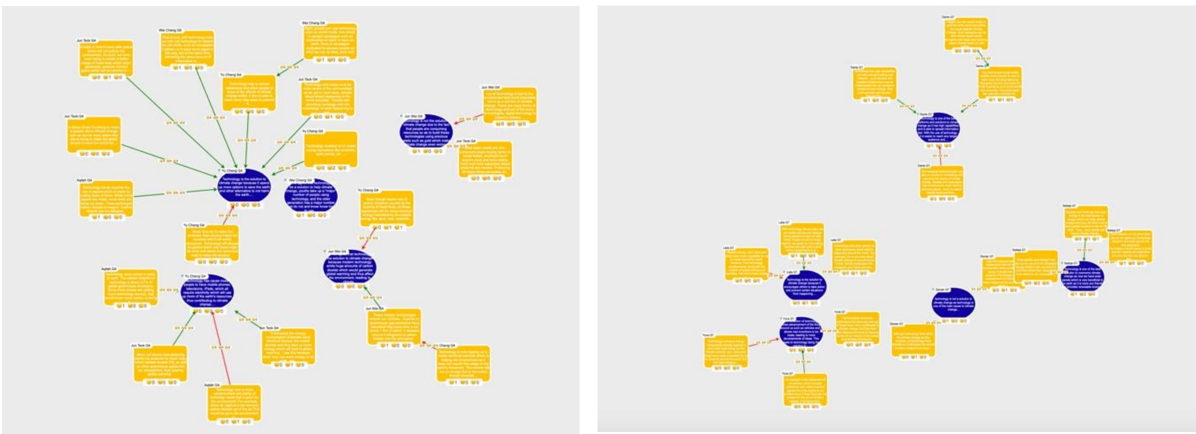
Figure 2. The mind map of high-performing group (Left) and low-performing group (Right) on the Appletree System

The students' learning outcome(argumentative writing) was coded according to the code scheme, including four dimensions (Table 1). Among them, Logical reasoning was modified based on Toulmin's way (1958) of viewing argumentation, Depth was modified based on Fan et al (2020)'s assessment rubric for argumentation with a closer look at thinking skills, Clarity was adopted from (Andrade et al., 2010) focus on the quality of writing/meaning-making of students' argumentative artifacts, Persuasiveness (Connor, 1990) looks at the effectiveness of rhetorical techniques including logical appeals, affective appeals, and ethical appeals, and writers' ability to keep audience in mind represented in students' argumentative artifacts.

Table 1. Coding scheme of quality of learning outcome (argumentative writing)

Dimension	0	1	2	3
1. Logical reasoning	No clear point or has so many errors in logic that it is invalid.	Makes a point but is not well articulated, or not supported by evidence; contains some errors in logic.	The logic is acceptable; provides some logical supporting reasons.	Well-articulated and logically strong; sound and cogent; nuanced arguments consider multiple perspectives logically.
2. Depth	Irrelevant ideas.	A superficial argumentation, more implicit than analytical or explanatory, unexamined hunch or borrowed ideas, lack of explanation and interpretation.	Reflects some in-depth thinking process such as reflecting, evaluating, and considering different perspectives.	A thorough, explanatory, and sophisticated argumentation; supported, justified; consider and evaluate multiple perspectives to back up the claim; deep and broad.
3.Clarity	The central idea and the clarity of purpose are absent.	The central idea is basically expressed though it may be vague or too broad.	The central idea and the clarity of purpose are generally evident.	The central idea and the clarity of purpose are well developed; very compelling statement.
4.Persuasiveness	No persuasive appeals used (e.g., logos, pathos, ethos) / not attuned to audience.	Make use of simple persuasive appeals; not very effective word choice and language use attuned to audience.	Make use of several persuasive appeals and techniques; relatively effective word choice and language use attuned to audience.	Make good use of several persuasive appeals and techniques; sophisticated word choice and language use attuned to audience.

The students' online interactions were coded by adopting the coding schemes of Curtis & Lawson (2001) and Popov et al., (2019). There were seven categories of online collaborative behaviors (Table 2): organizing, contribution, seeking input, monitoring learning analytics, refining and revising, social interaction and activity-related individual behavior. Each category of collaborative behavior had several subcategories. In total, there are 17 subcategories of collaborative behavior.

Table2. Coding of on-screen behavior

Behavior categories	**Code**	**Description**
Organizing	OGM	Organize Group mind map
	OIM	Organize individual mind map
Contributing	ASE	Add supporting evidence
	AOE	Add opposing evidence
	AI	Add idea bubble
Seeking input	RGW	Read Group members' work (within Group)
	ROW	Read other's work (other Groups)
Monitoring learning analytics	MCC	Monitoring contribution count
	MSNA	Monitoring SNA (within Group/within class)
	MMS	Monitoring mind map structure

Refining and Revising	RPW	Revising previous work
Social interaction	GM	Group message chat (unrelated to activity)
	RARE	Read activity requirements and extracts
Activity-related individual behavior	NAV	Navigate the system
	INT	Internet information search
	TH	Thinking, drafting, idling

Inter-coder reliability. Two researchers coded all the data independently by using the aforementioned coding scheme. An overall Cohen's Kappa of .706 was found, a satisfactory result.

4. Results

4.1 The differences in terms of interaction networks between the high- and low-performing groups in CSCA?

Social interaction behaviors in CSCL have been found to be effective in predicting learning (Kang et al., 2018). Social Network Analysis (SNA) helps researchers in the analysis of these patterns by illuminating the 'flow' of information that are exchanged among students. SNA was used to answer the first research question by examining the dyadic interaction of the participants. Figure 3 shows the SNA results of the two groups. The node represents each student collaborator. The line represents the relationship between collaborators. The interaction means the exchanges between students. For example, the line between students indicates they build on each other's idea by adding ideas or evidence on each other's ideas. The diagrams in Figure 3 show how students connect to the members in the group and the patterns of collaboration (one-to-one or many-to-many). According to SNA results, there were regular interactions among students within high-performing group (N=27). In contrast, there was only one interaction relationship between two students within the low-performing group. The results also indicated high cohesiveness and tight interaction relationship among students in the high-performing group.

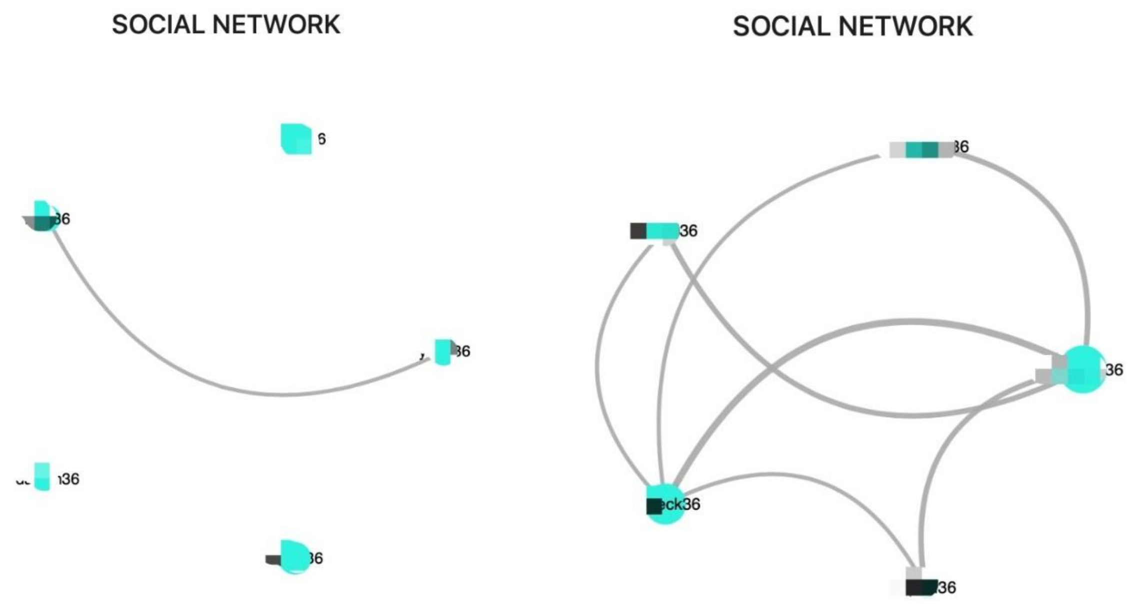

Figure. 3 Comparison of the Social Networks of high-performing group (Left) and low-performing group (Right) (the dots represents students, the thickness of the lines represent exchanges of information)

4.2 *The differences in terms of behavioral characteristics between the high- and low-performing groups in CSCA*

To answer the second research question, Lag Sequence Analyses (LSA) was conducted. LSA tests the probability that one behavior occurs after another behavior, and whether it is statistically significant (Bakeman & Gottman, 1997). GSEQ 5.1 was used for LSA. GSEQ5.1, has been widely used in many behavioral pattern studies (Hou & Wu, 2011). Firstly, we imported the coded collaborative behavior sequences into GSEQ 5.1 and saved it as an independent document. Then the function of calculating table statistics in GSEQ 5.1 was used to summarize the frequency of behavioral types and the adjusted residual results of transitions (Z - score > 1.96 indicates the behavior path has significance). Finally, we illustrated the behavior transition diagrams based on all the sequences that were statistically significant.

The LSA results of the two groups were shown in Figure 4 to illustrate the behavioral patterns of knowledge construction in group collaboration.

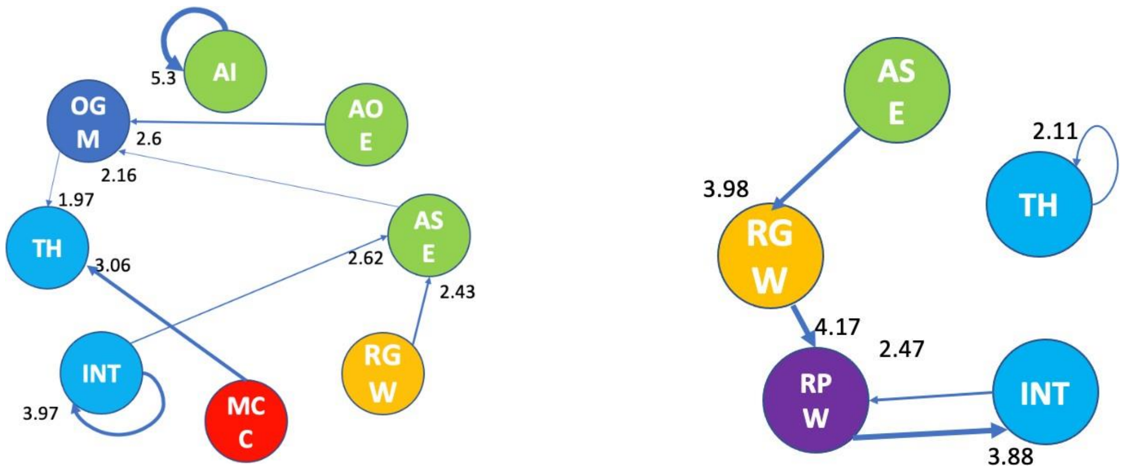

Figure 4. Behavioral transition diagram of high-performing Group (Left) and low-performing group (Right)

Behavior transition diagrams of high-performing group and all sequences that reached statistical significance are shown in the Figure 4. In total, there were eight significant behavioral sequences identified in the high-performing group. Behavioral paths ASE→ OGM, and AOE → OGM showed that after students added new evidence, they would usually organize the group argumentation graph. Behavioral paths MCC → TH and OGM → TH showed that students monitored contribution count or organized group mind map, followed by thinking or idling. Behavioral paths INT → ASE showed that students searched for online information, after which they added supporting evidence. Behavioral paths RGW → ASE showed that they added supporting evidence after reading group members' work.

Behavior transition diagrams of low-performing group and all sequences that reached statistical significance of the group are shown on the right of Figure 4. There were five significant behavioral sequences in this group in total. The Behavioral paths RGW→ RPW, and INT → RPW showed that after students read the ideas from their group members on the AppleTree system or searched online for information, they tended to revise their work individually. Behavioral paths ASE→ RPW showed that students read group work after adding supporting evidence.

Among all the transitions, some behavioral paths yielded much higher z-scores than 1.96. These paths include MCC → TH and INT → ASE in the high-performing group, and RGW→ RPW, INT → RPW in low-performing group. These significant transition paths indicate the main differences between the two groups. High-performing group members tend to add supporting evidence after reading group members' work, in contrast, low-performing group members tend to read group members' work after they add supporting evidence. The results suggested that high-performing group members concentrated on completing, monitoring and improving their group argumentation graph. Besides, low-performing group members tended to refine and revise their previous work after reading group work and searching internet information, while high-performing group members did less refinement and revision.

5. Discussion and conclusion

This study analyzed the interaction patterns of students' collaborative argumentation behaviors in small groups. Firstly, it was found that high-performing group members have more frequent social interactions than low performing group members. This echoed the previous research studies that cognitive processes needs social interaction to take place as only then can new ideas, critical comments, other viewpoints, feedback, shared understanding be exchanged (Kreijns et al., 2003). In addition, high-performing group members tended to have more diverse interactive patterns than low-performing group members.

Secondly, high-performing group members seek input from group members before they work on improving their argumentation. In contrast, low-performing group members put forth their ideas before they seek input from others. Thirdly, unlike the students in high-performing groups, members in low-performing group tended to revise their work based on group members and online information. The high-performing group members concentrated on within-group ideation in collaborative argumentation activities by frequent interaction and monitoring the group work. Compared with the high-performing group members,the low-performing group members focused less about the whole group work, including organizing group argumentation graph, monitoring the argumentation structure. A possible explanation was that students from low-performing group lacked the ability to build on peers' ideas. Previous studies have shown that students do not spontaneously build on peers' ideas, which is considered to play an essential role in collaborative learning (Molinari et al., 2008).

The findings from this study provide further evidence of how students from high-performing group and low-performing groups interact and monitor in collaborative argumentation activities within their groups. The findings have implications for teaching and facilitating collaborative learning. First, teachers should encourage active idea exchange within group members, instead of only building independent work. Second, teachers utilise learning analytics generated by the system to encourage and enable students on monitoring and regulating inter-and intra-group interactions. Extra scaffolds for the lower performing groups in productive interaction and monitoring are needed. Teachers are suggested to provide intervention when students are not building on each other's work in CSCL. This study also has limitations. The sample size was small as this study was exploratory in nature. In addition, the collaboration setting was a specific graph-based collaborative argumentation platform. Bigger-scale studies in wider CSCL contexts are needed to explore the interaction mechanism of small group collaborative learning.

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