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The Effect of Individual Ideation before Discussion on Computer Supported Collaborative Argumentation in a Primary Classroom

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Abstract: This study investigated the effect of an individual preparation activity before collaboration on students' collaborative argumentation process and outcome. Conducted in a fifth-grade English class in a Singapore primary school, this study analyzed students' computer supported collaborative argumentation behaviors in two conditions: immediate collaboration condition and individual ideation before discussion condition. The results from statistical analyses and lag sequential analyses show a higher quality of collaborative argumentation in the individual ideation before discussion condition than in immediate collaboration condition. The results from content analyses and process-oriented bubble diagram show that students generated new ideas more frequently in the immediate collaboration condition. They engaged in behaviors of reading and revising existing ideas more frequent in individual preparation before collaboration condition. The findings contribute to the current understanding of CSCL scripts in terms of individual preparation activity before collaboration on the following collaboration outcome as well as the process. The implications on how to design and implement collaboration scripts in authentic teaching and learning scenarios are discussed.

Keywords: Collaboration scripts, individual preparation before collaboration, computer-supported collaborative learning, computer-supported collaborative argumentation

1. Introduction

The literacy of logical reasoning, arguing, and critical thinking are some of the most vital education objectives nowadays (Noroozi et al., 2012). Argumentation could be a vehicle for collaborative learning processes such as meaning-making and knowledge construction, with an interactive and collaborative nature (Baker, 2003). Collaborative argumentation has been integrated into real-world classroom contexts, identified as a fruitful and engaging process for students (Stegmann et al., 2012; Wang, 2014). Following the shift from page to screen, various computer-supported systems with unique learning affordances have been developed to facilitate collaborative argumentation processes. The learning approach of computer-supported collaborative argumentation (CSCA) aims at scaffolding productive argumentative learning by supporting sharing, constructing, and representing arguments in multiple formats (Kirschner et al., 2012). Research that closely examined CSCA illustrated its impact on the development of argumentation skills (Hsu et al., 2016; Lu & Zhang, 2013), critical and elaborative discussions (Scheuer et al., 2014), domain-specific knowledge (Stegmann et al., 2012) and problem-solving (Gillies & Khan, 2009). However, researchers found that collaborative argumentation remains challenging for primary school students despite the technological support. Appropriate instructional support is still required to engage students in quality argumentative practices (Harney et al., 2017; McNeill & Krajcik, 2006).

One effective approach to support CSCA is collaboration scripts, which consist of "sets of coordinated scaffolds that specify and sequence individual and collaborative learning activities and thereby aim to facilitate knowledge acquisition" (Stegmann et al., 2012, p. 301). Some collaboration scripts examples include the JIGSAW scripts (Aronson et al., 1978), ConceptGrid (Jermann et al., 1999), and the WiSim (De Jong & Van Joolingen, 1998). One common characteristic of the existing collaboration scripts is a combination of individual work and joint work (e.g., the MURDER Scripts) with the purpose to prepare individual-level contributions (Mende et al., 2021). Though being designed in multiple ways, the integration of individual work and joint work shared one similar temporal structure: individual work before joint work. With an interest in the mechanism of collaboration scripts (Dillenbourg & Hong, 2008) to adapt to the different learning contexts, it is worthy of a deep examination of the effect of the particular phase shared by multiple collaboration scripts, individual preparation before collaboration.

Studied in various research contexts, individual preparation before collaboration refers to "providing learners with time to perform activities directed at processing the instructional material on their own before the collaboration" (Mende et al., 2021, p. 30). Empirical studies reported that with individual preparation, learners can prepare for the subsequent discussion and collaboration, e.g., reflect on their perspectives, create their own arguments, and prepare their individual solutions which they can be compared and integrated during the subsequent collaboration (e.g., Chen et al., 2021; Asterhan & Schwarz, 2007; Van Boxtel et al., 2000; van Dijk et al., 2013). However, Tsovaltzi et al. (2015, 2017) identified negative effect of individual preparation on subsequent collaboration. When there was an individual preparation activity before collaboration, some students experienced idea solidification without ongoing communication and ultimately. Other students presented lower quality of knowledge co-construction and less knowledge acquisition than without individual preparation condition.

Several under-studied areas are identified from the literature. First, there are mixed results reported in existing empirical studies, offering an unclear understanding of the effect of individual preparation before collaboration on collaborative learning, especially in CSCA activities. Second, most studies focused on students' individual learning outcomes or collaboration products without looking into the collaborative learning process in CSCL context, making it difficult to explain how and why students collaborated differently and produced different products. Therefore, this study aims to expand the existing understanding of the effect of individual preparation before collaboration on students' collaborative learning process and results, represented in collaborative argumentation product and the moment-by-moment on-screen behaviors. The following questions are proposed:

RQ1: What is the effect of the individual ideation phase on students' collaborative argumentation outcome?

RQ2: What is the effect of the individual ideation phase on students' CSCA process?

RQ3: What are the sequential patterns of CSCA behaviours emerged in immediate collaboration condition and individual ideation before discussion condition?

2. Method

2.1 Participants and Learning Context

A quasi-experimental design was employed in this study to explore the effect of the individual ideation activity on students' collaborative learning. A total of 28 fifth graders from the same class of a Singapore Primary school participated in this study. All participants were females, and their average age was 10 years. The teacher was a senior English language teacher who had taught the participating students for more than two semesters.

2.2 CSCL Environment

This study leveraged the AppleTree (Chen et al., 2013; Tan & Chen, 2022), a web-based system (www.appletree.sg) to support students' CSCA. The system was developed by the first author's research team at National Institute of Education, Nanyang Technological University. The AppleTree system supports both individual and group argumentation. The graph-based argumentation workspace of the AppleTree system allows the participants to construct the graph-based argumentation in a mind-map structure. Figure 1 shows the graph-based workspace of the AppleTree system. When engaging in argumentation on AppleTree, user would construct evidence (rectangle shape) to support claims (oval shape) or tentative ideas/claims (cloud shape). The arrows connecting evidence to claims dementated the reasoning of the argumentation - green arrows indicate supporting evidence, red arrows indicate counterevidence, and grey arrows indicate neutral evidence.

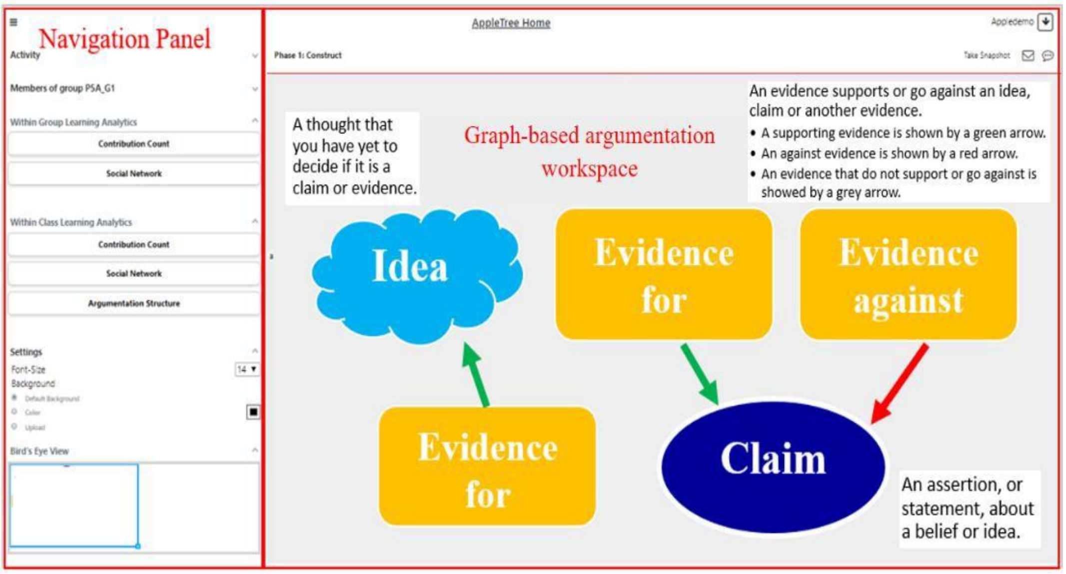

Figure 1. User interface of AppleTree

2.3 Design and Procedure

The two different collaboration conditions were conducted in two English lessons given on two separate school days. Designed by the schoolteacher and researchers of this study, the two lessons involved two comparable collaborative argumentation tasks that required the same amount of time (24 minutes) to complete. The first collaborative argumentation task is ranking three toys in terms of their education value: mystery board game, remote control car, and cube. The other task is ranking three class outing activities regarding how effective it will help class bonding. In each task, the two collaborating students sit together and work on AppleTree using their personal tablets.

On the first day, the immediate collaboration condition (control condition) was implemented. All the students worked in dyads and collaborated on the argumentation topic for 24 minutes. On the second day, the individual ideation before discussion condition (experimental condition) was implemented. For the first 10 minutes' individual ideation, students were asked to independently think and work on their individual argumentation graph (see Figure 2) on the AppleTree platform, during which no communication between students was allowed. After the individual ideation activity, the students were asked to start the discussion and co-construct their argumentation graph (see Figure 3).

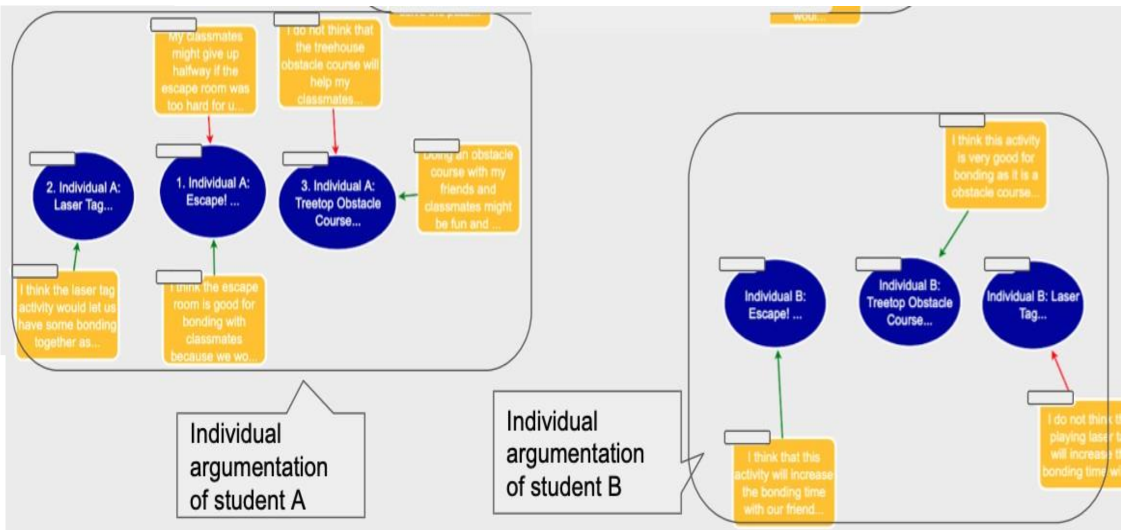

Figure 2. Individual argumentation for experimental condition

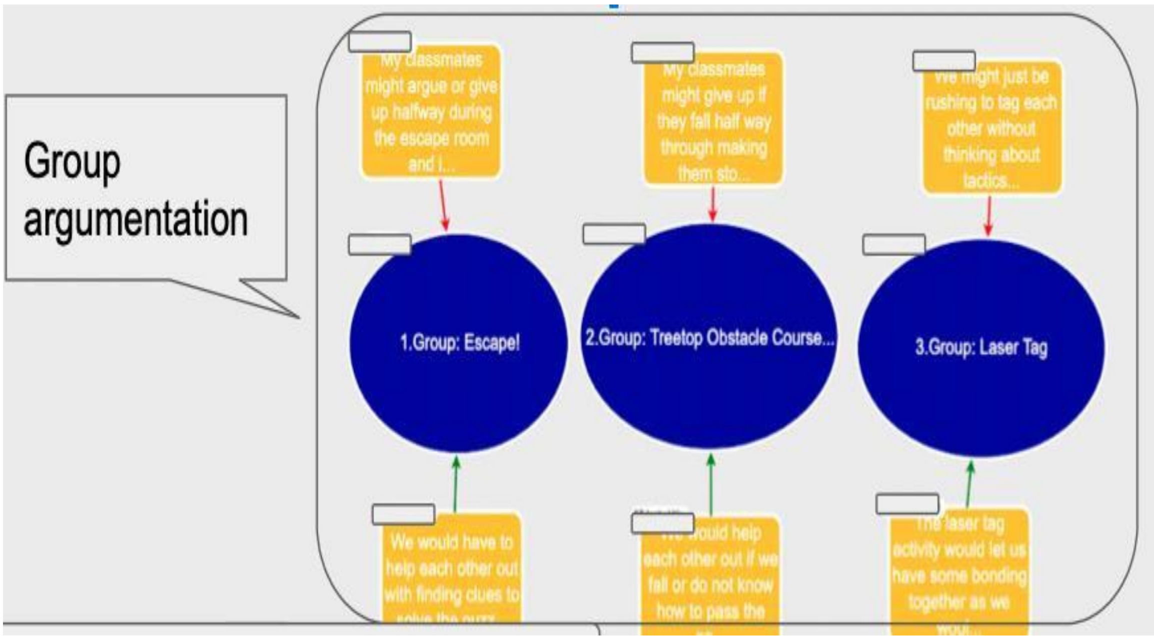

Figure 3. Group argumentation for experimental condition

2.4 Data Collection

To answer research question 1, all group's collaborative argumentation artefacts on the AppleTree platform were collected and analysed. To answer research questions 2 and 3, each individual student's screen recordings were collected. The video data was imported to the video analysis software Datavyu for further process-oriented analysis.

2.5 Research Instruments

2.5.1 Coding of Argumentation Artefacts

Content analysis was performed to examine the quality of the argumentation artefacts. The unit of analysis was the collaborative argumentation graph constructed by each group on AppleTree. Each group's CSCA artefacts on AppleTree platform were scored in four dimensions: clear position, multiple reasons to support the position, elaboration of reasons, and balance of supportive and objective evidence (counterarguments). Each dimension received a score ranging from 0 to 3. The scoring rubric was adapted from the basic argument schema developed by (Reznitskaya et al., 2007), informed by Toulmin's model (Toulmin, 1958). This basic argument schema was chosen for this study because it was developed and applied for evaluating fourth- and fifth-grade students' argument writing in both individual and collaborative learning contexts (e.g., Chen et al., 2016; Silverman et al., 2021).

Two trained coders coded the argumentation artefacts in the four dimensions according to the scoring rubrics. The sum of the four dimensions represents the overall performance of each group's collaborative argumentation artefact. The scores of both researchers were compared to check for inter-coder reliability. The inter-coder reliability was high (Cronbach's alpha = 0.75).

2.5.2 Coding of CSCA Process

To answer the second research question on CSCA process, this study analysed the CSCA behaviours for each student based on the screen recording data. To derive the coding scheme, the researchers coded the screen recordings for several students using a grounded coding approach. Then the researchers continuous adjusted coding scheme until the coding categories were applicable and suitable for further coding (see Table 1 for the coding scheme). The unit of analysis for the on-screen actions was each action taken by the student, such as creating one piece of evidence, editing on one piece of evidence, reading a partner's evidence, and messaging others via the chat-box function. One online action was the same action from initiated till the next action was initiated. At the same time, the starting timepoint and ending timepoint of each coded action were noted down along with one specific code. In the end, the duration of each coded action was calculated for further analysis.

The two researchers coded all students' screen recordings. Both inter-coder reliability between two trained coders (Cohen's k = 0.807) (Landis & Koch, 1977) and intra-coder test-retest reliability for each coder for 10% of the data (95% of identical scores) were sufficiently high.

Table 1. *Coding Scheme of CSCA Behaviours*

Behavioural category	**Code**	**Description**
Generating Ideas	NISE	Generating a new idea individually without discussing with others.
	NIP	Generating a new idea based on partner's idea, not discussed at the group level.
	NISH	Generating a new idea that has been discussed at the group level.
Reading existing ideas	RS	Revisiting and reading ideas created themselves.
	RP	Revisiting and reading ideas created by the partner.
Editing existing ideas	CO	Copying and pasting the ideas without making changes
	CUT	Cutting existing ideas.
	EXP	Revising existing ideas by expanding them
Managing	CLAIM	Ranking on the given claims by editing the claim.
	LA	Checking learning analytics function on the platform.
	SEARCH	Searching information on the Internet that related to the argumentation.
	GA	Adjusting graph.
Off-tasking	ID	Idling on the platform.
	MESS	Off-task messaging with classmates from other groups via the chat function.
	PS	Playing the platform, such as moving around the argumentation artefact, zooming in and out without purpose.

3. Results

3.1 Effect of Individual Ideation Before Discussion on CSCA Outcome

A paired-sample t-test was conducted to compare the collaborative argumentation performance of each dyad under two different conditions. As shown in Table 2, the result of the paired-sample t-test presented a significant difference in the overall argumentation quality for the immediate collaboration condition (M= 5.571, SD=3.23) and the individual ideation before discussion condition (M= 7.929, SD= 3.050) (t (13) = -4.359, p < .01). The effect size of the significance test was calculated with Cohen's d of 1.44 which suggested a large effect size. This result indicates that students co-constructed higher quality collaborative argumentation artefacts when there was an individual ideation activity before discussion, compared to immediate collaboration.

Table 2. *Paired-Sample t Test of Argumentation Quality*

Condition	Control Group (without individual preparation)		Experimental Group (with individual preparation)		*t*
	M	SD	M	SD	
Score of quality of argumentation artefacts	5.571	3.23	7.929	3.050	-4.359**

**p< .01.

3.2 Effect of Individual Ideation Before Discussion on CSCA Process

To answer the second research question on the individual ideation's effect on the collaborative learning process, this study first adopted the content analysis to examine the nature of students' behaviours demonstrated in the CSCA process. A Chi-square test was conducted to compare the frequency distribution of the five categories of collaboration behaviours in the two conditions. As shown in table 3, there was a significant difference in the online collaboration behaviours between the control condition and experimental condition: X^2 (4, N = 14) = 217.5023, p < .01. Students demonstrate more frequent behaviours of "generating new ideas", "reading existing ideas", "editing existing ideas", and "managing" behaviours in the experimental condition than the control condition.

Table 3. *Chi-Square Analysis Results*

Behaviours	Immediate Collaboration		Individual Ideation before Collaboration			Chi-Square
	Frequency	Proportion	Frequency	Proportion	Total	
Generating Ideas	146	35%	199	29%	345	
Reading existing ideas	26	6%	128	19%	154	
Editing existing ideas	17	4%	102	15%	119	217.5**
Managing	94	22%	204	30%	298	
Off-tasking	140	33%	55	8%	195	
Total	423	100%	688	100%	1111	

** p <.01

On top of content analysis, the study employed a bubble diagram (Figure 4), a process-oriented analytical approach to examine students' CSCA behaviours in chronological order. The rows of the bubble diagram represent different behaviour categories. Different sub-dimensions of behavioural categories were assigned with different colours. Each bubble on every row indicates one behaviour happening at one certain time point, with its size indicating the duration of one behaviour.

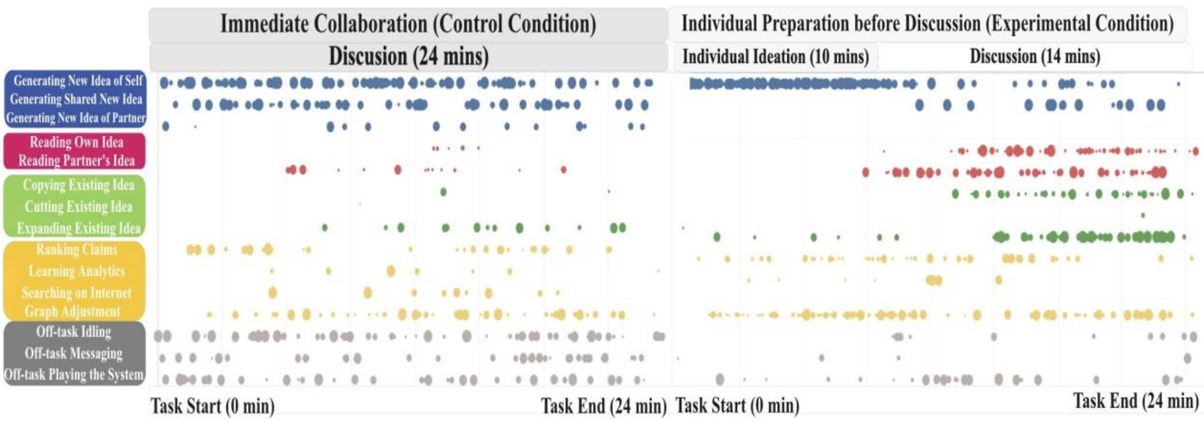

Figure 4. Distribution Diagram of CSCA Behaviours.

Figure 4 shows that there were differences in the distribution of different codes between the two conditions. Students generated new ideas (blue lines) in different timepoint as well as approaches. In the control condition (immediate collaboration), students tended to generate new ideas on their own (1st blue line) as well as from shared discussion (2nd blue line), a few new ideas were directly borrowed from their partner (3rd blue line). In the experimental condition (with individual preparation), most new ideas were produced at the individual ideation phase, based on students' own thinking processes (1st blue line). There were a few new ideas generated during their discussion phase (2nd blue line). There wase no idea directly borrowed from partner (3rd blue line).

More action of reading existing ideas (red lines) were identified in experimental conditions. In the immediate collaboration condition, students randomly read existing ideas, either those written by themselves (1st red line) or the partner (2nd red line). In contrast, there were much more reading actions identified in the experimental condition, happening mainly during the discussion. Students tend to read ideas written by themselves (1st red line) and those written by their partner (2nd red line) much more frequently till the end of the task.

More editing actions (green lines) were identified in the experimental condition. In the immediate collaboration condition, students barely did actions of copying (1st green line) or cutting idea (2nd green line) though they expanded existing ideas (3rd green line) a few times. In comparison, students spent much more time editing existing ideas in the experimental condition. In particular, there was a higher frequency and longer duration of copying (1st green line) and expanding (3rd line) existing ideas during the discussion.

Students in the immediate collaboration condition showed more off-tasking actions (grey lines) than in the experimental condition, including idling, messaging others, and playing the system.

3.3 Sequential Analysis and Behavior Transition Patterns

To answer the third research question, the lag sequential analysis (LSA) (Bakeman & Gottman, 1997) was applied to examine the statistical significances of sequential patterns of behaviours under the two conditions. Lag sequential analysis takes into account of the occurrence, temporal order, as well as the sequential correlation between every learning behaviours (Kapur, 2011). GSEQ 5.1 is a computer program designed to analyse sequential data. The authors imported the coded collaborative learning behavior sequences into the GSEQ 5.1 and employed the table statistical calculation function, summarizing the frequency continuity of all behavior categories as well as the remaining results after adjustment of every transition. The z-score of each transition from one behavior to another, indicated by the adjusted residual results, determines the significance of the specific behavior transition (z score > 1.96, Bakeman & Gottman, 1997). Exported from the GSEQ 5.1, the lag sequential analysis results were presented in a symmetric matrix, in which the significant transitions were visualized in a transition diagram Figure 5. There were 19 and 21 significant behavioral sequences identified in the control condition and experimental condition respectively.

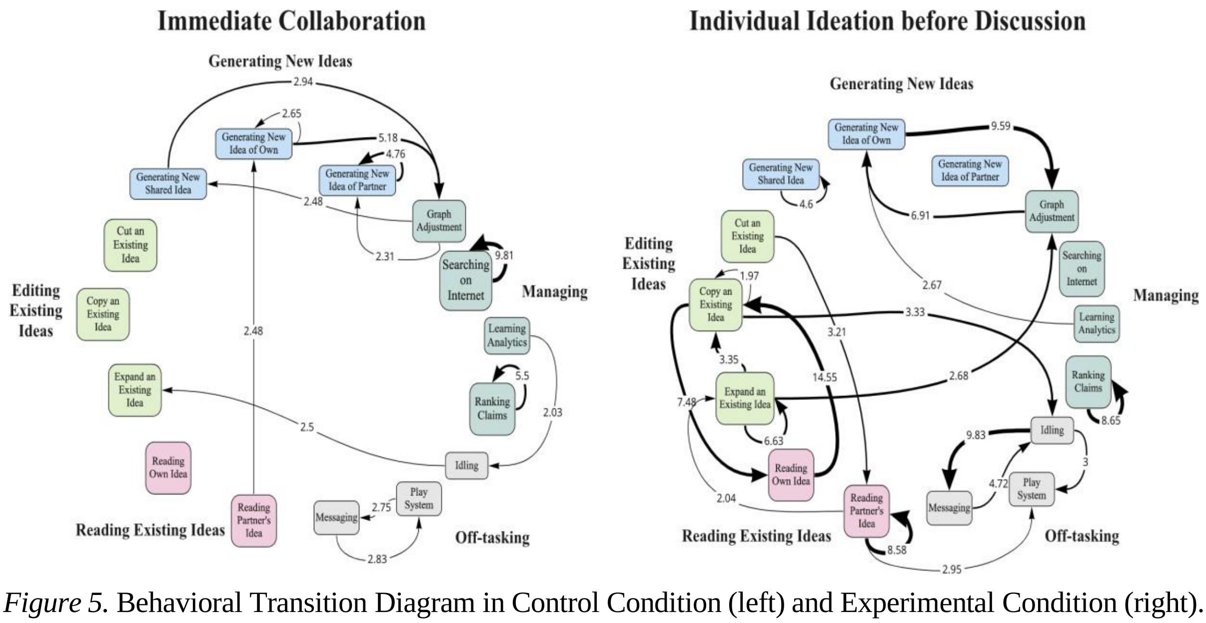

Figure 5. Behavioral Transition Diagram in Control Condition (left) and Experimental Condition (right).

Some transition patterns appeared in both conditions were "generating new idea of own" → "graph adjustment", which is understandable as students worked in a graph-based argumentation platform, and they tended to organize the argumentation graph as they added new content to it. Another shared transition was the repeated “ranking claims”, meaning students in both conditions made decisions on the argumentation claim together. These two paths were aligned with the specific CSCL context and the task requirement (ranking three toys or activities as a group).

There were distinctive paths in the transition diagram of the control condition. There was a central role of the dimension “generating new ideas”, including generating ideas of own, partner, and shared. There were repeated occurrences of generating new idea of themselves, as well as new ideas of partner, indicating the students’ generated new ideas intensively in control conditions. This finding echoed the findings on the frequency result and distribution trend identified in research questions 2 and 3. Besides, there was only one significant transition under the editing existing ideas dimension, from “idling” to “expanding existing ideas”, indicating the few expanding actions were usually executed after some idling actions.

There are several transition features identified in the experimental condition. The first feature was the transitions between different “editing existing ideas” actions and the different “reading existing ideas” actions. Several transitions surrounding the “expanding existing idea” included its self-repetition and “reading partner’s idea” → “expanding an existing idea”. The self-repetition paths indicated that students’ improvement of existing ideas usually constantly happened in the experimental condition. The path “reading partner’s idea” → “expanding an existing idea” indicated that students were likely to work upon them by adding their input after reading the partner’s ideas.

Another online collaborative behaviour that stands out in multiple significant transitions was “copying an existing idea” in the experimental condition. Keeping in mind its high frequency and even distribution identified in previous research questions, this diagram indicated that it not only happened continuously (“copy one’s idea” → “copy one’s idea”), but also strongly interacted with “reading one’s own idea” (“copy an existing idea” → “reading one’s own idea”, “reading one’s own idea” → “copying an existing idea”). These paths represented that apart from “expanding existing idea”, students were also likely to copy and paste their written ideas produced during individual work without any changes to their group artefacts. In addition, the “copying an existing idea” action was also likely to lead to off-task action “idling”, usually happening at the very end of the task according to the distribution graph. This inferred that some students tended to go off-task following the copying and pasting actions during the latter part of the task.

The diagram of the experimental condition indicates several significant transitions among the different off-tasking actions: idling to play system, idling to massaging, messaging to idling. Taking the results on the LSA, frequency account and distribution graph together, the findings show that students tended to get disengaged at the end of individual ideation activity as well as the overall task although they had significantly less off-tasking actions in the experimental condition than in the control condition.

4. Conclusions and Discussion

This study examined the effect of the collaboration script, individual preparation before collaboration on students’ collaborative argumentation outcomes and processes. In terms of collaboration outcomes, there were significant improvements in students’ collaborative argumentation, including the position, breadth, and balance dimensions. This finding contributes to existing literature on the effect of individual preparation before collaboration on students’ collaboration products.

Proposed by (Lam & Kapur, 2018), the preparatory mechanism identifies the key roles of some cognitive preparation activities before future collaboration and knowledge consolidation. A preparation activity before collaboration would activate learners’ knowledge, expose them to knowledge gaps, motivates them to engage in collaboration, and increase sensitivity to noticing relevant information (Lam & Kapur, 2018). In this study, the preparatory role of individual work before joint work was also reflected in the different collaborative learning behaviours. The immediate collaboration condition presented the central role of generating new knowledge throughout the overall task, and most of the ideas were barely improved further. In comparison, students were more prepared for in-depth discussion when there was individual ideation before the discussion. According to the frequency results and LSA, the findings on increasing reading of existing idea behaviors and editing existing idea behaviors indicated that students were able to not only generate new ideas, but also increase sensitivity to others’ input, and put efforts to elaborate on the ideas.

The findings of the study resonated with the pre-requisite for meaningful discussion proposed by previous scholars of CSCL (Wichmann & Rummel, 2013). Accumulating research identified that quality communication in CSCL context is not easy to occur, as there lacks a “common focus” of collaboration, which is the basis for group coordination, generating shared ideas, gaining mutual understandings (Hord & Tobia, 2015). As found in primary school settings by Barron (2003), group members did not pay attention to others’ opinions, interrupted them, and rejected other’s suggestions without justification. These behaviours inhibited group functioning as well as individual’s learning. The study by Ross (2008) also found primary schoolers often failed to realize shared knowledge construction, as the help-seekers were unable to formulate effective requests for help, and accordingly, the help-givers were barely able to provide meaningful help .

The process-oriented analyses results revealed various approaches students generated, read on, and improved ideas on their collaborative argumentation artefacts. With the analysis from multiple perspectives, the results indicated that in the immediate collaboration condition, there emerged a central role of sharing new knowledge and generating new ideas throughout the task. In the individual ideation before discussion condition, students tended to add more elaborations to support their standpoint or ideas and devoted more time to reading and editing existing ideas on the shared space. These findings were insightful for both educators and researchers who are interested in designing or implementing collaboration scripts in real-world classroom settings.

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