# The role of individual preparation for knowledge construction in collaborative argumentation: An Epistemic Network Analysis

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**Abstract:** Through collaborative argumentation, students gain in-depth understanding of learning content when they build on one another's knowledge. Although individual preparation (IP) is found to be effective to foster collaborative learning, the mechanism of how IP influence the knowledge construction behavior is underexplored. This study investigated how IP influenced secondary school students in relation to knowledge construction behavioral patterns when participating in online collaborative argumentation activities. 20 students participated in two computer-supported collaborative argumentation lessons with one group with IP, and the other group without. Screen video recordings of students constructing arguments in groups during two lessons were collected and analyzed. Epistemic Network Analysis was conducted to examine students' knowledge construction behaviors in the two lessons with and without IP. The results show that there were significant impact on students' knowledge construction characteristics between the two lessons. Students who did not go through the IP phase tended to exhibit behaviors related to ideas refinement more than the students who went through the IP phase. The implications of how to design and implement effective knowledge construction are discussed.

**Keywords:** Collaborative argumentation, individual preparation, knowledge construction behaviors, Epistemic Network Analysis

## 1. Introduction

Learning and working environments require people to solve problems collaboratively (Graesser et al., 2018). To promote students' collaboration competency, collaborative learning is widely used in various classrooms (Nokes-Malach et al., 2015). Studies showed that collaborative learning does not spontaneously bring benefits to students (Menekse & Chi, 2019). Various strategies have been used to promote students' effective collaborative learning. One of the strategies is individual preparation (IP) for collaboration, which provides students with time to process the learning materials individually before collaborative learning was implemented (Tsovaltzi et al., 2015). To examine how IP influences the students' knowledge construction behaviors, this paper analyzes students' on-screen knowledge construction behaviors in collaborative argumentation environments with and without IP.

## 2. Literature Review

### *2.1 Computer-supported Collaborative Argumentation*

Argumentation is crucial in solving ill-structured problems in the real world, which typically call for the collecting of observational data, adherence to formal logic norms, and the reasonable settling of conflicting viewpoints in discussions (Jonassen & Kim, 2010). As one of the promising approaches to improve students' argumentation, computer-supported collaborative argumentation (CSCA) supports the sharing, constructing, and representing of arguments in multiple formats. Various online systems with various learning affordances including graph-based argumentation(Scheuer et al., 2014), representational guidance tools (Hsu et al., 2015), and micro-scripting or macro-scripting (Noroozi & Hatami, 2018) have been designed to facilitate students' collaborative argumentation processes. Graph-based CSCA was found to improve students' learning outcomes (Chen et al., 2021). In graph-based argumentation, students use nodes or bubbles to represent different argument parts and use links or arrows to show how these parts relate to one another.

### *2.2 Individual preparation*

In collaborative learning activities, various collaboration scripts have been designed and implemented to foster the quality of students' contributions and improve the collaboration process (Weinberger & Fischer, 2006). As one of the effective collaboration scripts, individual preparation (IP) before collaboration is defined as "providing students with time to perform activities directed at processing the instructional material on their own before the collaboration" (Mende et al., 2021). During IP, students can prepare for the subsequent discussion, e.g., recall their prior knowledge and experience, create their own arguments, and prepare their individual ideas which they may compare or combine during the subsequent collaboration (Asterhan & Schwarz, 2007). Understanding how IP influences students' subsequent knowledge-construction behaviors during the collaborative learning phase is of great importance.

### *2.3 Knowledge construction*

Knowledge construction emphasizes that students construct new knowledge from social interactions (Leach & Scott, 2003). The quality of knowledge construction is dependent on how groups of students negotiate meaning, come to an agreement, coordinate tasks, and monitor the knowledge consctruction or group work, which are all highly correlated with group performance and project quality (Lin et al., 2016). The analysis of behavior counts across several categories has been the main focus of research on online collaborative activities (Christy & Fox, 2014). There is a need to capture the process of online collaborative argumentation and to reveal the relationships between different knowledge construction behavior.

This study investigated on students' knowledge construction behaviors in a CSCA context to gain more CSCA design insights. The research question is: What is the difference between knowledge construction behaviors in the CSCA activities with and without individual preparation conditions?

## 3. Method

The case study method was applied to examine the process of one class's collaborative argumentation that took place in two English language lessons. In the first lesson, students were asked to do a 5-minute IP followed by a 15-minute collaboration. In the second lesson, students were asked to have a 20-minute collaboration without IP. The teacher had rich experience in facilitating collaborative activities in classrooms. A CSCA environment entitled AppleTree System (Chen et al., 2021) was used to support the groups' collaborative content editing, group management, and activity monitoring with learning analytics. When students co-constructed and refined the arguments on the Appletree system, the on-screen behaviors on the Appletree System were recorded for further analysis.

### *3.1 Participants*

20 secondary school Singaporean students participated in this study. All the students were female students in Grade 9, aged between 14 to 15. They had experience in collaborative discussions on the CSCA system, AppleTree system. Students were randomly assigned into groups of four or five by the teacher. The students in the class are familiar with each other and have previously participated in group learning activities, although not in the same group settings as in this study.

### *3.2 CSCA system*

The AppleTree system allows students to externalize their knowledge construction processes in an argumentation graph structure (Chen et al., 2021). On the system, students could develop graph-based argumentation to represent argument elements, and relationships between them, in which different bubbles represent ideas, claims, and evidence. Learning analytics, including social network analysis and contribution count, demonstrate on the system synchronously.

### *3.3 Design and Procedure*

Two collaborative argumentation activities conducted across two weeks were co-designed by the teacher from the school and the researchers in this study. The students were engaged on two topics: "*Foreigners are not welcomed in Singapore. Do you agree?"* and *"The Singapore government's efforts have been effective in managing racial and religious tensions. Do you agree?"* Each group discussed and co-constructed their group argumentation in the joint working space on the AppleTree platform for 20 minutes. Students sat together with their group members and worked on the Appleree system with their personalized learning devices. In the lesson with IP, students were asked to write individual ideas for 5 minutes before they continued to write group ideas collaboratively for another 15 minutes. In the lesson without IP, students were asked to work collaboratively for 20 minutes without IP.

### *3.4 Data Collection and Analysis Method*

To explore students' online knowledge construction behaviors, this study collected each student's online collaboration process data. To answer the research questions, screen recordings of all the students (N = 20) of the two lessons were collected and analyzed. Each student's screen recording was loaded into the Datavyu (release 1.3; Datavyu Team, 2014), a video coding tool to analyze students' online behaviors. The on-screen behaviors demonstrated how students contributed and shared their ideas to the group through their behaviors.

A coding scheme was developed to examine the characteristics of the students' knowledge construction behaviors. The unit of analysis is each action presented by the student in the online platform, such as writing one piece of evidence and monitoring the learning analytics of the platform. Students' knowledge construction behaviors were coded based on the coding schemes adapted from the schemes of Curtis and Lawson (2001) and Popov et al. (2019) to identify different behavioral categories of knowledge construction. Seven main categories of online collaborative behaviors (Table 1) were identified: organizing, contributing, seeking input, monitoring learning analytics, refining and revising, social interaction, and activity-related individual behavior. To adapt to this study context, some codes were added to represent how students add ideas to the collaborative argumentation diagrams. In total, there are sixteen subcategories of behaviors, which are illustrated in the coding scheme in Table 1.

Table 1. The coding scheme of on-screen knowledge construction behavior

| Behavior categories | Code | Description |
|---|---|---|
| Organizing | OGM | Organize group argumentation graph |

| | | |
|---|---|---|
| Contributing | OIM | Organize individual argumentation graph |
| | AS | Add strategy |
| | ASE | Add supporting evidence |
| | AOE | Add opposing evidence |
| Seeking input | RGW | Read group members' work |
| | INRR | Internet information read |
| Monitoring learning analytics | MCC | Monitor contribution count |
| | MSNA | Monitor SNA |
| | MAC | Monitor argumentation count |
| | MMS | Monitor argumentation structure |
| Refining and Revising | RE | Revise by elaboration |
| | CHANGE | Change position |
| Social interaction | RARE | Read activity requirements and extracts |
| Activity-related individual behavior | NAV | Navigate CSCA system |
| | INT | Internet information search |
| | ROWW | Read one's own work |
| | TH | Thinking, drafting, idling |

Two coders coded the online screen recording data independently using the same coding scheme. Cohen's Kappa coefficient was used to calculate the inter-coder reliability and the reliability coefficient value between the two raters was 0.704, which suggested a reasonable level of agreement between the two coders. The students' online behavior data was organized according to the ENA data standard. The encoded data was analyzed using the ENA web application. The codes in the scheme for classifying knowledge construction behavior were chosen as the codes. Utterances in both conditions were examined for the co-occurrence of knowledge construction codes, and the relevant networks were displayed in an ENA space.

## 4. Results

The ENA results reveal the connections among the students' different collaboration behaviors in different conditions for both lessons. Each node in the network graphs (Figure 1) stands for a different collaboration behavior code. The links between the various nodes show that the two codes co-occur. The red edges in Figure 2 indicate the network of the lesson with IP and show the connections between the nodes that were stronger among Internet information read (INRR), Organize individual argumentation graph (OIM), Organize Group argumentation graph (OGM), Thinking, drafting, idling (TH), Read Group members' work (RGW), and Read one's own work (ROWW) than the connections among other behaviors. The blue edges in Figure 1 indicate the network of the lesson without IP and show the connections between the nodes that were connected among Internet information read (INRR), Organize individual argumentation graph (OIM), Organize Group argumentation graph (OGM), Thinking, drafting, idling (TH), Read Group members' work (RGW), and Read one's own work (ROWW), monitoring social network analysis (MSNA), and Revise by elaboration (RE) ) than the connections among other behaviors.

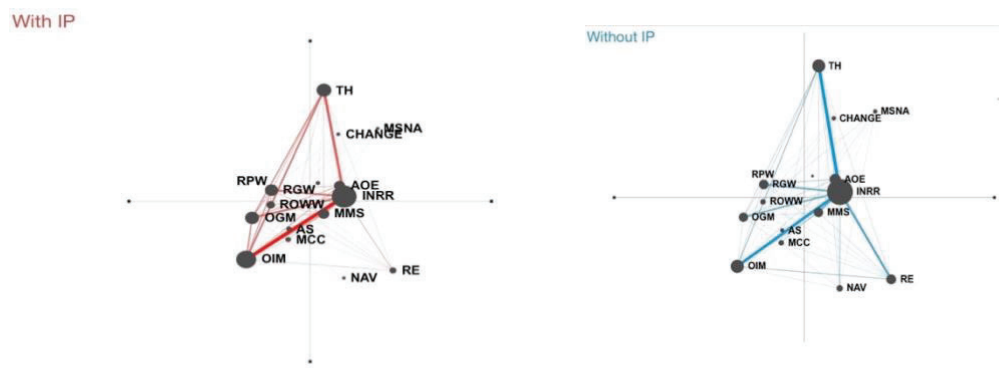


*Figure 1.* Epistemic frames in the lesson with IP (left) and without IP (right).

Epistemic networks of the different knowledge construction behaviors in lessons with and without IP reveal the difference between the two conditions. First, connections among organizing individual argumentation graph (OIM), organizing Group argumentation graph (OGM), thinking, drafting, and idling (TH) centroids are stronger in the lesson with IP than in the lesson without IP. Second, Internet information reading (INRR), thinking, drafting, idling (TH), monitoring social network analysis (MSNA), and Revise by elaboration (RE) centroids are stronger connected in the lesson without IP than in the lesson with IP.

## 5. Discussion and Conclusion

In summary, students in the CSCA lesson with IP mainly differ from those in the lesson without IP in which students have more behaviors connected with organizing group argumentation graph, organizing individual argumentation graph, but connected less with refining the argumentation graphs and monitoring social network analysis during collaborative activities. These behaviors represented how students' knowledge construction happens and how these behaviors interact with each other. In the future design and implementation of argumentation activities, educators may provide specific guidance, such as encouraging more refining activities when students start collaborative without IP.

This study also examined the students' knowledge construction behaviors of collaborative argumentation in two lessons, with and without IP. The ENA results contribute to and extend our previous IP research in argumentation activities by offering empirical evidence for supported evidence of the knowledge construction process following IP. The results confirmed that (1) students' knowledge construction behaviors presented different characteristics with and without IP conditions, (2) students tend to have more behaviors connected to refining ideas behavior without IP conditions than with IP conditions, which corroborates with the past findings that IP may lead to the solidification of prior misconceptions (Judele et al., 2014). Besides, the different connections with refining behavior in two conditions indicates that students tend to make decisions without further refining when they write arguments in groups, which resonates that students with IP may rush to decision-making without integrating each other's ideas (Lyu et al., 2022). In addition, though the preparatory mechanism confirms the key roles of cognitive preparation activities before the collaboration (Lam & Kapur, 2018), however, when students spend them developing their ideas during IP, it might solidify students' cognition and that might result in a reduction of students' refining or integrating ideas in the subsequent collaborative argumentation activities. Thus, this may result in students losing the opportunity to improving in the multiple-perspective dimension (Stapleton & Wu, 2015) despite being in a collaborative learning context, which is one indicator of an effective argumentation. There are a few limitations of this study. Firstly, the time allocated to students to work on their group argumentation artifacts is relatively short. Students had less than 20 minutes to construct knowledge and co-create the argumentation graph. Secondly, the sample size of the two lessons was small. Future work may extend this exploratory application of ENA to more students.

## References

Asterhan, C. S., & Schwarz, B. B. (2007). The effects of monological and dialogical argumentation on concept learning in evolutionary theory. *Journal of Educational Psychology*, *99*(3), 626.

Chen, W., Tan, J. S., & Pi, Z. (2021). The spiral model of collaborative knowledge improvement: an exploratory study of a networked collaborative classroom. *International Journal of Computer-Supported Collaborative Learning*, *16*(1), 7-35.

Christy, K. R., & Fox, J. (2014). Leaderboards in a virtual classroom: A test of stereotype threat and social comparison explanations for women's math performance. *Computers & Education*, *78*, 66-77.

Curtis, D. D., & Lawson, M. J. (2001). Exploring collaborative online learning. *Journal of Asynchronous learning networks*, *5*(1), 21-34.

Graesser, A. C., Fiore, S. M., Greiff, S., Andrews-Todd, J., Foltz, P. W., & Hesse, F. W. (2018). Advancing the science of collaborative problem solving. *psychological science in the public interest*, *19*(2), 59-92.

Hsu, P. S., Van Dyke, M., Chen, Y., & Smith, T. (2015). The effect of a graph-oriented computer-assisted project-based learning environment on argumentation skills. *Journal of Computer Assisted Learning*, *31*(1), 32-58.

Jonassen, D. H., & Kim, B. (2010). Arguing to learn and learning to argue: Design justifications and guidelines. *Educational Technology Research and Development*, *58*, 439-457.

Judele, R., Tsovaltzi, D., Puhl, T., & Weinberger, A. (2014). Collaborative learning in Facebook: Adverse effects of individual preparation. 2014 47th Hawaii International Conference on System Sciences,

Lam, R., & Kapur, M. (2018). Preparation for future collaboration: Cognitively preparing for learning from collaboration. *The Journal of Experimental Education*, *86*(4), 546-559.

Leach, J., & Scott, P. (2003). Individual and sociocultural views of learning in science education. *Science & education*, *12*, 91-113.

Lin, C.-L., Hou, H.-T., & Tsai, C.-C. (2016). Analyzing the social knowledge construction and online searching behavior of high school learners during a collaborative problem solving learning activity: A multi-dimensional behavioral pattern analysis. *The Asia-Pacific education researcher*, *25*, 893-906.

Lyu, Q., Chen, W., Su, J., & Heng, J. G. (2022). The Interaction Effect of Group Formation and Individual Preparation on Computer Support Collaborative Engineering Design: An Exploratory Study. *ASCILITE Publications*(Proceedings of ASCILITE 2022 in Sydney), e22102-e22102.

Menekse, M., & Chi, M. T. (2019). The role of collaborative interactions versus individual construction on students' learning of engineering concepts. *European Journal of Engineering Education*, *44*(5), 702-725.

Nokes-Malach, T. J., Richey, J. E., & Gadgil, S. (2015). When is it better to learn together? Insights from research on collaborative learning. *Educational psychology review*, *27*, 645-656.

Noroozi, O., & Hatami, J. (2018). The effects of online peer feedback and epistemic beliefs on students' argumentation-based learning. *Innovations in Education and Teaching International*.

Popov, V., Biemans, H. J., Fortuin, K. P., van Vliet, A. J., Erkens, G., Mulder, M., Jaspers, J., & Li, Y. (2019). Effects of an interculturally enriched collaboration script on student attitudes, behavior, and learning performance in a CSCL environment. *Learning, Culture and Social Interaction*, *21*, 100-123.

Scheuer, O., McLaren, B. M., Weinberger, A., & Niebuhr, S. (2014). Promoting critical, elaborative discussions through a collaboration script and argument diagrams. *Instructional science*, *42*, 127-157.

Stapleton, P., & Wu, Y. A. (2015). Assessing the quality of arguments in students' persuasive writing: A case study analyzing the relationship between surface structure and substance. Journal of English for Academic Purposes, 17, 12-23.

Tsovaltzi, D., Judele, R., Puhl, T., & Weinberger, A. (2015). Scripts, individual preparation and group awareness support in the service of learning in Facebook: How does CSCL compare to social networking sites? *Computers in Human Behavior*, *53*, 577-592.

Weinberger, A., & Fischer, F. (2006). A framework to analyze argumentative knowledge construction in computer-supported collaborative learning. Computers & Education, 46(1), 71-95.