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The Effectiveness of Collaborative Concept Map Recomposition and Discussion with Kit-Build Concept Map in Online Learning

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Abstract: Collaborative learning with concept maps has been recognized as a learning tool that positively impacts learning. Recently, transforming the learning environment into online settings becomes a priority to face the shift towards distance learning in the current pandemic. Learning with Kit-Build concept map is also no exception. Finding the factors that influenced student's comprehension in online collaborative learning with Kit-Build concept map could help teachers optimize their teaching strategy and aid students to learn in a better way; thus, improve the desired learning outcomes. In the context of online learning with concept maps, this study aims to investigate whether student's comprehension is affected by the direct influence of concept mapping strategy or the activeness of the discussion during collaboration. The results suggested that Kit-Build concept map encouraged better discussions, influenced and improved students' comprehension better than the traditional open-ended concept mapping.

Keywords: Collaborative learning, concept map, Kit-Build, learning effect, online

1. Introduction

Concept maps can be used to visualize ideas, depict relationships between two or more concepts, and structure knowledge. Learning with concept maps allows teachers and students to construct their understanding of concepts and relationships logically and in a structured sense. Therefore, a concept map has been acknowledged as an alternative tool for teaching, learning, assessment (Hirashima et al., 2011; Hirashima et al., 2015), exploring knowledge in research (de Ries et al., 2021). Furthermore, concept maps can be presented in digital forms and provided in an online environment (Metcalf et al., 2018) to improve its applicability in distance learning.

Elaborating concept maps into collaborative learning may cultivate deeper learning (Chen et al., 2018) and enhance critical thinking skills (Tseng, 2020) in conflict resolutions. Kit-Build is one learning framework that uses a concept map recomposition strategy to help students understand learning materials better (Hirashima et al., 2015). Collaboratively recomposing concept maps with Kit-Build could promote more active discussions and encourage students to share their understanding better than the traditional open-ended concept mapping (Wunnasri et al., 2018).

Many factors could affect student understanding during collaborative learning. For example, active discussion and participation of students were found to affect student understanding (Dallimore et al., 2016; van Blankenstein et al., 2011). Finding the factors that influenced their learning and further improved the quality of said factors could help teachers revamp their teaching strategy and the quality of teaching materials. A study in online collaborative learning (Pinandito et al., 2021) suggested that Kit-Build concept map could encourage more active and engaging discussion among students. As a result, it helped students to understand and comprehend better than using an open-ended concept mapping approach. However, their activeness in the discussion during learning could also be the factor that influenced student understanding. This study investigated factors that could affect group com-

prehension during collaborative learning with Kit-Build concept map. To further guide this study, the following research questions were addressed:

1. Is using the Kit-Build concept map method improve group comprehension better than the open-end concept mapping method in online collaborative learning with concept maps?
2. Is the activeness of students in the discussion affect group comprehension? If so, what kind of talks in the discussion influenced their comprehension?

The result suggested that the Kit-Build concept map method could improve group comprehension better than the traditional open-end approach in an online collaborative learning environment. In addition to encouraging more active and engaging discussions, Kit-Build also encourages students to discuss the problem more, thus affecting their comprehension and memory retention positively.

2. Online Collaborative Learning with Kit-Build Concept Map

Kit-Build concept map (Kit-Build) is a learning method that uses concept map re-composition strategy in its learning activities. In learning with concept maps, students or teachers compose a concept map of a learning topic and help readers to understand the ideas quickly. Instead of composing a concept map from an empty workspace (scratch mapping), Kit-Build uses the re-composition style by providing a predefined set of concept map components—a kit—to recompose (Sugihara et al., 2012). This re-composition activity is called kit-building. In kit-building, students are guided to recompose their concept maps to a structure similar to their teacher's concept map in the form of feedback. Even though kit-building is more restrictive than scratch mapping, it is less cognitive-demanding (Tseng, 2020).

The kit of a Kit-Build concept map held the critical key of learning with it. It guides the students to focus on particular concepts and ideas of a learning topic and helps them comprehend the topic better. Kit-Build concept map can also be used as a formative assessment in learning (Yoshida et al., 2013, Pailai et al., 2017) by its feedback and automatic comparison mechanism (Hirashima et al., 2015). Extensions and variations of learning with Kit-Build concept map have been conducted in several studies. Extending Kit-Build with scratch mapping could help the students comprehend the learning material and compose their concept maps better (Prasetya et al., 2021). Support for concept map composition through a semi-automatic concept map authoring system was given to improve the concept mapping efficiency (Pinandito, Prasetya, Hayashi, & Hirashima, 2021b, 2021a).

In previous studies (Andoko et al., 2020; Pinandito et al., 2021), Kit-Build effectively supports learning English as a Foreign Language (EFL) reading comprehension. Using Kit-Build in collaborative learning also showed a positive learning effect while also encouraged the students to discuss more actively (Wunnasri et al., 2018, Pinandito et al., 2021). The system has been enhanced further (Pinandito, Prasetya, Az-zahra, et al., 2021) to support real-time collaboration and online use. Additionally, the system allowed the students to discuss with a unique node-related text-based communication interface, separating general discussions from concept-or-link discussions and help them manage and keep the discussion in control when discussing several topics or ideas at the same time. However, it is yet to be confirmed whether the factor affecting group comprehension is the concept mapping activity, their activeness in the discussion during collaboration, or both; thus, addressed in this study.

3. Methodology

This study used the term Scratch Mapping and Kit-Building to differentiate two concept map composition methods. Scratch Mapping represents concept mapping activity where concept map authors can freely compose concept maps from scratch. On the other side, Kit-Building represents concept map recomposition activity from a predefined set of concept map components—a Kit-Build concept map kit.

An experiment, as shown in Figure 1, was designed to answer the research questions. Before the actual collaboration activity, the participants were given a tutorial about concept maps and training on creating a good concept map from English reading with the Kit-Build system directly. Before the concept mapping, they read a 900-words of English text about "Wagyu, a Japanese Breed Cow" and take a 10-minute pre-test. After the collaboration, the students take a 10-minute post-test. During the 30-minute concept mapping, they have access to the reading text, but they neither could see nor talk

with their partner to communicate directly. They can only talk with their partners using the communication channel provided within the system.

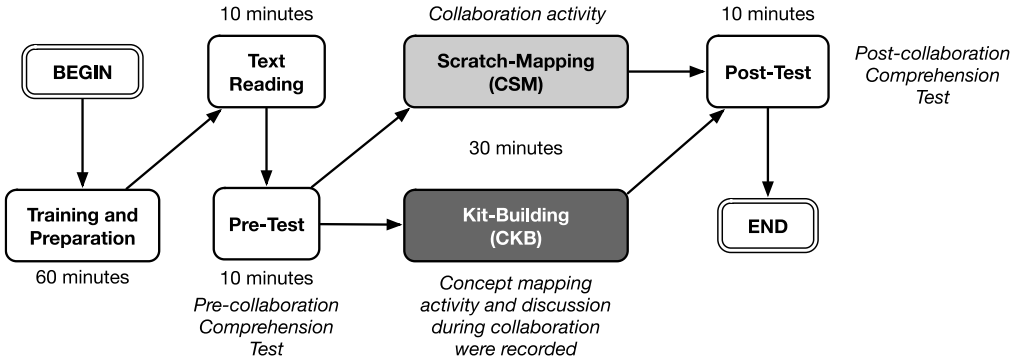

Figure 1. Experiment Flow of Collaborative Learning with Concept Maps.

The participants were 36 graduate students from Hiroshima University and four students from Miyazaki University, Japan. They were non-Japanese international students whose mother language is not English and used English as their primary language during their study in Japan. The students were forming groups of pairs (dyads) and divided into two groups, i.e., Scratch Mapping (CSM) and Kit-Building (CKB). To form the pairs, every student invited one friend at the same education level as their collaboration partner to eliminate language and communication problems during collaboration. According to the demographic questionnaire given, all participants have a minimum Test of English as a Foreign Language (TOEFL) Institutional Testing Program (ITP) equivalent score of 500. Therefore, they were assumed to have adequate English proficiency, especially in reading.

One Kit-Build concept map was made by an English teacher that consisted of 20 concepts and 19 propositions. The concept map represented the knowledge structure of the reading text, decomposed into a Kit-Build kit in a complete decomposition manner. The tests used the same set of questions that consisted of eight multiple-choice questions, and the questions were provided in random order.

4. Result and Discussion

4.1 Student Comprehension and Group Discussion

The pair group comprehension score was defined as the average individual test score of each pair group member. The pre-test and post-test scores were normalized to a maximum score of 10 and are shown in Table 1. The pre-test score data were analyzed with the Levene and Shapiro-Wilk tests to evaluate the homogeneity of variance and normality, respectively. The tests suggested that they were homogeneous (*p-value* = 0.08029 > 0.05) but fail to conform the normality (*p-value* = 0.02513 < 0.05). Therefore, non-parametric analysis methods were used in this study.

In addressing the first research question, whether the Kit-Building method improves group comprehension better than scratch mapping, the Mann-Whitney U tests were carried out to compare the students' pre-test and post-test scores. According to the Mann-Whitney U test *p-values* shown in Table 1 and Figure 2, all students have similar understanding levels before collaboration. However, the difference in both groups' understanding levels after the collaboration activity was statistically significant. The CKB group has better comprehension than the CSM group after the collaboration. Therefore, it can be said that the kit-building method could improve student comprehension better than scratch mapping.

Table 1. *Group Comprehension Test Score*

Test	Approach	n	Mean	Min	Max	Std. Dev.	Median	*p-value*	Sig.
Pre-Test	Kit-Building	10	4.25	3.75	5	0.493	4.38	0.7869	n.s.
Pre-Test	Scratch Mapping	10	4.29	2.14	5.71	1.12	4.64		
Post-Test	Kit-Building	10	7.62	6.88	9.38	0.768	7.5	0.0012	**
Post-Test	Scratch Mapping	10	6.14	5	7.86	0.768	6.07		

The system captured each message sent by the students and counted the message as one talk. Each talk was labeled with one category of the Advanced Interaction Analysis for Teams (act4teams) coding scheme (Kauffeld et al., 2018). The distribution of the talks is also shown in Figure 2. According to the classification, students of the Kit-Building group discuss more the problem because the students of the Kit-Building group have a kit to discuss since the beginning of the collaboration activity. On the contrary, students of the Scratch Mapping group talk about procedural matters more than discussing the topic (Pinandito et al., 2021).

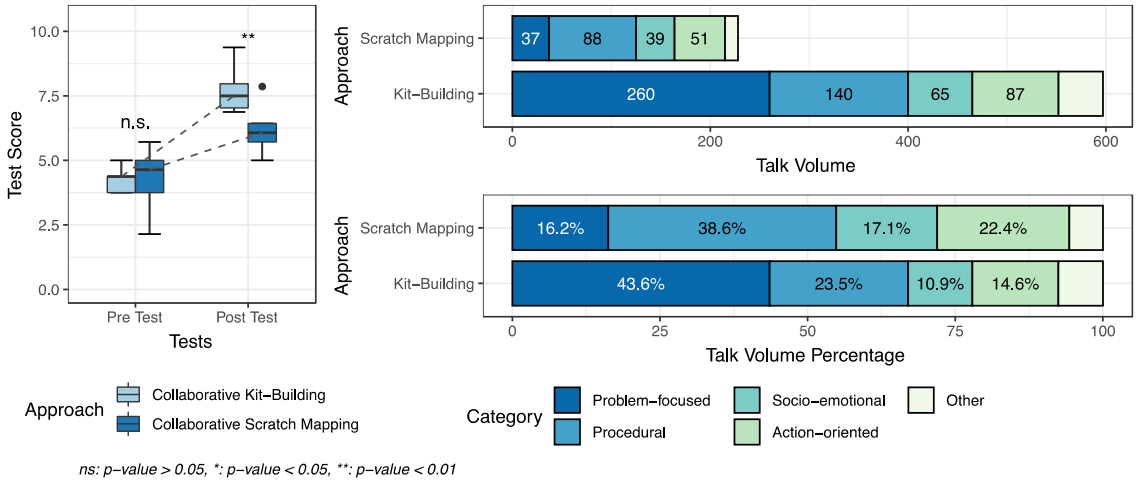

Figure 2. Comparison of Test Score and Talk Distribution.

4.2 The Effect of Concept Map Activity and Discussion Towards Group Comprehension

In addressing the second research question regarding students' activeness in the discussion that affects group comprehension, this study classifies the talks into act4teams categories and analyzes the talks after the collaboration. The group comprehension level after the collaboration was measured by post-test score. The Spearman correlation analysis at a 5% significance level between the volume of the talks to post-test score suggested no correlation for both kit-building and scratch mapping methods (*p-values* > 0.05). Furthermore, according to the Generalized Linear Model (GLM) analysis result as shown in Table 2, the students' comprehension was also not affected by the volume of discussion (*p-value* = 0.73017 > 0.05). Thus, an active discussion during collaboration does not necessarily reflect a higher comprehension of the learning topic. Students who actively discussed the concept maps with their partners have higher post-test scores than less active students. However, there were situations where students who comprehended the reading before collaboration talk and discussed less. Students who did not comprehend the topic may ask to get more information; thus, discuss more actively.

Table 2. *Generalized Linear Model Analysis Result for Post-Test*

	Estimate	Std. Error	t-value	*p-value*	Sig.
(Intercept) (Kit-Building)	7.79403	0.542588	14.365	6.14×10^{-11}	***
Method (Scratch Mapping)	-1.585756	0.459751	-3.449	0.00306	**
Total Talk Volume	-0.002831	0.008075	-0.351	0.73017	

*Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*

Analyzing the talks of act4teams categories with GLM also yielded similar results, as shown in Table 3. Neither of the volumes of the talks of each category influenced the student comprehension. The GLM analysis set the Kit-Building method as the reference variable of the linear model. The Estimate value for the Intercept represented the mean of the Kit-Building concept mapping method. According to the Estimate value of the model, the mean score of the Scratch Mapping method is lower than the reference Kit-Building method (-1.80488). In other words, the post-test score of the Kit-Building method

has a higher mean score (7.85373) than the Scratch Mapping method (6.04885). Both concept mapping methods are shown to significantly influence students' group comprehension (*p-value* < 0.05).

Table 3. *Generalized Linear Model Analysis Result for Post-Test of Each Act4teams Talk Category*

	Estimate	Std. Error	t-value	p-value	Sig.
(Intercept) (Kit-Building)	7.85373	0.66802	11.757	2.67×10^{-8}	***
Method (Scratch Mapping)	-1.80488	0.61683	-2.926	0.0118	*
Problem-Focused Talk	-0.0217	0.02107	-1.03	0.322	
Procedural Talk	0.01115	0.03825	0.291	0.7753	
Socio-Emotional Talk	-0.03052	0.06982	-0.437	0.6692	
Action-Oriented Talk	0.03329	0.05289	0.629	0.54	
Other Talk	0.01957	0.07663	0.255	0.8024	

*Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*

5. Limitation and Future Work

This study used a small number of participants in representing a collaboration group. Insignificant statistical results in this study may also be affected by the low number of samples be involved in the analysis. Therefore, it is difficult to interpret and generalize the result in a larger context due to a larger sampling error. Thus, evaluating the effects with larger samples is strongly suggested for future studies. This study also assumed that the participants could create a well-composed concept map after a short training session and use the collaboration system effectively.

Larger group size may affect how they collaborate and discuss while the concept mapping activity is carried out. Investigating how the students collaborate in a larger group with Kit-Build concept map is one interesting research topic to discuss and investigate in the near future. The act4teams coding scheme was used to categorize the talks during discussion. This study quantifies the discussion activeness based on the talk volume on each act4teams coding scheme rather than investigating the quality or how the students discuss with their collaboration partners.

6. Conclusion

This study suggested that concept mapping is a critical factor for successful collaborative learning in online settings. Using the Kit-Build concept map method helped students improve their comprehension better and encourage more active discussion than the traditional open-end concept mapping method in online collaborative learning with concept maps. According to the analysis result of this study, both concept mapping activities were suggested to influence student comprehension during collaboration. Students who actively discuss during collaboration could improve their comprehension even though the talks were not directly influencing their understanding. Nevertheless, Kit-Build concept map could help the students improve their comprehension better and further emphasized the benefit of Kit-Build as an alternative approach to support online collaborative learning.

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