ATLANTIS PRESS
Advances in Economics, Business and Management Research, volume 184
Proceedings of the Business Innovation and Engineering Conference 2020 (BIEC 2020)

Preliminary Review of Online Collaborative Kit-Build Concept Map Tool in Practical Use

Aryo Pinandito[1,3,*], Didik Dwi Prasetya[2,3], Hanifah Muslimah Az-Zahra[1], Yusuke Hayashi[3], Tsukasa Hirashima[3]

[1] *Information System Department, Computer Science Faculty, Universitas Brawijaya, Malang, Indonesia*
[2] *Department of Electrical Engineering, Engineering Faculty, Universitas Negeri Malang, Malang, Indonesia*
[3] *Graduate School of Engineering, Hiroshima University, Higashihiroshima, Japan*
[*]*Corresponding author. Email: aryo@ub.ac.id*

ABSTRACT
Kit-Build concept map framework is one of the learning frameworks that involves and uses concept maps in its learning activities. The learning process that uses the Kit-Build concept map framework is called the Kit-Build method. Previously, the use of the Kit-Build concept map framework in learning is known to be useful in promoting students' understanding. Several extensions to the Kit-Build concept map framework have been developed to fulfil various use of the framework in different learning subjects, including the use of the concept map framework in a collaborative learning environment. Recently, the need to shift the learning activities towards distant or online learning emerged. Thus, the need for innovations and supports to accommodate online learning become highly demanding. An online collaborative concept mapping tool has been developed to support the students' collaborative learning activities that use the Kit-Build method in the online learning context. The tool allows the students to collaboratively work together to create and construct concept maps, as well as having text-based discussions among group members during the collaborative work of concept mapping. This research presents a preliminary evaluation of how the online collaborative tool supports the students' collaborative work of concept mapping and supports their discussion during collaboration. A comparison of students' learning outcomes between the use of the Kit-Build method and a traditional concept mapping activity in online collaborative work of concept mapping is also presented.

Keywords: *collaborative learning, concept map, Kit-Build, online, tool*

1. INTRODUCTION

The recent change in the educational policy in Indonesia introduces the "Freedom of Learning" program, where it discusses mostly how the national education system will change the assessment method to the students learning outcome [1]. Assessment of the student's competence is not only carried out with a written test but also with other evaluations. The teachers, schools, and universities now have more freedom to assess the student's learning outcomes. In addition to that, the program also mentions the change in carrying out the learning process. The teachers can also have more freedom to choose, create, use, and develop their lesson plans. Moreover, their freedom does cover not only the assessment but also its learning activities.

As the Internet has become more integrated into our daily lives, the demand for information through the Internet is also increasing. Online education also becomes more accessible for people who have access to the Internet. Moving towards online and digital learning has become the most common term in recent discussions about the learning and education system. There are many things to consider when shifting from a regular classroom toward online classrooms. Online learning offers more flexible ways to learn, improves the accessibility of learning contents, and enables the students to set their own pace in learning despite its loss and limitations to have an affective and emotionally engaging learning environment [2][3].

Due to the recent pandemic situation, the government shuts schools, limiting most public and in-school activities, hence encouraging regular classroom activities to

shift towards online classrooms. The teachers and students are forced to conduct the learning activities remotely, while most of them are having difficulties with the online learning due to various reasons. Hence, this situation is resulting in a dramatic change to the learning and education system where requirements for innovations and sophisticating educational technologies to support distant and online learning are unavoidable [4].

One of the learning frameworks that uses computer technology to support learning with concept maps is Kit-Build Concept Map (KB map) [5]. KB map supports learning activities with concept maps that use a computer-supported tool to create and construct the maps. Recent studies show that using a KB map in its practical learning activities effectively improves students' understanding [6][7]. Several studies extend the KB map framework in collaborative learning with concept mapping despite the limitation of its concept mapping tool, which only allows one user to work with a concept map simultaneously [8][9][10].

Though concept mapping activities may reduce student's cognitive load in learning [11], in the KB map, the teachers are required to create the initial concept maps for the students to reconstruct. Several computer-supported concept mapping tools of the KB map has been developed for various purposes [7][12]. Another study tries to extend the functionality of the KB map tool for a situation where a more efficient concept map creation is demanding. It evaluates its usability and user experience in supporting the concept map creation process [13].

There is research that develops an online collaborative concept mapping tool [14] and extends the use of KB map into collaborative use with the existing computer-supported Kit-Build concept map tool [8][9][10]. Although the tool can be used and accessed online, it can only be used by a single user from a single computer terminal and cannot facilitate group discussions. In addition to extending the Kit-Build concept map framework into collaborative use, this research extends the computer-supported concept mapping tool to the next level. The concept mapping tool's current development allows several users to collaboratively work with the same concept maps and let them have a discussion through the system in real-time. Hence, making concept mapping activities with multiple users from a distance made possible.

This research intends to evaluate and review the use of the newly developed online collaborative Kit-Build concept map tool that allows students to collaboratively learn and work with a concept map in an online learning environment. Hence, it explores how the use of the online collaboration tool would affect students' understanding of whether they create the concept maps from scratch or when they reconstruct the teacher's concept maps. As the students should discuss their concept maps during their collaborative work, the volume of the discussion, and the duration of their concept mapping activity are investigated. Potential problems with the use of the tool during this preliminary study are also identified for further improvement of the tool.

2. LITERATURE REVIEW

2.1. Kit-Build Concept Map Framework

Kit-Build concept map framework, also known as Kit-Build framework or KB method, is a learning framework that uses concept maps in its learning activities. The framework offers a quick and easy assessment of student's understanding through the reconstruction of a concept map. The concept map reconstruction is carried out from the components of a concept map, namely a Kit-Build kit [5]. The assessment of students' understanding with Kit-Build is performed by comparing the teacher's and students' concept maps.

A Kit-Build kit, or a "kit," is a collection of several predefined components of a concept map made by a teacher. The kit may be defined from a full or partial deconstruction of the teacher's concept map. A fully deconstructed kit from a concept map has all of its concept and link nodes disconnected. The deconstruction process is yielding a kit comprising concept and link nodes of the teacher's concept maps. Later on, the students will try to reconstruct the teacher's concept map representing their understanding of a particular learning topic or subject with the kit. The reconstruction activity of a concept map kit, which is obtained from the deconstruction of another concept map, is called Kit-Building.

2.2. Online Collaborative Concept Mapping Tool

In facilitating the discussion among users during the collaborative concept mapping work, the system provides a text-based communication channel that they can use to communicate and discuss the map. Part of the discussion can also be linked to a concept or link node. When a discussion is linked to a node, the students can have a separate discussion and also can become more focused on the linked concept, or link node. As the discussion may be located in a different location, a notification to the user interface is given when a new message arrives. The general architecture of the system that is related to the concept mapping tool is shown in Figure 1.

The concept mapping tool, which is implemented as a web application, is provided by a web application server. The tool can be accessed through the Internet and used with modern web browsers that support HTML5 technology, such as Chrome, Firefox, and Chromium-based Edge. The browsers should be configured to run Javascript as most of the application functionalities were written in Javascript. Although the tool is usable with touch-based input, the use of the tool with a smartphone

is not recommended due to the lack of working space and usability on small screen devices.

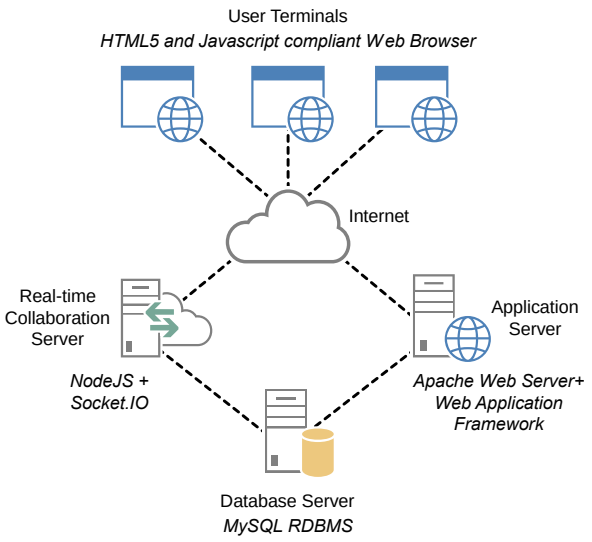

Figure 1 System architecture.

The real-time collaborative concept mapping work and communication are handled by a real-time collaboration server application running over NodeJS and Socket.IO framework. Application, concept map, communication data, activity logs, and analytic data were stored on a MySQL database server. Once the tool and the concept map data have been loaded into the user's web browser, it automatically connects to the real-time collaboration server to synchronize all of the users' collaborative events.

III. METHODOLOGY

3.1. Context and Participants

This research observes the use of Kit-Build concept map tool in online collaborative learning through the concept mapping activity. The main context of this research is to observe how the tool would perform in online or distant learning that uses the Kit-Build concept map framework practically. This research involves an experimental use of the concept mapping tool to support the learning process of several undergraduate classes whose learning activities were carried out online through the internet. The experiment was conducted from April to May 2020, during the 2nd term of the semester, whose learning activities were shifted from a regular offline class to fully online due to preventive action to the recent pandemic issues.

The participants in this experiment were students of the Information System department of Faculty of Computer Science at Universitas Brawijaya, Indonesia. The students who participate in the experiment were all 3rd-grade undergraduate students who enrolled in the class of User Interface Interaction Design course. The Kit-Build concept map framework was integrated into the class learning process.

3.2. Experiment Design

As the target classes and subjects were recently moving to fully online-based learning, several learning procedures were adapted to support the changes. As the use of the online collaborative Kit-Build concept map tool is also new for them, preparations for the experiment need to be carried out to familiarize the teacher and the students in using the tool. The experiment design flow of this research is shown in Figure 2. It is not easy to control an experiment in a class where all of the learning activities were carried out online.

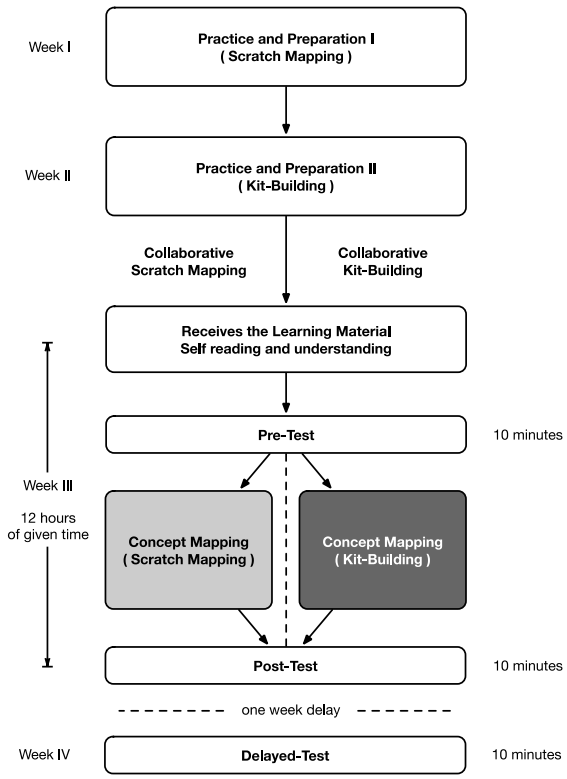

Figure 2 Experiment design.

The experiment was conducted in four weeks. However, the actual data used for analysis were obtained from the last two weeks, while the first two weeks were intended to introduce the system and familiarize the students in using the tool. Before the beginning of the experiment activities, the students were given a user manual, a username with a password, a basic tutorial of concept mapping, and a learning material related to the learning subject in which to create a concept map for them. They were asked to form a group of two students (a dyad) to collaborate in the concept mapping activities.

During the first and the second week, they were asked to create a concept map based on given learning materials

and submit their concept map creation through the university e-learning platform once they had finished their concept map creation. Before each concept mapping session (each week), an instructional document was given as a learning activity guide. The students were instructed to collaborate with their partners to create a concept map that represents their understanding of the given learning material.

In introducing how to create concept maps with the online Kit-Build concept map tool, they were instructed to create the map from a blank canvas (Scratch Mapping) on their first week of learning with Kit-Build. In the second week, they were instructed to do the Kit-Building activity, where they construct a concept map from a Kit-Build kit. They were also instructed to discuss their map during the collaborative work using the provided communication channel so that their discussion can be recorded for further analysis in this research.

In the third week, the actual experiments for practical use of the Kit-Build concept map begin. The dyads of students were randomly divided into two groups, where they differ in the approach of concept mapping activity used. The first group creates a concept map from scratch (Scratch Mapping) and behaves as the control group, while the other group construct a concept map from a kit (Kit-Building) and behaves as the experiment group.

At the beginning of the third week of the experiment, they distributed a learning material to read before using the system. The learning material is composed of a document that contains the topic of the course subject of that week and several linked contents over the Internet. After they read the document, they were instructed to do the experiment activity together with their partner. Before they do the concept mapping activity, they were given a pre-test to measure their current understanding level.

When they were collaboratively creating a concept map, they were instructed to express their understanding of the given learning subject. The students were given a maximum of 12 hours to create and complete a concept map with their partner and use the specified concept mapping approach. They were instructed to create a concept map as complete and satisfying as possible to their understanding. During the concept mapping activity, they were allowed to read the learning subject and access the Internet. After they complete their concept map, a post-test is given to measure their level of understanding after they had a discussion with their partner in a collaborative work of concept mapping. All of the tests were carried out individually, including the delay-test that they took one week after.

3.3. Measurement of Student Understanding

Students' understanding of the learning subject is measured through a sequence of tests, i.e., pre-test, post-test, and delayed-test. The pre- and post-tests are used to measure students' understanding before and after they create a concept map, respectively. The delayed-test is used to measure the amount of knowledge that they were able to retain after one week.

The tests consist of 20 multiple-choice questions related to the learning subject and made by the teacher conforming to Bloom's taxonomy, up to the Apply level. Each question has five options, and each question only has one correct answer. All of the tests used the same set of questions and were provided in random order. The options to the questions were also randomized to minimize students' memorizing effect on the answers. They were given 10 minutes to answer the questions on every test. The system provides an integrated online testing platform to manage the questions and time of the test. They can only take each test one time, and their answer is automatically saved when the time is up.

4. RESULT AND DISCUSSION

From the two groups, five dyads from the Kit-Building experiment group and one dyad from the Scratch Mapping experiment group data were omitted from analysis as their test data is either incomplete or the collaborative work was not carried out. The exclusion of irrelevant data was done because this research investigates the impact of concept mapping activity with Kit-Build in an online collaborative context. Hence, leaving 24 dyads data, composed of 10 dyads that use the Kit-Building approach and 14 dyads that use the Scratch Mapping approach for analysis.

Based on quick review and analysis of activity log data and to the class group discussion, several technical and non-technical issues have occurred during the class. Some of the technical issues that were occurred include problems related to the Internet connection, computer specification, and some other run time issues. On the other hand, several non-technical issues, which prevent the collaboration to be carried out, include communication problems between group members, time allocation for collaboration, and some miss understanding of the instruction that is given before class.

4.1. Student Understanding

Student's understanding was measured by pre-test, post-test, and delay-test scores. The descriptive statistics of student's test scores for the learning topic given in an online class before and after the collaborative concept mapping activity is shown in Table 1.

Table 1 Descriptive Statistics of Test Score

Test	Approach	n	mean	sd	min	max
Pre-Test	Kit-Building	20	14	1.39	11	16
Pre-Test	Scratch Mapping	28	13.4	3.59	5	19
Post-Test	Kit-Building	20	14.7	1.53	12	17
Post-Test	Scratch Mapping	28	14.8	2.75	9	20

Delay-Test	Kit-Building	20	15	1.61	12	17
Delay-Test	Scratch Mapping	28	14.8	3.17	7	19

Based on the evaluation of student's understanding through pre-test, post-test, and one-week delayed tests, it can be seen that there is a slight difference between the pre-test and post-test scores. The difference in the pre-test and the post-test score describes the improvement of students' understanding regarding the learning subject through the concept mapping activity. The comparison between the students' pre-test, post-test, and delay-test scores are shown in Figure 3.

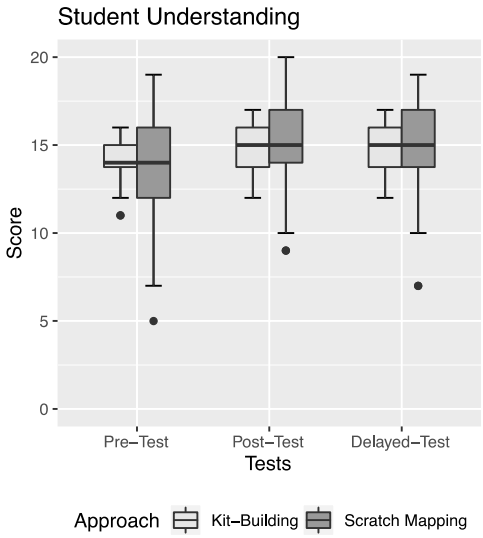

Figure 3 Comparison of student's understanding between approaches before and after the concept mapping activity.

The comparison of test scores between Kit-Building and Scratch Mapping approach in the collaborative concept mapping activities was analyzed using the Mann-Whitney U test as the scores were failed to conform the Shapiro-Wilk normality test with a p-value less than 0.05. Even though both approaches have a slight improvement in the average test score result, the difference between pre-test and post-test scores are statistically significant. The Mann-Whitney U test results between pre- and post-test scores result in a p-value of 0.03984 and 0.00584 (p-value < 0.05) for the Kit-Building and Scratch Mapping approach respectively. Hence, it can be said that both Kit-Building and Scratch Mapping approaches are effectively improving the understanding of students of a learning topic.

Similarly, there are no statistically significant differences between the post-test and the delay-test result for both Kit-Building and Scratch Mapping approaches (*p-value* of 0.586 and 0.5268 respectively) as in [15]. Even though there are no statistically significant differences were found, the standard deviation for the test score was increasing; hence, more diverse in the students' scores. Most of the students can retain most of their understanding after one-week delay.

4.2. Discussion

The student's utterance in the discussions during the collaborative concept mapping activities was recorded. As students were not strictly limited in concept mapping time, they were given more freedom to create, construct, and discuss their concept map until they think a satisfactory concept map has been created. The descriptive statistics of student's discussion during the concept mapping activities are described in Table 2.

The system was able to capture 901 utterances of 24 dyads during the collaborative concept mapping activities. Although some group discussions data were omitted from this research analysis due to completeness issues, it is interesting to investigate potential issues that they had encountered for not being able to do the concept mapping activities collaboratively with their partners. Figure 4 depicts the volume distribution of the students' utterance during collaborative work of concept mapping.

Table 2 Descriptive statistics of discussion during collaborative concept mapping.

Approach	n	mean	sd	median	min	max
Utterance Volume (n)						
Kit-Building	10	32.2	28.6	19.5	6	93
Scratch Mapping	14	41.4	30.8	37.5	11	112
Duration of Collaboration (hours)						
Kit-Building	10	0.791	0.305	0.815	0.41	1.38
Scratch Mapping	14	1.54	0.814	1.38	0.6	3.51

Based on the distribution of the volume of utterance data as described in Table 2 and Figure 4, it can be seen that concept mapping activity with the Scratch Mapping approach tends to have a more active discussion than the Kit-Building activity in volume. However, the differences between both concept mapping groups are not statistically significant. The Mann-Whitney U test that compares the utterance volume of both groups showed an insignificant statistical difference with a p-value of 0.3819.

Despite having a similar volume level of discussion, the use of the Kit-Building approach in collaborative concept mapping requires less time to carry out. The groups' time duration needed to carry out the collaborative work is shown in Figure 5. The duration data of students' collaboration in concept mapping were conforming to the statistical Levene's homogeneity of variance test and Shapiro-Wilk's normality tests. Hence comparing the duration data with Welch's Two-Sample T-Test show a significant statistical difference (*p-value* = 0.01093) between both groups. Hence, it can be said that the use of the Kit-Building approach toward creating a concept map

requires less time than the Scratch-Mapping approach. The comparison of both groups' discussion, in terms of the utterance volume and the duration of their collaborative work, is shown in Figure 6.

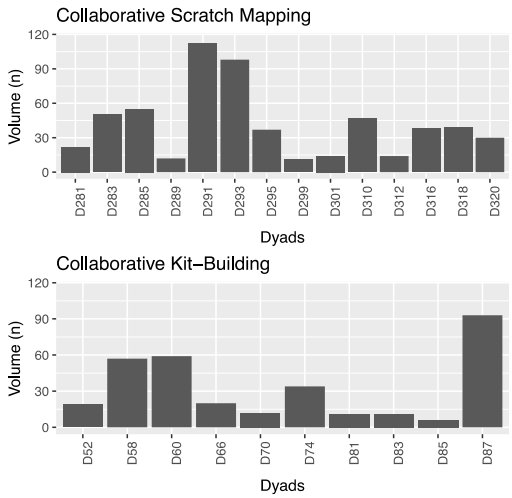

Figure 4 Data distribution of student utterance volume.

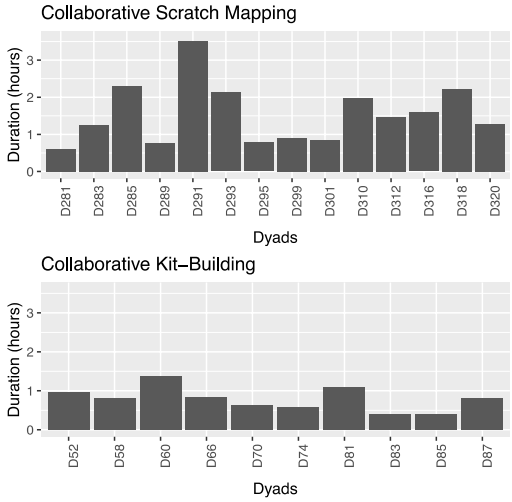

Figure 5 Data distribution of duration of collaboration.

Similar to the experiment results in [8][9], the students' understanding improves after discussing the learning material while collaboratively doing the concept mapping activities. Even though their improvement of understanding was no different despite the approach used during the concept mapping activities, the students, who use the Kit-Building approach, construct the concept map more efficiently.

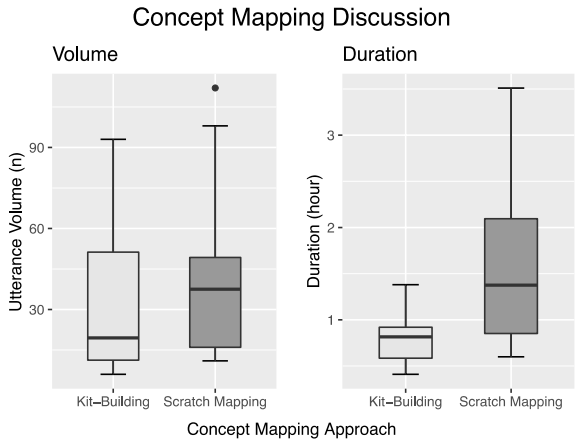

Figure 6 Comparison of students' discussion during concept mapping between Kit-Building and Scratch Mapping.

In a traditional class, most learning activities are usually limited to a specific duration. However, in this research experiment, the students were given enough time to determine when their concept mapping activity end. In connection with that matter, if the students create and discuss the concept map in a similar shorter duration, the discussion is expected to change. Hence, affecting their understanding differently.

5. CONCLUSION AND FUTURE WORKS

The use of the online collaborative Kit-Build concept map tool is effective in improving student's understanding of the given learning material in the context of collaborative learning with the Kit-Build concept map. Even though the tool can only provide text-based communication channels to facilitate group discussion during collaborative work, no notable problems were found during its use. Hence, it can be said that the use of the online collaborative Kit-Build concept map tool can assist the online learning activities that use the Kit-Build concept map framework.

In the context of distant collaborative learning through concept mapping, both traditional collaborative concept mapping approach and Kit-Building approach are shown to be effective in improving student's understanding of the given learning materials. It is also known that the learning process through concept mapping activities requires a significant effort from and put more cognitive load for the students. Both the Kit-Building and the Scratch Mapping approaches show no significant differences in terms of gain in student's understanding. The Kit-Build concept mapping approach is more efficient than the traditional concept mapping approach in a collaborative learning context even though the duration of the collaboration may affect the student's understanding of the learning subject contents.

The use of the online collaborative tool allows the students to deepen their understanding of course materials through concept map creation and reconstruction activities. In addition to the collaborative concept mapping features, the tool also allows the students to discuss the course materials with another student through the system online. Although there are many challenges in facilitating online learning, the system is suitable for use in an online class or in a Massive Open Online Courses (MOOCs) class where the learning materials discoursed online. The use of the tool is also suitable for a group of students who expected to describe, thus deepen their understanding of a learning topic and do the problem-solving activities through concept mapping collaboratively.

This research is yet to evaluate the yielded concept maps and yet to investigate the concept of mapping activities from the student's collaborative concept mapping work. Despite the difficulties in comparing all of the concept maps yielded from these two approaches, it is interesting to investigate the quality of the concept maps that are yielded from both approaches. A more in-depth investigation and analysis of the student's conversation in the discussion may reveal some interesting findings on how they communicate, discuss, and effectively solve problems during the concept map creation process. Some student's collaboration data, which were omitted due to its lack of conformance for analysis, may indicate potential issues in a fully online collaborative learning environment that uses the Internet. Exploration of these issues may help improve the online collaborative system further.

AUTHORS' CONTRIBUTIONS

AP designed and developed the system. AP, DDP, and HMA designed, prepared, and conducted the experiment under the supervision of YH and TH. AP and DDP analyzed the data and prepared the manuscript.

ACKNOWLEDGMENTS

This research is partially supported by Japan Society for the Promotion of Science (JSPS) KAKENHI Grant Numbers 19H04227.

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