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Concept Map Recomposition Approach for Advanced Formative Assessment in Large-Scale Online Course

Sho YAMAMOTO[a*], Aryo PINANDITO[b] & Tsukasa HIRASHIMA[c]
[a]*Faculty of informatics/ Cyber Informatics Research Institute, Kindai University, Japan*
[b]*Faculty of Computer Science, Universitas Brawijaya, Indonesia*
[c]*Graduate School of Advanced Science and Engineering, Hiroshima University, Japan*
*yamamoto@info.kindai.ac.jp

Abstract: Assessment of learner understanding and feedback based on that assessment are important to promote learning in asynchronous online learning. Often, automatic feedback by the learning environment is used as a way of realizing this feedback. However, usual tests are difficult to identify learning objects exhaustively. Concept maps can provide a comprehensive and detailed check of a learner's understanding but are difficult to assess. Therefore, this study used a recomposition concept map called Kit-Build concept map (KB map). KB map system can provide semantic feedback to the learner on differences in understanding automatically. We used this feedback as a formative assessment for the entire lecture. Using the KB map as an assignment for a formative assessment, we conducted a large-scale asynchronous course with a class of 1,380 students from 16 faculties. The results show that learners' understanding is enhanced by concept maps, and that formative assessment by means of concept maps may encourage revision of lesson materials.

Keywords: Formative assessment, asynchronous online learning, assignment, kit-build concept map

1. Introduction

Since the COVID-19 outbreak, online learning has spread rapidly and divergently, and the demand for effective online learning has become an increasingly important issue. There are two types of online learning methods, namely synchronous and asynchronous. In asynchronous online learning, the teacher prepares teaching materials and provides them to learners, who then study at their own pace and time. The asynchronous type is the subject of this study. This type of online learning allows learners to manage their own learning and provides personalized learning opportunities (Garrison, 2003; Nguyen, 2015).

On the other hand, some learners do not have sufficient opportunities to interact during learning (Thamri, Hasan, et al, 2022). Formative assessment is known to help these learners to adjust their own learning (Meusen-Beekman, Joosten-ten, and Boshuizen, 2016). Formative assessment is broadly defined as feedback provided during the learning process (Dunn & Mulvenon, 2009). However, it is also known that this is difficult to realize (Gulikers, Veugen, and Baartman, 2021).

In facilitating appropriate learning for learners, we felt that it was important to be able to assess comprehensively and semantically against the content being taught, and KB maps uses concept maps to externalise learners' understanding and provides automatic semantic feedback on the difference in understanding with the teacher (Hirashima, Yamasaki, et al, 2015). The possibility of such personalized auto-assessment means that personalized formative assessment is also possible in asynchronous online learning, which may promote learners' reflection on the teaching material. This study examines the effectiveness of formative assessment using KB maps in asynchronous online lectures. The lecture is an

introduction to data literacy for all faculties of a single university and is conducted on a large scale with 1380 students.

2. Related Works

Formative assessment is defined as feedback provided during the learning process (Bennett, 2011). Formative assessment is useful for learners to self-regulate their learning, it is difficult to achieve appropriate formative assessment (Gulikers, Veugen, and Baartman, 2021). For appropriate formative assessment, it is important to provide feedback on understanding of the learning subject in a form that is both comprehensive and easy for learners to understand in order to progress their learning. Various automated systems have been proposed to achieve this appropriately and at a low cost. They are often primarily automated for scoring general tests (Febriani & Abdullah, 2018). However, even when test results are given as scores, it is difficult for learner to reflect on s/he's understanding. Tests also make it difficult to comprehensively assess what learners have learnt. Contrastingly, we focused on formative assessments and self-regulated learning using concept maps. A concept map externalizes the structure of a target concept by connecting concepts as nodes and their relationships as links (Novak & Cañas, 2006). Concept maps can provide a comprehensive and detailed check of a learner's understanding and provide semantic feedback. Thus, it is useful to understand the learner's state of understanding more directly and has been suggested as an effective tool for formative assessment (Beaudry & Wilson, 2010).

However, concept maps are difficult to assess automatically, and they incur high costs for map assessment. They often operate such that teachers and peers view the learner's map and interact with it for learning. It is difficult to carry out such activities in asynchronous online learning. We therefore turned to KB maps. In contrast, KB maps are used to automatically assess learner maps (Hirashima, Yamasaki, et al., 2015). KB maps allow the comparison of maps constructed by the teacher and the learner to provide automatic feedback on the differences between each map as errors or lack of understanding of concepts by the learner.

The validity of the automatic assessment of KB in comparison with several manual methods has already been confirmed (Wunnasri, Pailai et al., 2018). The Kit-Build concept map system (KB Map System) has been used in face-to-face learning for the formative assessment of each lesson and has been shown to enable teachers to provide more relevant feedback to learners (Pailai, Wunnasri, et al., 2017). Therefore, we considered that integrating KB Maps into asynchronous online classes would contribute to building a cycle in which learners could deepen their own learning.

3. Kit-Build Concept Map System for Asynchronous Online Classes

A procedure of the formative and summative evaluations based on the KB map used in this study is shown in Figure 1. The teacher represents summarized concepts that s/he wants to transfer to the learner as a concept map (summarized map). The summarized map can be created on a KB map system and automatically decomposed into a set of links and nodes by a KB map system. The decomposed map is referred to as a kit, were created for each class.

For each class, the learner downloads a kit created by the teacher and build it to represent his/her understanding of the taught content (learner map) as assignment. Feedback is available at any time for each assignment. The learner can press the feedback button during map building to determine whether there are links that are improperly connected. In this study, assessment carried out at this time is called formative assessment. In this case, incorrect or unconnected concepts are highlighted using untagged links.

In asynchronous online classes, learners are free to attend classes at any time, making it difficult for teachers to directly intervene in learners' learning. However, the KB Map system provides real-time and semantic feedback based on concepts and its relationships, so that learners can reconsider the lesson content accordingly, leading to a higher quality their understanding of each lecture. After a series of individual lessons, the learners completed a

KB map-building test and a fill-in-the-blank test to check their understanding of the lesson. In this study, the assessment of these tests is referred to as summative assessment. The results of formative assessment are provided to learners as feedback, whereas those of summative assessment are only used by teachers.

Based on the above, the following are the research questions (RQ) for this study as an initial evaluation of the formative evaluation framework using the KB Map: (RQ1) Does formative assessment using the KB maps improve summative assessment performance? (RQ2) Does formative assessment using KB maps encourage positive learner behavior?

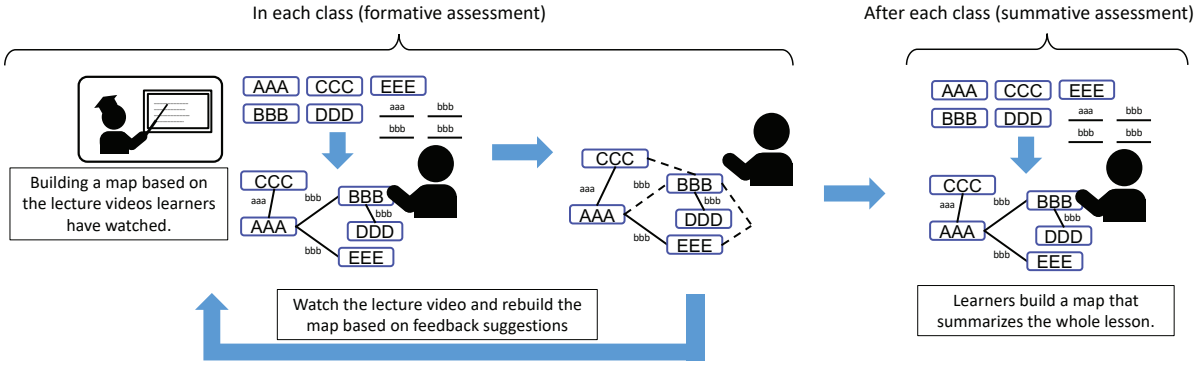

Figure 1. Framework for formative and summative assessment using KB map.

4. Design of the Online Course

4.1 Procedure of Practical Use

This practical application was targeted at a lecture called “Introduction to Data Literacy.” The classes discussed in this paper are lectures 1st, 3rd to 9th, which were delivered in the format described in chapter 3. The participants were 1380 first-grade university students from 16 different faculties. Data from 1113 participants were analyzed in this study. There were three reasons for adopting the log data: (1) Participants agreed to use the data, (2) The feedback from the KB Map system is not an outlier, and (3) complete data. The data were handled in compliance with the ethical codes established by the first author’s university.

Contents of 1st, 3rd to 8th lectures will explain. The target classes are asynchronous online lectures with weekly instructional videos and students may view the videos at their own pace and timing. However, learners were required to view videos within two weeks. After viewing the instructional videos, students work on KB Map assignments based on the instructional videos, which are accepted until two weeks after the end of the 15th class. However, students are informed that points will be reduced by 50% after two weeks—the deadline for the videos.

The second lecture was in an omnibus class in which the learner selected several of the video materials to take; thus, the KB Map assignment was not conducted. In the 9th class, a KB map test and a fill-in-the-blank test were conducted; the KB map test consists of the concepts used in the KB map assignments from classes 1, 3 to 8. The fill-in-the-blank test is provided in the form of a text using these concept. The fill-in-the-blank test is a multiple choice question; all answers are presented as choices for each question. In addition, the KB Map and fill-in-the-blank tests each had a 30-minute time limit.

4.2 Scale of Concept Maps and Assignments for Each Class

A concept map was created by extracting and connecting concepts from slides that served as class materials. The KB Map does not strictly follow the notation defined in the concept map, but the emphasis is on students and teachers agreeing with the concepts being represented. The scale of the KB Maps that the learners were asked to build was such that the assignments had an average number of 39.57 nodes and 39.14 links. Note that some of the nodes and

links were pre-built, so the actual number of nodes averaged 33.42, and the number of links was 32.71. In KB map test, the nodes and links were 42 and 41, respectively. Excluding the pre-built map, there were 23 nodes and 22 links. Two class co-tutors approved the concepts used in the map.

Learners can use immediate feedback while building maps to deepen their understanding of poorly understood concepts and relationships. However, because this feedback is not presented until the links that should be used to connect them are determined, the learner is relearned to confirm his/her understanding of the necessary concepts and their relationships by, for example, referring to the class video.

5. Results and Discussion

5.1 Data Acquisition

The data used in this analysis are the log data of the KB Map, the scores of the fill-in-the-blank test, and the log data of viewing online videos. The log data of the KB Map are the map scores and feedback counts for the KB map assignments. The log data for the KB Map test is only the map score. The fill-in-the-blanks test scores were also used by converting the scores of all 21 questions into percentages of 100. From the viewing logs of online video materials, the number of times the speed of the video is changed, the number of times the viewing point of the video is changed (seek bar operation) and the number of times the video is stopped can be obtained. For our analysis, we divided these data by the number of classes and used them as the average number of times per class. The map score, fill-in-the-blanks test score, and assignment score were scored on a 100-point scale, but other parameters were not capped.

5.2 Results

The means and standard deviations for each data point are listed in Table 1. The average assignment score was 94, with a submission rate of 95%. The average number of times the feedback was actively used was 90. The fact that many students were active despite the KB Map was a new assignment suggests that it was accepted as an assignment.

Multiple regression analysis (MRA) was used to determine the relationship between each test or log. Note that for all results in Table 2 to 5, the Signif. codes are denoted as: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1. From the result of Table 2, there appeared to be a relationship between scores on the fill-in-the-blanks test and the KB map test, as well as scores on the tasks. However, the multiple R-squared value was 0.06, which is not highly explanatory. Spearman's correlation analysis was conducted between the KB Map and fill-in-the-blank test scores. The results showed a slightly positive correlation (r = .23). There was also little correlation between fill-in-the-blank test scores and the number of feedbacks (r=.11).

The result of Table 3 showed that both the number of feedbacks and the average score on the KB Map assignment have an effect. However, the multiple R-squared value was low (.17). Therefore, Spearman's correlation analysis was conducted on the map test scores and feedback counts; however, there was no correlation (r = - .02). The average score on the KB Map assignment was positively correlated with the average score on the KB Map test (r = .40).

Table 1. *Mean and Standard Deviation of Each Collected Data*

	Means	S.D.
Average score of KB map test	87.12	14.55
Average score of fill-in-the-blank test	72.08	15.83
Average score of KB map assignment	94.47	14.39
Average number of feedbacks	90.05	76.16
Average number of seek bar operations	25.99	40.54
Average number of changing video speed	1.91	2.13
Average number of stop operations	7.27	8.54

The results of Table 4 indicated that the number of feedback sessions had an effect. However, the multiple R-squared value was low (.06). Spearman's correlation coefficient was calculated, and no correlation was found (r = .17). The results of Table 5 showed that feedback counts were related to the number of seek bar operations, speed changes, and stop operations. The multiple R-squared value was low (.02). When the correlation coefficients were determined, it was found that the feedback count and seek bar operations were quite positively correlated, with r = .41. The number of stopped operations was also positively correlated (r = .46). However, there was little correlation with the speed change (r = .13).

Table 2. *MRA results with the objective variable as the fill-in-the-blank test score and the explanatory variables as the KB Map test score, number of feedbacks, and KB Map assignment score.*

	Estimated Std.	Error	t value	Pr(>|t|)	
(Intercept)	45.63	3.34	13.67	< 2e-16	***
Score of KB Map test	0.22	0.04	5.76	1.11e-08	***
Number of feedbacks	0.02	0.01	3.41	0.0007	***
Score of KB Map assignment	0.06	0.04	1.44	0.15	

Table 3. *MRA results with the objective variable as the KB Map test score and the explanatory variables as the number of feedbacks, and KB Map assignment score.*

	Estimated Std.	Error	t value	Pr(>|t|)	
(Intercept)	35.12	2.41	14.56	< 2e-16	***
Number of feedbacks	-0.03	0.005	-6.76	2.2e-11	***
Score of KB Map assignment	0.58	0.026	22.39	< 2e-16	***

Table 4. *MRA results with the objective variable as the KB Map assignment score and the explanatory variables as the number of feedbacks, seek bar operations, speed change operations, and stop operations.*

	Estimated Std.	Error	t value	Pr(>|t|)	
(Intercept)	90.59	0.74	121.77	< 2e-16	***
Number of feedbacks	0.05	0.006	8.23	5.22e-16	***
Number of seek bar operations	-0.001	0.01	-0.09	0.93	
Number of speed change operations	-0.11	0.20	-0.55	0.59	
Number of stop operations	-0.03	0.05	-0.52	0.60	

Table 5. *MRA results with the objective variable as the number of feedback and the explanatory variables as the number of seek bar, speed change, and stop operations.*

	Estimated Std.	Error	t value	Pr(>|t|)	
(Intercept)	63.98	3.31	19.35	<2e-16	***
Number of seek bar operations	0.29	0.06	5.08	4.39e-07	**
Number of speed change operations	1.67	1.04	1.60	0.11	
Number of stop operations	2.12	0.27	7.74	2.19e-14	***

5.3 Discussion and Limitation

Analysis results indicate that a deeper understanding of the KB Map test may also improve scores on the fill-in-the-blank test. The KB Map test scores are also related to the KB Map assignment scores, with a deeper understanding of KB Map assignments also improving the KB Map test scores. This is a reasonable result because the concept of KB Map assignment was used in the KB Map test. However, while we found that the KB Map assignment scores were related to the number of feedbacks, we did not find any correlation. One possible reason is that more frequent feedback does not necessarily lead to more effective learning. Therefore, although the possibility of meeting RQ1 was identified, further analyses are necessary.

In addition, analysis results suggest that feedback may have encouraged learners to engage in activities to review the class video again. This confirmed the possibility that formative assessment of the KB Map assignment in the asynchronous online class using feedback could point out the learners' lack of understanding and allow them to recheck the material, thereby enabling them to acquire concepts that the teacher wanted to transfer through appropriate trial and error. These results indicate that RQ2 was identified. However, a detailed analysis of the feature of learners and how feedback is used remains a challenge.

6. Conclusion and Future Works

In this study, we propose the use of a KB Map and framework to realize effective formative assessment in asynchronous online classes. This formative assessment should be comprehensive and able to point out sources of error against the learning content in order for the learner to reflect on his or her own learning and to be effective. Therefore, in this study, we evaluate asynchronous online learning using the KB Map System, which automatically evaluates learners' concept maps.

Consequently, it was confirmed that formative evaluation in the KB Map system may reaffirm the learning material. We were also able to confirm that the performance of the KB Map building influenced the final summative evaluation, and we believe that we were able to provide a useful cycle of asynchronous online learning to learners. However, we have not yet been able to examine how formative assessment was utilized and how the effects differed depending on the attributes of the learners; therefore, a detailed evaluation is needed.

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