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KB-Mixed: A Reconstruction and Improvable Concept Map to Enhance Meaningful Learning and Knowledge Structure

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Abstract: Kit Build (KB) is a closed-ended and reconstruction concept map that proven positive effects in assessment and learning regarding learners' knowledge understanding. The KB design emphasizes the centralization of teacher understanding that would be reconstructed by learners and ignores their knowledge structure itself. This study focused on a new extension of the KB concept map reconstruction, which is combined with the open-ended style called KB-Mixed. KB-Mixed does not only aim to increase knowledge understanding, but also enhance meaningful learning and facilitate knowledge structure. This study involved university students as participants who were divided into two groups, experimental and control. Students in the experimental group were requested to construct concept maps using the KB-Mixed method, while those in the control group used the open-ended concept map which called Extended Scratch-Build (ESB). The experiment results indicated that KB-Mixed outperformed the control group in terms of knowledge understanding and knowledge structure.

Keywords: Concept map, reconstruction, improvable, meaningful learning, knowledge structure

1. Introduction and Motivation

Concept maps are flexible tools for teaching, learning, organizing, and representing knowledge that can be implemented in various fields and education levels, starting from preschool to higher education and corporate training (Novak and Gowin 1984). Concept maps were developed by Novak and Gowin based on the meaningful theory proposed by Ausubel (1963). Meaningful learning occurs when a student chooses to relate new knowledge to prior knowledge. Meaningful learning requires individuals to have a well-organized relevant knowledge structure in a particular area and strong emotional commitment to integrating further with existing knowledge (Novak, 2008). In the context of construction style, concept maps can be classified into two categories: (1) open-ended; and (2) closed-ended (Taricani, 2006). In the open-ended concept maps, learners may use any concepts and any linking words in their maps. The main advantage of open-ended style is the possibility to capture learner's knowledge structure (Ruiz-Primo, 2001; Hirashima, 2018) and facilitate knowledge building, although it will be more challenging to assess and provide feedback. In the other side, a closed-ended style contains finite concepts and links provided beforehand. In this case, learners must use provided components to construct their maps by connecting one concept to another. The main advantage of closed-ended style is offering a well-structured concept map to promote knowledge understanding, although it will be less facilitate the knowledge building situation.

Kit-Build (KB) is a closed-ended style concept map framework introduced by Hirashima (2015). In KB, a learner is provided to nodes and links that are composed of teacher's concept map, and the learner is required to make a concept map by combining them. Thus, the workings of KB consist of three main stages. First, a teacher creates a concept map that will become a goal map. Second, the KB system will decompose the goal map into concepts and links called "kit". Third, the students will be asked to reconstruct the concept map from the provided kit. Therefore, KB map requests a learner to reconstruct the original map by using provided components, and it can be called "reconstructional concept map" (Hirashima, 2018). Some previous studies have revealed many positive effects on the KB concept map to improve learning outcomes, both individually and in groups. The KB design is a

promising method to capture the learner's knowledge understanding in particular material based on the teacher's understanding. However, this concept of map building would be not suitable for capturing learner's knowledge structure itself. From here, we can see the potential work to extend the KB system to facilitate knowledge building and enhance meaningful learning.

2. Proposed Method

The present study focused on a new extension of a closed-ended KB map that calls KB-Mixed. KB-Mixed extends the existing KB framework by integrating the open-ended method to facilitate meaningful learning well. In KB-Mixed, learners will be requested to construct a concept map using a KB approach, and then they continue to extend or improve their previous concept map using an open-ended approach. The main purpose of KB-Mixed is to examine whether the KB extension with the open-ended approach can facilitate learner's comprehension of new knowledge based on their prior knowledge. KB-Mixed also promotes knowledge building, which is usually difficult to obtain either using KB or open-ended concept maps.

KB-Mixed offers two interconnected phases concept map construction, as shown in Figure 1. In the first stage, the use of the KB method that provides kits to be reconstructed by learners is to give learners' knowledge structure and support for meaningful learning. Furthermore, the second stage that allows learners to improve the concept map by adding new concepts and links is to expand existing structures and support knowledge building. Two phases of concept map construction are the main characteristic of KB-Mixed to increase meaningful learning and promote learners' knowledge understanding and knowledge structure.

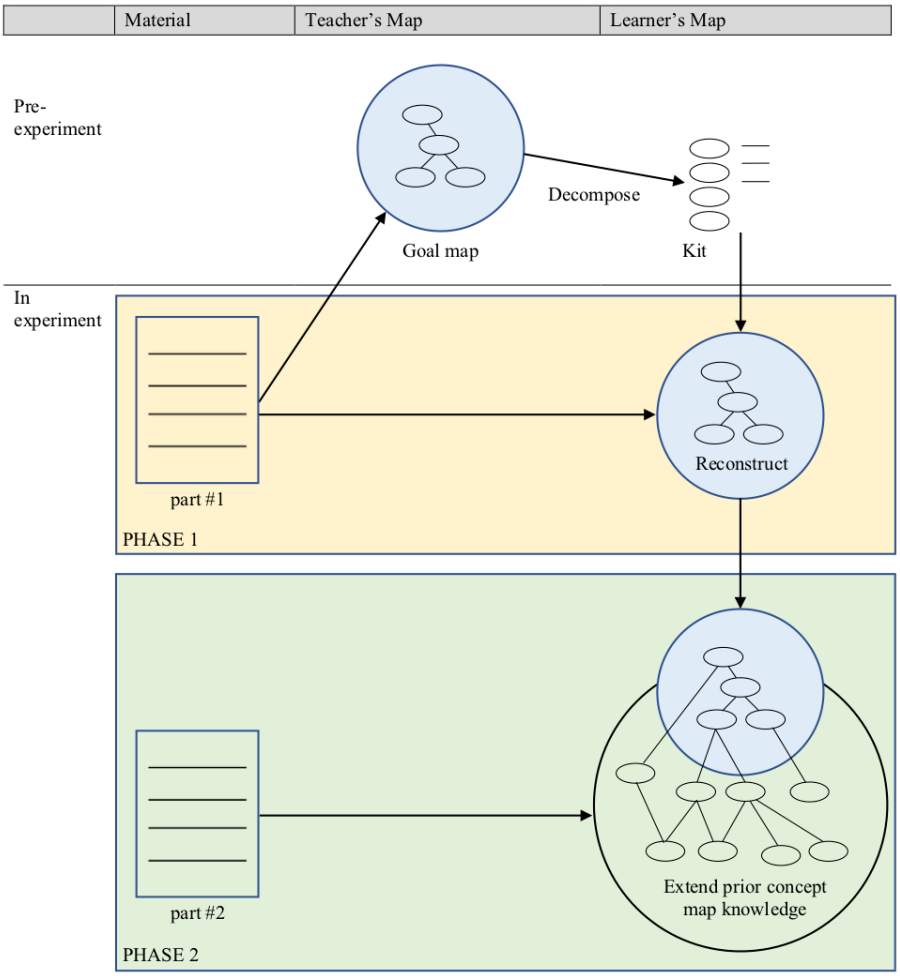

Figure 1. The practical flow of KB-Mixed concept map

Three measurements analysis will be involved to investigate the KB-Mixed performances, including (1) analysis of students' learning comprehend; (2) analysis of knowledge-building through the knowledge structure; and (3) analysis of students' creative thinking. Analysis of students' learning

understanding involved pre-test and post-test design. In the context of this concept mapping, we define knowledge-building as the ability to visualize learners' ideas related to a particular topic. The assessment of the concept map is based on propositions by adopting the quality rating of propositions introduced by Osmundson (1999). To measure the learners' creativity, the Novak & Gowin's (1984) structural method was adopted.

3. Experiment

The first experiment involved 55 students from the State University of Malang, Indonesia, majoring of informatics engineering. Based on their major, participants are familiar with using a computer and the Internet for learning. The participants were divided into two groups randomly, which consists of 27 students for the control group and 28 students for the experimental group. Students in the control group were requested to create concept maps using an open-ended and then extend it using the same method which called extended open-ended, while the experimental group using KB-Mixed approach. In this comparison, we focus on a concept map that provides extensibility through two-phase construction.

This study was conducted in the "Basis Data 1" (Database 1) subject which was delivered in Indonesian. The material used here was "Basis Data Relasional" (Relational Database). The experienced lecturer was involved in conducting theoretical learning in both control and experiment classes. The control and experimental group used the same learning environment, including classrooms, personal computers specifications, and Internet connection. This experiment was conducted in a computer laboratory during one lecture session. Before the investigation was conducted, at the previous course meeting, participants had been given an introduction to concept maps. Table 1 shows the experimental procedure of the control and experimental group. Both groups had different lecture schedules, but they were held in the same 1st-course hours, with a total duration of 100 minutes.

Table 1

The experiments schedule

No	Control group's activity	Experimental group's activity	Duration
1	Pre-test		10 min
2	Teaching material part #1		25 min
3	Create a concept map using the ESB method	Create a concept map using the KB method	15 min
4	Teaching material part #2		25 min
5	Extend previous concept map using the open-ended method		15 min
6	Post-test		10 min

The first experiment involved pre-test and post-test design in identifying learners' performances. The pre-test was designed to examine whether students in the control group and the experimental group had equivalent knowledge regarding related instructional design. Pre-test and post-test design used the same multiple-choice questions, where the post-test is randomly presented. Pre-test and post-test evaluations were carried out by a class teacher because this study was in class experimental. The teacher who conducted the assessment here was also a teacher who taught in class, a senior teacher with more than ten years of teaching experience in database subjects.

4. Results

To identify students' learning performance, we involved post-test used multiple-choice questions. Descriptive statistics of the post-test results of the control group and experimental group can be shown in Table 2.

Table 2

Descriptive statistics of the post-test for both groups

Item	Control Group	Experimental Group
Mean	81.02	87.50
Standard Deviation	10.612	9.001
Minimum	62.50	75
Maximum	100	100

The results of the post-test of both control and experimental groups were analyzed by the Mann-Whitney U test and are shown in Table 3. The results revealed a statistically significant difference in learners' learning performance between the control group and the experimental group after the intervention ($U = 259.0$, $p = .030 < 0.05$). An evaluation of the effect size (ES) indicated a medium effect with Cohen's d value was 0.7.

Table 3

The Mann Whitney-U results of the post-test for both groups

Groups	N	Mean Rank	Sum of Ranks	*U*	*Z*	*p*
ntrol group	27	23.59	637.00	259.0	-2.164	.030
perimental group	28	32.25	903.00			

5. Discussion, Conclusion, and Future Work

This study proposed an idea to extend the existing KB map to promote learners' comprehension of new knowledge. The first experiment results revealed that the experimental group outperformed the control group in terms of students' learning performance indicated by the post-test score. The two phases of concept map construction offered by KB-Mixed has proven to be able to have a positive impact on learning outcomes. Nevertheless, further experiments are still needed to investigate the effects of knowledge building and creative thinking. The second experiment will focus on knowledge building and creative thinking analysis. Also, studies on the automatic scoring of KB-Mixed concept map results are necessary to facilitate the assessment. However, the result of the KB-Mixed concept map is an open-ended style that has too many variations and will make it difficult for the teacher. The future work should focus on automatic scoring in the concept map using novel methods such as machine learning and deep learning.

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