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Investigating the Tightness of Connection between Original Map and Additional Map in Extension Concept Mapping

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Abstract: Extension concept mapping extends an existing original map by linking it to a new additional map. This technique encourages learners to review and improve their knowledge structure. Previous studies have demonstrated the difference of knowledge structure achievements between the original and additional maps in the Extended Scratch-Build (ESB) and Extended Kit-Build (EKB) approaches. However, no information has been provided related to the extent of the tightness between the concept maps. The tight interconnectedness of knowledge structures represents expertise and depth of personal knowledge. This study investigated the effect of different concept mapping tools on the student's ability to connect concept maps. Fifty-five second-year university students participated and were divided into two groups: the control group utilized the ESB map, and the experimental group used the EKB map. Extension Relationships (ER) scores were used to confirm that learners could associate prior existing with new concept maps. ER is a particular link that tightly interconnected the previous original map with the additional map. ER scores evaluate both the quantity and quality of relations that the learners have made. The statistical analysis results emphasized that the experimental group outperformed the control group regarding the number and quality of ER scores.

Keywords: Concept map, extension concept mapping, tight connection, extension relationships (ER)

1. Introduction

A concept map is a visual representation of an individual's knowledge structure. It explicitly expresses the most relevant relationships between a set of ideas (Novak, 2010). Conceptual knowledge in a particular domain requires a highly integrated structure to be meaningful and valuable in its context (Ruiz et al., 1997). In practice, Vanides et al. (2005) said, "highly proficient learners tend to produce highly interconnected maps, whereas novices often create simple structures." Hence, concept interrelatedness is an essential property of personal knowledge. Knowledge structures that are tightly interconnected encourage learners to recall information and achieve meaningful learning (Turns et al., 2000).

The construction style of a concept map can be categorized into two kinds: open-ended and closed-ended maps (Taricani and Clariana, 2006; Ruiz-Primo et al., 2001; Hirashima, 2019). Open-ended fashion is a mapping activity that allows learners to add links, concepts, and form propositions freely that express their knowledge. It enables the teacher to reveal the difference between students' knowledge structures (Ruiz-Primo et al., 2001; Hirashima, 2019). However, it is hard to assess (Taricani and Clarina, 2006) and provides feedback to learners. On the contrary, a closed-ended fashion provides finite links and concepts. The existence of map components enables individuals to recall critical concepts they have learned and reach the maximum test scores (Vanides et al., 2005). However, it is not easy to reveal the differences among students in the closed-ended method.

The initial study proposed Extended Kit-Build (EKB) concept mapping approach to reflect students' knowledge structure in the closed-ended method (Prasetya et al., 2019). The EKB employs a recomposition Kit-Build (KB) framework in providing a solid knowledge structure. A recomposition map is an important learning activity that requests learners to understand other's understanding. During the reconstruction, KB explicitly directs learners to understand the teacher's understanding (Yamasaki et al., 2010; Hirashima et al., 2015). Further investigations were carried out by comparing the performance of EKB and Extended Scratch-Build (ESB), a similar extension concept mapping design (Prasetya et al., 2021). ESB uses the open-ended technique to build the original map and extend it to produce the additional map (Prasetya et al., 2020). The results reported that although the size of the ESB's original map was broader, the overall achievement of the EKB's map was superior. However, there is no information available regarding the extent of the tightness between the original map and the additional map that describes an individual's meaningful learning achievement. Vanides et al. (2005) emphasized that highly interconnected concept maps represent proficiency and depth of personal knowledge.

The present study compared ESB and EKB concept mapping to reveal which approach promotes highly interconnected knowledge structure the extent of the effect. In addition, students' performance in both groups was measured using Extension Relationships (ER) scores consisting of the number of ER and quality of ER. The following research questions guide this study:

1. What is the effect of ESB and EKB approaches on the ability of students to connect concept maps tightly?
2. To what extent is the quality of ER in the EKB compared to the ESB concept mapping?

2. Literature Review

2.1 Extension Concept Mapping

Extension concept mapping is an activity for extending an existing concept map by integrating new relevant information. It provides learners with the opportunity to review initial ideas and connections, elicit missing ideas and relationships, adding new concepts and links, and revising knowledge integration (Foley et al., 2018; Schwendimann & Linn, 2016). Extension concept mapping comprises two interrelated activities creating an *original map* and an *additional map* (Prasetya et al., 2021).

The current study investigated the EKB concept mapping that employs Kit-Build (KB) framework to facilitate students in expressing their understanding (Prasetya et al., 2019). First, EKB's students were requested to recompose the teacher's map related to the original material. Next, they were asked to extend their concept map by adding new concepts and links. The EKB was compared with the ESB concept mapping to confirm its learning effects. ESB's students were allowed to add any concepts and any links in their blank canvas. Furthermore, they were requested to extend the previous map with the same technique. The results confirmed that the EKB group outperformed the ESB group regarding comprehension scores and map size.

2.2 Extension Relationships

Extension concept mapping connects the original map and additional map to form a unified knowledge structure. The relation that links tightly between the original map and the additional map can be called an extension relationship (ER). ERs are an essential component of extension concept mapping activities. The tightness of connection depicts enhanced meaningful learning and depth of personal knowledge (Vanides et al., 2005). In principle, ER is a proposition as in standard concept maps. However, this proposition links directly between the original map and the additional map. An illustration of the ER on the extension concept map can be shown in Figure 1.

Since the ER is a proposition, it could be assessed using proposition-based measurement. ER could be considered to confirm improved meaningful learning in extension concept mapping situations. ER measurement is based on the meaningful learning theory in which learners engage to make sense of their experience, connect one idea to another, and deliver what was studied to answer new obstacles. It denotes that learners are not merely able to apply previously acquired knowledge to build concept maps but also improve meaningful learning to attain new knowledge and solve complex problems. ER represents the deep and broadness of personal knowledge structure and could be assessed quantitatively and qualitatively.

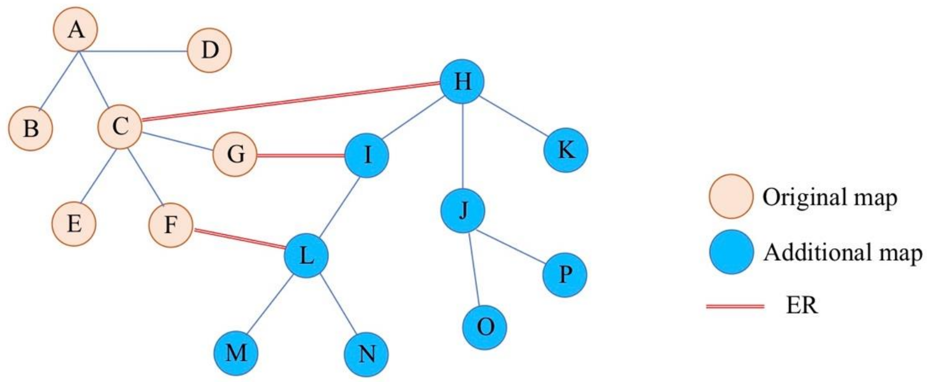

Figure 1. ER illustration in Extension Concept Mapping.

3. Methods

3.1 Participant and Context Material

The participants of this study were 55 second-year university students from two regular classes (A and B). A pre-test was conducted before determining the role of the group, and the results stated that both classes were homogeneous (p = .389 > .05). Therefore, class A was randomly assigned as the control group, and class B was the experimental group. The control group consisted of 27 participants, and the experimental group had 28 participants.

This study was conducted on the Database 1 course with Relational Database topic. The lecturer used a presentation, and she delivered paper-based handouts to students before the teaching activity. In the EKB approach, the lecturer first determined the teacher's map that will be decomposed and then given to students for reconstruction. Original material in the Relational Database topic consists of 283 words (10 slides), and the lecturer provided ten propositions. The content of the additional part consists of 237 words (8 slides), and there was no teacher's map provided for this phase. A senior lecturer who has 11 years of teaching experience taught in both groups.

3.2 Instruments

ER achievement was confirmed using two measurements: the number of ER and the quality of ER. The ER number was calculated through links directly related to the concept between the original and additional maps. The number of ERs represents the number of propositions that act as intermediaries on mapping activities. The amount of propositions symbolizes the broadness of student knowledge in a particular domain (Stoddart, 2006; Jaafarpour et al., 2016). ER demonstrates the extent of students' knowledge structure in extended concept mapping activities.

The ER quality was evaluated using the quality of propositions scores. The quality of propositions is one of the most critical and recommended judgments in the concept mapping assessment and states the quality of personal knowledge (Raud et al., 2016). The lecturer formulated the quality of the ER scoring method to examine the level of students' understanding. Four level scoring were defined: 0 = incorrect; 1 = partially incorrect; 2 = correct with thin scientific understanding; and 3 = scientifically correct. The quality measurements on both groups were judged manually by the same lecturer.

3.3 Procedures

Figure 2 depicts the experimental procedures of the control and experimental groups. Experimental activities begin by giving the original material to the learners for 25 minutes. The lecturer used the same approach in both groups, which consists of conveying the material and discussion as usual. After delivering the first material, next is the concept map construction of Phase 1. Students in the control group requested to create an original concept map used an open-ended technique, while those in the experimental group were utilized the KB approach. During the activity, students were allowed to read the handouts.

Furthermore, the teacher continued presenting additional material for both groups in Phase 2. The second teaching was carried out for 25 minutes with the same approach. Next, students in the two groups were requested to extend their previous map using the same approach within 15 minutes. Students in both groups could add any concepts, links, and form propositions related to the additional material and connect them to the original map. Students could review their previous maps in expanding maps, elicit missing elements, add new ideas, and improve knowledge structures.

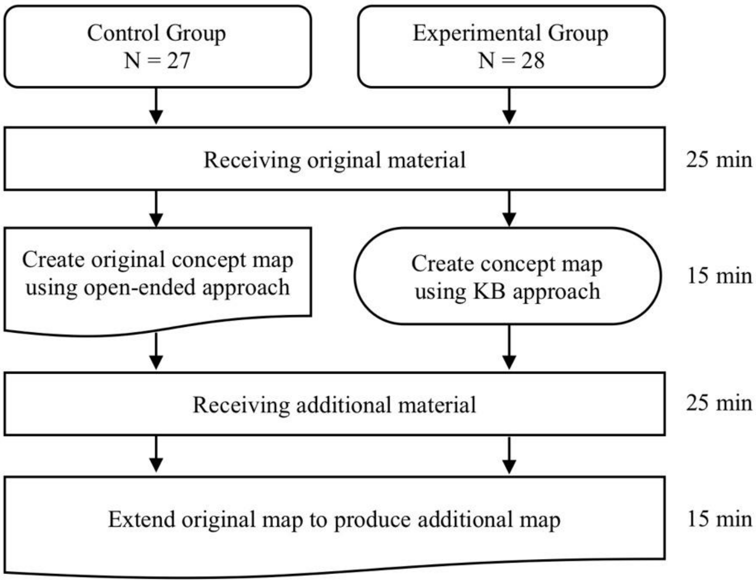

Figure 2. Experimental Procedure.

4. Results and Discussion

4.1 Analysis of the Number of ER

Detailed statistics on the achievement of ER numbers for both groups are shown in Table 1. The average achievement of students in the experimental group was higher than the control group, which was 5.32 compared to 1.63.

Table 1. *Descriptive Statistics of the Number of ER for Both Groups*

Group	N	Min	Max	Median	Mean	SD
Control group	27	1	2	2.00	1.63	0.49
Experimental group	28	2	11	4.00	5.32	3.10

Students' achievement on the ER number between the control and experimental groups was further analyzed using the Mann-Whitney U test. The results showed greatly significant difference for both groups (Z = -5.994; p = .000 < .05). The mean rank of the ER number for the control group was 1.63, while the experimental group was 5.32. The effect size, expressed through Pearson's r, could be calculated using Z values obtained from the Mann-Whitney U test. The results indicated a large effect size (Pearson's r = -.808).

Students' performance in the experimental group who used the EKB approach was superior to participants in the control group who used ESB. The EKB approach that employs KB recomposition on original map reconstruction impacts achieving the number of ERs. Recomposition teacher's map encourages learners to understand knowledge target well. It states an essential learning activity in KB that provides a solid knowledge structure to promote meaningful learning (Prasetya et al., 2021; Pinandito et al., 2021). The kit in recomposition activities encourages students to build original concept maps that have a well-organized basic structure.

4.2 Analysis of the Quality of ER

Table 2 depicts representative statistics of the quality of ER scores for both groups. The attainment of ER quality scores on control and experimental groups has a similar pattern to the number of ERs. Participants in the experimental group surpassed control groups in terms of minimum, maximum, and median values.

Table 2. *Descriptive Statistics of the Quality of ER Scores for both Groups*

Group	N	Min	Max	Median	Mean	SD
Control group	27	2	6	3.00	3.74	1.35
Experimental group	28	5	27	12.50	14.43	7.54

Mann-Whitney U test was undertaken to examine the significant discrepancy between the groups' quality of ER scores. The statistical analysis results indicated significant differences (Z = -6.160; p = .000 < .05) between the experimental and control group, with Pearson's r of -.831, explaining a large effect size. The mean rank of the control group was 3.741, while that of the experimental group was higher at 14.429.

Students' performance in the experimental group in terms of quality of ER scores consistently outperformed those in control groups. The EKB approach in the experimental group facilitates students to discover ER extensively and attained higher quality semantically. In line with Raud's opinion (2016), the EKB approach encourages learners to have a better quality of personal knowledge than the ESB method. KB’s kit is an important learning activity that provides an essential and solid knowledge structure (Prasetya et al., 2021; Pinandito et al., 2021). Referring to the provided kit, students could understand the teacher's understanding well.

5. Conclusion and Future Work

The highly interconnected concept maps represent proficiency and depth of individual knowledge in the particular domain. The present study sought to reveal the extent of the tightness of the connection between the original map and the additional map on the ESB and the EKB concept mapping tools using ER scores. The experimental results showed that the EKB approach facilitates students to define ER numbers more than ESB. In addition, EKB utilizes KB recomposition which encourages learners to understand the teacher's understanding and produces a solid knowledge structure. In the context of the quality of ER scores, students' achievement using EKB also outperformed those using ESB. However, this is a preliminary study, so further studies are needed to determine the measurements' reliability.

The present study had several limitations that should be considered for further work. First, the number of participants involved in this experiment was relatively small. Thus, future works should consider a larger group of participants to examine the effects of extension concept mapping tools on a broader scale. Second, this study was only conducted at a one-course meeting. However, for more optimal results, continuous experimentation is required. In addition, the experimental groups used the incomplete structure provided, while the control groups did not. For future research, it may be necessary to design a genuinely equitable treatment for both groups. Last, ER achievements may be further analyzed with comprehension tests to obtain useful information.

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