Doctoral Thesis

Enhancement of Meaningful Learning with Extension Concept Mapping

(拡張概念マッピングによる有意味学習の強化)

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Abstract

Concept maps are graphical tools for representing the conceptual knowledge structures of individuals. The concept maps' construction style is categorized into two types: open-ended or low-directed and closed-ended or high-directed maps. Open-ended provides no elements, while closed-ended provides finite components. Concept maps have proven to furnish useful approaches for improving and assessing meaningful learning accurately. Meaningful learning engages students in building knowledge and cognitive processes needed to transfer acquired knowledge in new problems and situations. Meaningful learning is recognized as the most prominent factor in developing robust knowledge structures and an important educational goal. Meaningful learning can be improved by expanding the concept map in a student-centered situation.

Extension concept mapping is a technique for connecting the prior existing concept map with further knowledge. Extended mapping activity plays an essential task in knowledge building by reviewing initial ideas, eliciting missing statements, and adding new concepts and relationships. The expansion of the concept map encourages learners to increase their achievement through engagement in solving complex problems. The opportunity involves the learners actively in each phase of the knowledge integrating process, which is not perceived in the usual concept mapping. However, little information has been studied on the extension concept mapping activity and its effects on learners' achievements.

An earlier study attempted to employ extended concept mapping with an emphasis on critical collaborative activity. Positive results have been presented, but yet involved the original learners' knowledge structures. This study designed two extended mapping approaches: Extended Scratch-Build (ESB) and Extended Kit-Build (EKB) maps. These approaches allow learners to extend their previous original map using the open-ended technique that able to reflect the knowledge structure. The ESB's original map was created using the open-ended style, while the EKB used the Kit-Build (KB) framework.

The present study involved second-year students from a public university in Indonesia. A Database 1 course was selected as the context material. Two experiments were conducted on the Relational Database and Structured Query Language (SQL) topics. Students' learning outcomes were measured to confirm the effectiveness of the extended concept mapping.

This thesis consists of seven chapters.

- **Chapter 1** describes the research backgrounds, review existing literature, and identifies some of the challenges to this study. The research objectives

and research questions that guided the study are also presented, followed by the thesis's general structure.

- **Chapter 2** elaborates some of the relevant prior research that supports this study, consists of a concept map, Kit-Build (KB) map, and blended learning.
- **Chapter 3** explains the extension concept mapping activity, ESB, EKB, the participants' characteristics and course subject, experimental procedures, and collected data.
- **Chapter 4** aims to introduce the first extended concept mapping design, which ESB concept map. This section explains the effect of enhancing students' understanding and knowledge structure.
- **Chapter 5** presents the effects of the EKB concept map to improve students' achievements. To find out the performance of EKB, this section compares it with the ESB approach.
- **Chapter 6** explores a study on active and interactive learning content in blended learning. One of the content designs that be emphasized is concept mapping activity.
- **Chapter 7** draws the conclusion, limitations, and suggestions for potential future studies are made.

The experimental results reported that extended concept mapping has the potential to improve students' learning outcomes. Extended mapping activities allow learners to enhance their knowledge structures and learning outcomes. This approach is proven to involve learners more actively and increase meaningful learning. ESB, which extends the open-ended technique, shows that the map expansion can improve students' achievements. The same results were also demonstrated by students who employed the EKB. The EKB approach that extends the Kit-Build map consistently shows superior achievement; even the EKB outperformed the ESB in terms of students' attainment.

Dedication

To my beloved teeny family: my wife Hayu Noeritasari, my first prince Muhammad Alzam Assaqaf, my second prince Muhammad Abrisam Abbasy Assaqaf, and my princess Yukireina Khadeeja Assaqaf.

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List of Publications

Publications

Journal Articles

- IJACSA 2020: **Prasetya, D. D.**, Hirashima, T., Hayashi, Y. (2020). Study on Extended Scratch-Build Concept Map to Enhance Students' Understanding and Promote Quality of Knowledge Structure. *The International Journal of Advanced Computer Science and Applications*, 11 (4), 144-153. DOI: 10.14569/IJACSA.2020.0110420

- LITE 2020: **Prasetya, D. D.**, Hirashima, T., Hayashi, Y. (2020). Improving Knowledge Structure through Extended Scratch-Build Concept Mapping. *Letters in Information Technology Education*, 3 (1), 36-40. DOI: 10.17977/um010v3i12020p036

- EJEL 2020: **Prasetya, D. D.**, Wibawa, A. P., Hirashima, T., Hayashi, Y. (2020). Designing Rich Interactive Content for Blended Learning: A Case Study from Indonesia. *Electronic Journal of e-Learning*, 18 (4), 276-287. DOI: 10.34190/EJEL.20.18.4.001

- IEICE 2021: **Prasetya, D. D.**, Hirashima, T., Hayashi, Y. (2021). Comparing Two Extended Concept Mapping Approaches to Investigate the Distribution of Students' Achievements. *IEICE TRANSACTIONS on Information and System*, E104-D (2)

International Conference Papers

- ICEEIE 2019a: **Prasetya, D. D.**, Widiyaningtyas, T., Putro, S. C., Hirashima, T., Hayashi, Y. (2019). Extended Scratch-Build Concept Map to Enhance Meaningful Learning. In *IEEE 6th International Conference on Electrical, Electronics and Information Engineering (ICEEIE 2019)*, pages 187-191.

- ICEEIE 2019b: **Prasetya, D. D.**, Wibawa, A. P., Hirashima, T., Hayashi, Y. (2019). Digital Content Model for E-Learning System in Higher Education. In *IEEE 6th International Conference on Electrical, Electronics and Information Engineering (ICEEIE 2019)*, pages 192-195.

- ICCE 2019a: **Prasetya, D. D.**, Widiyaningtyas, T., Hirashima, T., Hayashi, Y. (2019). Reconstruction of Concept Map to Promote Learners' Comprehension on New Knowledge. In *The 27th International Conference on Computers in Education (ICCE 2019)*, volume 1, pages 369-371.
- ICCE 2019b: **Prasetya, D. D.**, Hirashima, T., Hayashi, Y. (2019). KB-Mixed: A Reconstruction and Improvable Concept Map with Automatic Scoring using Deep Learning. In *The 27th International Conference on Computers in Education (ICCE 2019)*, volume 2, pages 803-806.
- ICOVET 2020: **Prasetya, D. D.**, Pinandito, A., Hayashi, Y., Hirashima, T. (2020). The Performance of Extended Scratch-Build Concept Mapping Tool in Blended Learning. In *IEEE 4th International Conference on Vocational Education and Training (ICOVET 2020)*, pages 345-349.
- BIEC 2020: **Prasetya, D. D.**, Pinandito, A., Hayashi, Y., Hirashima, T. (2020). Investigating the Distribution of Knowledge Structure using Extended Concept Mapping. In *Business Innovation and Engineering Conference (BIEC 2020)*.

Local Conference Paper

- ALST 2019: **Prasetya, D. D.**, Hirashima, T., Hayashi, Y. (2019). KB-Mixed: Reconstructional and Improvable Concept Map to Promote Learners' Comprehend, Knowledge-Building, and Creativity. 先進的学習科学と工学研究会, 86:78-82.

Source and Original Work

The original material of my own from the above publications has been included in this thesis, with a citation to the appropriate publication appearing at the beginning of each chapter. Other external sources are cited, with the bibliography appearing at the end of the thesis.

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Chapter 1

Introduction

Summary: This chapter describes the background that underlying this research, following by challenges to this study and the general structure of the thesis. This study is based on the valuable potential of expanding the concept map that facilitates enhanced meaningful learning and improves learning achievements. The main goal of this thesis is to introduce two designs of extended concept mapping: ESB and EKB. Both designs were investigated to determine their effect on students' understanding and knowledge structure. The performance of the ESB and EKB was also compared to find out their effectiveness in supporting learning. Through a series of analyses, we are able to identify an extended concept mapping design that has a more positive effect.

1.1 Backgrounds

Concept mapping is a student-centered approach (Kilic & Cakmak, 2013) that facilitates complex problem solving (Kim, 2013), critical thinking (Novak & Cañas, 2008), and creative productions (Novak, 2010), which are the top skills needed in the 21st century. Concept maps are knowledge representations that show different ideas at nodes with linking words that connect two concepts and indicate the relationship between them, thus forming a simple phrase or proposition (Cañas, 2014). A proposition is the smallest semantic unit in a concept map that presents a particular meaning.

There are two kinds of concept map construction styles: low-directed or open-ended and high-directed or closed-ended maps (Ruiz-Primo 1998; Taricani, 2006; Hirashima, 2019). Open-ended provides no components, and it allows learners to use any concept and any linking words in their maps. On the contrary, a closed-ended style provides finite links and concepts. The learners must use the provided components to construct their maps. Both of these creation styles have their own advantages and disadvantages.

Concept maps have proven to furnish useful approaches for improving and assessing meaningful learning accurately (Edmondson, 2005). Meaningful learning occurs when new related ideas are combined with prior knowledge to form individual understanding. Meaningful learning is recognized as the most prominent factor in developing robust knowledge structures (Novak, 2010) and an important educational goal (Mayer, 2002). Meaningful learning can be improved by expanding the concept map in a student-centered situation (Estes, 2004; Prasetya, Hirashima, & Hayashi, 2020).

Extended concept mapping is a technique for connecting the prior existing concept map with further knowledge in certain domains. The extended concept map construction is efficient in organizing design work and building a solid knowledge base (Foley, Charron, & Plante, 2018). Extending activities play an essential task in each stage of the knowledge-integrating process through reviewing prior ideas and connections, eliciting missing ideas and relationships, and adding new concepts and relationships (Schwendimann & Linn, 2016). However, little information has been studied on the extended concept mapping activity and investigate its effects on learners' achievements.

A previous study posits that the initial "expert" map that was expanded through collaborative critique and revision activity could increase and construct a more coherent knowledge structure (Schwendimann and Linn, 2016). Based on these investigations, this study designed two extended mapping approaches: Extended Scratch-Build (ESB) and Extended Kit-Build (EKB) maps. Both of these approaches are a student-centered activity that allows learners to extend their previous original map using open-ended that able to reflect their knowledge. The original map on the ESB was created using the open-ended style, while the EKB used the Kit-Build (KB) framework.

Concept maps are powerful interactive learning media (Ibrahim, 2006) that emphasizes a student-centered approach (Kim, 2013). Concept maps have been widely applied in a challenging blended-learning environment. Previous studies agree that the concept map approach has positive effects on flexible blended learning (Ezequiel et al., 2019; Laer et al., 2019). While existing studies utilize concept mapping to promote students' understanding of blended learning, the students-centered extended concept mapping design is yet implemented in a blended learning environment.

1.2 Challenges

Extended concept mapping is considered a suitable approach to facilitate enhanced meaningful learning (Schwendimann and Linn, 2016; Prasetya et al, 2020). Extended mapping activities give learners the opportunity to review and improve their knowledge structure. However, little effort has been studied the student-centered extended concept mapping and investigate its effects on learners' achievements. The following issues have not been addressed in the previous studies and research literature:

1. Design of Extended Scratch-Build (ESB) concept mapping
   Previous studies posit that although open-ended concept mapping enables the teacher to reveal the difference between students' knowledge structure but the students' understanding is yet optimal achieved (Ruiz-Primo et al., 2001; Vanides, Yin, Tomita, and Ruiz-Primo, 2005). The expansion of open-ended techniques through ESB is sought to encourage students to improve learning outcomes.

2. Design of Extended Kit-Build (EKB) concept mapping

KB is a re-composition and closed-ended concept mapping method that has been shown to have a positive effect on students' understanding (Hirashima, 2019). The expansion of the KB map using the open-ended technique will be an interesting issue which will also allow KB to reveal the differences between students.

3. Comparing the effect of ESB and EKB on students' achievements
   Extended concept mapping has the opportunity to increase student achievement through reviewing and eliciting components (Schwendimann and Linn, 2016). Further investigations are needed to determine the effectiveness of concept maps expansion design. It is very important to compare two similar extended concept mapping approaches to reveal the results.

4. Study on interactive learning media in blended learning situation
   Concept map is an active and interactive learning media (Ibrahim, 2006) that emphasize on students-centered approach (Kim, 2013). Many researchers agree that the concept map approach has positive effects on blended learning environment (Laer and Elen, 2019). Students' engagement throughout the expanded activities would more influence the learning outcomes. Currently student-centered blended learning is also considered as one of the appropriate strategies in the post-COVID-19 era.

1.3 Research objectives

Based on the challenges mentioned above, the main purposes of this study are defined as follows:

1. Designing ESB concept mapping that extends the previous open-ended map using the same construction style in student-centered manner to enhance students' understanding and knowledge structure.
2. Designing the EKB concept mapping that extends the previous closed-ended map using open-ended technique and investigating its effect on students' achievements.
3. To investigate how the effect of student-centered interactive learning content in blended-learning situation.

1.4 Thesis Structure

This section describes the chapters of the thesis; the structure of the thesis and the publications associated with each chapter are illustrated in Figure 1.

- **Chapter 1: Introduction**
  This chapter describes the research backgrounds, review of related existing literature, and identifies some of the challenges to this study. The research objectives and research questions that guided the study are also presented, followed by the general structure of the thesis.
- **Chapter 2: Related works**
  This chapter elaborates some of the relevant prior research that support this study, consists of concept mapping, Kit-Build (KB) map, and blended learning.
- **Chapter 3: Extension concept mapping**
  This chapter explains the introduction of extension concept mapping, its characteristics and activities, ESB concept mapping, and EKB concept mapping design.

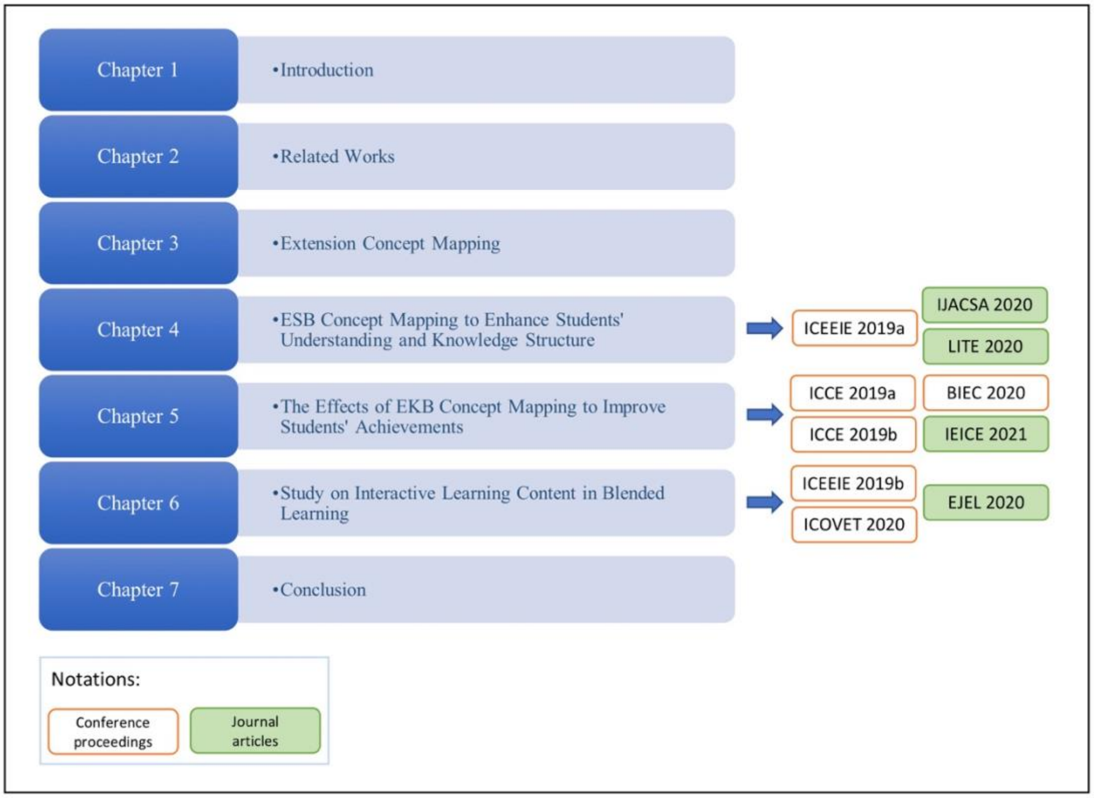

Figure 1. Structure of the thesis and related publications

- **Chapter 4: ESB concept mapping to enhance students' understanding and knowledge structure**

  This chapter focuses on the first research objective: Designing ESB concept mapping to enhance students' understanding and knowledge structure (Prasetya, 2019a; Prasetya, Hirashima, Hayashi, 2020a; Prasetya, Hayashi, Hirashima, 2020b). The ESB system design with the feature to enhance the meaningful learning is explained. The pre-test and post-test, map size, and quality of propositions scores was involved to examine the effect of ESB on students' achievements. The group's achievements on the original and additional map are also evaluated and analyzed further.

- **Chapter 5: The effects of EKB concept mapping to improve students' achievements**

  This chapter presents the analysis of the second research aim: Designing EKB concept mapping and investigate its effect on students' achievements (Prasetya, Hirashima, Hayashi, 2019c; Prasetya, Widiyaningtyas, Hirashima, Hayashi, 2019d; Prasetya, Pinandito, Hayashi, Hirashima, 2020e; Prasetya, Hirashima, Hayashi, 2021). To confirm its performance, the EKB was compared with the ESB and the results were further analyzed. Test scores and map size are used to measure student achievement.

- **Chapter 6: Study on interactive learning content in blended learning**

  This chapter presents the investigation of the third research objective: To investigate how the effect of active and interactive learning content in blended-learning situation (Prasetya, Wibawa, Hirashima, Hayashi, 2019b; Prasetya, Pinandito, Hayashi, Hirashima, 2019d; Prasetya, Wibawa, Hirashima, Hayashi, 2020c). The proper use of active and interactive media is one of the keys to the success of blended learning. Investigations are carried out on content that encourages active student-centered learning.

- **Chapter 7: Conclusion**

  This chapter revisits the studies presented in this thesis makes suggestions for possible future studies.

Chapter 2

Related works

Summary: This chapter outlines relevant prior research in the context of concept mapping and the KB map. Concept maps have been widely used in teaching, learning, and assessment. Concept map construction can adopt an open-ended or closed-ended style. Both of these styles have their own advantages and disadvantages. KB is a re-composition, which is a type of closed-ended concept map that has been shown to have a positive effect on learning. KB is a promising method to capture what the learner understands the teacher's perception.

2.1 Concept map

Concept maps are graphical tools for teaching (Sun and Lee, 2016; Roessger, 2018), learning (Chiou et al. 2015; Chen et al. 2019), organizing (Novak and Cañas, 2008), representing (Ruiz-Primo et al. 1997), and evaluating knowledge (Gökçearslan and Alper, 2015; Whitelock-Wainwright et al. 2020) introduced by Novak and Gowin (1984). Concept maps depict individual ideas that connect two concepts and form a proposition. Propositions can be perceived as components of knowledge (Aleven et al. 2016) that represent the unit's declarative knowledge to form meaningful statements.

Concept map creation can be categorized into two types: low-directed or open-ended and high-directed or closed-ended maps (Ruiz-Primo 1998; Taricani, 2006; Hirashima, 2019). Open-ended fashion is a mapping activity that allows learners to add any links and concepts that express their knowledge. The open-ended method enables the teacher to reveal the difference between students' knowledge structure (Ruiz-Primo, 2001) and develop learners' creative thinking (Ghani, Ibrahim, Yahaya, and Surif, 2017). The drawback to be ponder in the open-ended style are the difficulty of providing automatic assessment and feedback to learners.

On the contrary, a closed-ended style provides finite links and concepts. Learners are asked to use provided components to recompose their map. Because learners use the same components as teachers, the system could provide swift feedback and perform a handy automatic assessment. The existence of map components enables individuals to recall critical concepts they have learned and reach the maximum test scores (Vanides, Yin, Tomita, Ruiz-Primo, 2005). However, activities in closed-ended do not promote students to represent their knowledge because what they are building is the teacher's knowing.

Novak and Gowin (1984) proposed concept maps based on the Ausubel's assimilation theory which emphasized meaningful learning. Meaningful learning is a process of linking new information to relevant previous knowledge in a cognitive structure (Ausubel, 1968). In practice, when students create concept maps by linking one concept to another, meaningful learning is facilitated (Cañas and Novak, 2014). Ausubel (1963) believes that learning is meaningful when the relationship between concepts is scientifically appropriate and integrated. Meaningful learning requires individuals to have a well-organized, relevant knowledge structure in a particular area and strong emotional commitment to integrating new with existing knowledge (Novak and Cañas, 2008). Meaningful learning can be improved by linking prior concept maps to new related knowledge (Boffey et al. 2010).

Concept maps are not merely used to measure students' knowledge and understanding related to particular topics. They can also be employed to promote teacher creativity (González, 2017) and student creativity in a classroom (Chan, 2013; Huang, 2017; Chan, 2017). According to Novak and Cañas (2008), there are two main features of concept maps that are important in the facilitation of creative thinking: (1) hierarchical structure; and (2) cross-links. The hierarchical concept map has a structure that is effective and easy to understand, not solely for its creator but also others. Cross-links show the relationship between concepts in different segments of the concept map structure. Cross-links are a useful attribute that can be used to identify how some domains of knowledge represented on the map are interconnected (Novak and Cañas, 2008) and has been used as one of the crucial parameters in map scoring (McClure et al. 1999).

2.2 Kit-Build (KB) concept map

Kit-Build (KB) is a closed-ended concept map (Hirashima et al. 2015). The KB approach provides nodes and links components deconstructed from the teacher's map and asks students to reconstruct them. The practical uses of KB map can be described in four main phases: (1) a teacher creates a concept map as a goal map; (2) the KB system deconstructs the teacher's map into nodes and links called a "kit"; (3) the students are asked to reconstruct the concept map from the provided kit; and (4) the learners' maps are assessed by comparing them with the teacher's map (Hirashima, 2018). Teachers could prepare the goal map manually in a traditional way by segmenting and structuring map from learning materials or utilize supporting tools (Pinandito et al., 2019). Because the learners' maps are composed of the same elements as the teacher's map, it is easy to recognize the differences between them. Therefore, the KB map requires a learner to reconstruct the original map using the provided components; it can be called a "re-compositional concept map." Two primary aspects characterize the advantages of the KB framework: reconstruction of kit components and an automatic concept map assessment (Hirashima et al., 2015).

Reconstruction is an essential characteristic that identifies KB and distinguishes it from other concept mapping tools. In the original KB, reconstruction describes activities where learners are asked to rebuild maps based on the kit components provided. The kit component represents a closed-ended technique and has an essential role in providing a scaffold to be completed by students. The reconstruction approach allows KB to capture how students understand what is conveyed by the teacher through lectures or learning material in a particular domain (Hirashima, 2018). Reconstructing maps from the same component is very useful for confirming learners' understanding of instructors' explanations. KB matches the maps of teachers and learners at a proposition level to demonstrate the differences between the learners' understanding and the teacher's expectations (Pailai et al. 2017).

Previous studies have revealed many positive effects of the KB concept map on improving learning outcomes and supporting automatic assessment. Alkhateeb et al. (2015) compared the KB with open-ended concept mapping methods in terms of how they supported EFL (English as a Foreign Language) reading comprehension. The results showed that KB had a positive effect on recall after a while. Pailai et al. (2017) examined the practical use of the KB map on formative assessment. The results found the KB concept map to be effective in elementary school participants through three experimental uses in various lecture classes. KB is not only utilized in individual learning but is also suitable for facilitating collaborative knowledge building (Wunnasri et al, 2018; Sadita et al, 2018). Hirashima (2018) emphasized that the KB map is a promising approach for use in the classroom. While previous studies are concerned with the effect of the usual KB map, there is no study that addresses the expansion of the KB map.

2.3 Blended learning

Blended learning is a hybrid of traditional face-to-face and different types of online learning services. The concept of blended learning is derived from two terms, blend and learning. The term blend refers to combining things, and learning denotes the assimilation of new knowledge (Olivier, 2011). Blended learning can be defined as a mixture of face-to-face teaching, characterized by synchronous and human interaction, and full e-learning, which are asynchronous (Graham, 2006; Chaeruman, Wibawa, and Syahrial, 2018). Blended learning offers synchronous and asynchronous learning experiences that combine the conveniences of online courses while maintaining in-person contact.

Blended learning describes learning activities that involve a systematic combination of co-present (face-to-face) interactions and technologically-mediated interactions between students, teachers, and learning resources (Bliuc, Goodyear, and Ellis, 2007). There are several potential advantages to blended learning that are emerging. Some of these revolve around accessibility, pedagogical effectiveness, and course interaction (Dziuban, Moskal, and Hartman, 2005). According to Shih (2010), blended learning that integrates online and face-to-face instruction could create an effective teaching and learning experience for both instructors and students. Busy students like the ability to access course materials anytime, anyplace, and they are positive about the convenience and flexibility these blended courses provide them.

There are three essential components of blended learning: (1) learning environment; (2) instruction; and (3) media (Kaur, 2013). A learning environment can either be synchronous or asynchronous. The instructional component is used to select the most appropriate instructional strategies that support the learning objectives (Kaur, 2013). Media is often associated with technologies that are relied upon in supporting either a synchronous or asynchronous learning environment. Blended learning strategy is satisfactory if it is used student-centered interactive media and methods (Herlo, 2015). The media component has an essential role in appropriately delivering learning content.

Recently, blended learning has again become an interesting issue because it is considered as one of the right digital learning strategies in the post COVID-19 pandemic. Some researchers argue that the blended learning approach is more likely to be applied to the new normal era (Yussoff, 2020). Blended learning enables the face-to-face learning process, which is proven to be able to control the learners' emotions, to run optimally while still paying attention to social distancing. Blended learning strategy is satisfactory if it is used student-centered interactive media and methods (Herlo, 2015). The media component has an essential role in appropriately delivering learning content

Chapter 3

Extension concept mapping

Summary: Extension concept mapping is a technique to connect prior existing concept maps with a new knowledge structure. Design of extension concept mapping facilitates enhanced meaningful learning that occurs when learners link new concept maps to existing ones. This chapter specifically explains more about extended concept mapping. It also introduce two extended concept mapping design: Extended Scratch-Build (ESB) map and Extended Kit-Build (EKB) map.

3.1 Introduction

Extension concept mapping is an activity for extending an existing concept map by adding new components based on the related information (Foley, François, and Plante, 2018; Schwendimann and Linn, 2016). The activity provides learners with the opportunity to review initial ideas and connections, eliciting missing ideas and relationships, adding new concepts and links, and revising knowledge integration (Schwendimann and Linn, 2016). The opportunity engages the learners actively in each phase of the knowledge integrating process, which is not perceived in the usual concept mapping. The added extension of the map illustrates the ability of a learner to achieve enhanced meaningful learning.

Extension concept mapping is composed of two interrelated activities (Prasetya et al., 2021). In the first activity, the learners are requested to construct the concept map (original map) as usual according to learning material (original material). Next, learners are given a new material (additional material) related to the original one, and then they are requested to extend the prior original map based on the additional material that would yield an additional map. Extended concept mapping activity facilitates enhanced meaningful learning that occurs when learners link new concept maps to existing ones. In this paper, the extended concept mapping refers to a composite of the original map and the additional (partial) map. As long as the maps are stored in separate tables, it is possible to evaluate the distribution of students' achievement for each section.

A previous study (Schwendimann and Linn, 2016) compared the performance of two collaborative critique activities using a Knowledge Integration Map (KIM) on "expert map" and "peer map" conditions. The results confirmed that the initial map that was expanded through two forms of collaborative critique and revision activity could increase and construct a more coherent knowledge structure. Based on these investigations, the extended mapping activity in this study has been designed.

3.2 ESB concept mapping

Extended Scratch-Build (ESB) concept map is a graphical tool aimed to enhance meaningful learning and facilitate knowledge building (Prasetya et al., 2019a). ESB is a computer-based and client/server concept mapping tool to support and improve learning services. Students and teachers can use the ESB concept mapping in learning situations. However, teachers only have access to monitoring students' maps because the scoring method was done manually. The ESB tool can be implemented in various learning styles, including face-to-face or traditional learning, e-learning, and blended learning.

ESB inspired by an open-ended concept mapping technique that experienced to capture differences across students' knowledge structures. An open-ended method is a potential approach to reflecting and measuring students' knowledge structure, but the achievement of understanding scores often cannot be maximized (Ruiz-Primo, 2001). ESB attempts to offer an expansion of a two-phase concept map to improve students' learning outcomes. The main difference between ESB and other open-ended concept mapping tools is the expansion feature, which is a unity in map construction.

The expansion of the concept map provides opportunities for students to think more organized and is a realization of improved meaningful learning. As shown in Figure 2, ESB provides a concept mapping feature consisting of two phases: Phase 1 and Phase 2. In Phase 1, students are asked to create a concept map in accordance with the first material or original map with an open-ended approach. Students are allowed to add concepts, links, and define propositions according to their understanding.

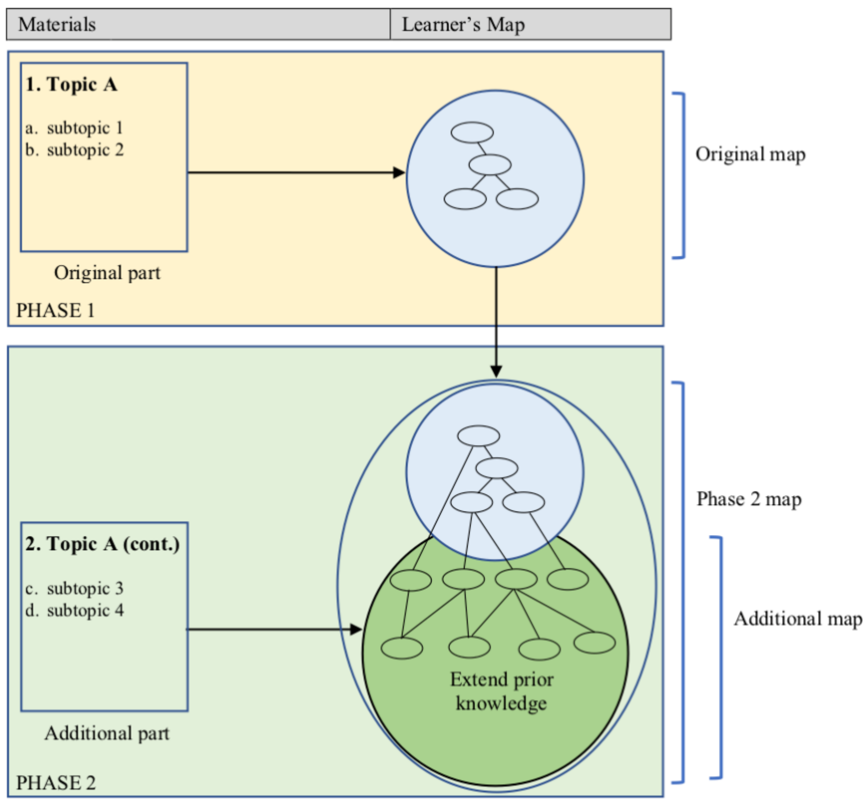

Figure 2. The practical flow of ESB concept map

Furthermore, in Phase 2, students will expand the original concept map by adding new concepts, relationships, and propositions and linking them to the prior concept map. Unlike Phase 1, which started making concept maps from scratch, Phase 2 has provided an original map to be expanded according to additional material. In this situation, students were also allowed to modify their previous concept maps if necessary. In Phase 2, the final result of the individual map would be a combination of the original map and the additional map. However, the evaluation of the expansion of concept maps only considers additional maps, without including the original map.

A map expansion feature is an essential characteristic that identifies the ESB map and distinguishes it from other concept mapping tools. This expansion is also a strategy to realize improved meaningful learning. ESB approach not only realizes meaningful learning when students create concept maps but also enhances them through extended concept mapping. According to Cañas and Novak (2010), meaningful learning is promoted when learners built concept maps, and this activity has been realized in Phase 1 of ESB. Furthermore, Phase 2 requested the students to extend the previous concept map, which also enhances the implementation of two-stages meaningful learning. The design of interconnected two-phases concept map construction provides more opportunities for students to improve their ideas and connect the new information to the existing knowledge structure. Efforts to expand the concept map by correlating new concept maps with current concept maps can be said to be improved meaningful learning.

3.3 EKB concept mapping

The EKB is a new Kit-Build (KB) extension that integrates the open-ended technique. KB map is a kind of re-compositional concept map, which is a subcategory of a closed-ended concept map (Hirashima, 2019). KB style requests a learner to reconstruct a concept map by using provided a kit (set of nodes and links) components that are prepared by decomposing a teacher's map (Hirashima et al., 2015). The teacher who is an expert in related materials would create a teacher's map first.

Extension of the KB map by integrating open-ended techniques into a single concept mapping activity, as shown in Figure 3, was proposed as a solution to reflect students' knowledge structures. The practical flow of the extensible KB concept map can be categorized into two activities: pre-experiment and in-experiment. In the pre-experiment condition, the main role is that of the teacher. Before the experimental activity, a teacher who has mastered a particular topic would make a teacher's map. The KB system deconstructs the teacher's map into the kit made up of nodes and links. Next, in the experiment situation, there are two phases of interconnected concept map construction: Phase 1 and Phase 2. In Phase 1, the usual KB was employed, while Phase 2 utilized the open-ended technique to extend the previous concept maps. Although Phase 1 utilized the KB framework, it did not use the teacher analyzer module since the final individual map produced was open-ended and would be assessed manually by experts. The purpose of dividing the learning material into two parts was to adjust to the experimental setting as a realization of extensible concept mapping.

Referring to the extensible concept mapping has been defined, it can be determined two areas of KB learners' concept maps results: (1) regarding the teacher's map; and (2) not regarding the teacher's map. "Regarding the teacher's map" describes the concept map in original material reconstructed by students based on the kit component of the teacher's map decomposition result. A concept map based on the teacher's map was obtained from each learner in Phase 1. Structurally, the number of concepts and links components in this concept map was precisely the same as those in the teacher's map. On the other hand, "not regarding the teacher's map" is a term used to describe a concept map in the additional material that is not directly related to the teacher's map.

“Not regarding the teacher’s map” is an expansion of the concept map by the learners and represents their knowledge structure.

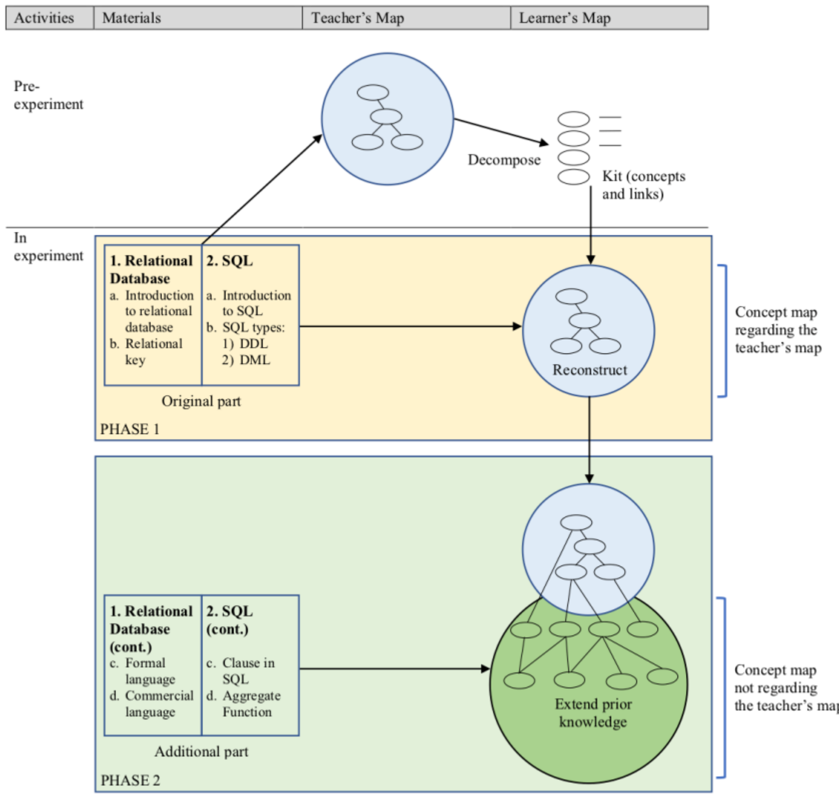

Figure 3. The practical flow of EKB concept mapping

In Phase 2, learners continued with the concept map worksheet they had previously completed to extend or improve their knowledge. In contrast to the previous phase, in this phase, the number of concepts and links in each student was anticipated to be very different from one student to another because they represented their knowledge. KB allows students to build their knowledge by adding new concepts and links, connecting them, and deleting them when they are not required. As long as the purpose of creating concept maps was to facilitate the knowledge-building situation, learners were allowed to read the material while they made concept maps. The results of the concept mapping in Phase 2 represent the final individual map, which is a combination of Phase 1 and its expansion. However, the present study focused on concept maps not regarding the teacher's map, ignoring concept map Phase 1, as an intrinsic representation of the expansion of concept maps.

Chapter 4

ESB concept mapping to enhance students' understanding and knowledge structure

Summary: Open-ended concept map is a standard for reflecting learners' knowledge structure accurately. However, previous studies posit that the students' understanding of learning with this type of concept map tended to be less than optimal. This chapter aimed to introduce the design and effects of ESB concept mapping. ESB is an extended concept mapping design that requests student to connect the prior-existing original concept map with the new additional map on related material topics. The performance of ESB was confirmed through students' achievements and a questionnaire. A pre-test, post-test, delayed-test, and number of propositions scores were involved to assess students' attainment. The results indicated that ESB could improve meaningful learning through extended concept mapping approach and had a positive effect on students' learning outcomes. This study also emphasized that there was a correlation between the original and additional maps on students' learning outcomes.

4.1 Introduction

Open-ended concept mapping is an approach to creating a concept map that allows learners to add any concepts and links according to their own understanding. The open-ended method enables the teacher to reveal the difference between students' knowledge structure accurately (Ruiz-Primo, 2001). Because there is no initial component, learners have the opportunity to think more creatively in completing concept mapping (Ghani et al., 2017).

Several reasonably popular old studies argue that the open-ended technique is an appropriate standard for reflecting the differences among students' knowledge structures (Ruiz-Primo et al., 2001; Vanides et al., 2005; Yin et al., 2005). Hartmeyer (2018) suggested that open-ended concept maps suitable to evaluate students' knowledge and seemed appropriate for formative assessment. Wang et al. (2019) studied a concept map-based learning environment with and without expert template support. The results suggested that the hyperlink support with constructing the map from scratch had a positive impact on the development of comparative strategies and enhanced learning. Tseng (2019) compared the fill-in-the map (closed-ended) and the construct-the-map (open-ended) approaches on students' critical thinking skill development. The investigation results reported that the critical thinking skills scores of the open-ended group were better than students who used closed-ended method.

The present study investigated the effects of ESB concept mapping on students' learning outcomes. The performance of ESB was evaluated using (1) test scores, and (2) map sizes. Test scores were used to measure students' understanding and consist of pre-test, post-test, and delayed-test. A post-questionnaires were also involved to collect the information relating to students' perceptions after using ESB concept mapping.

4.2 Methods

4.2.1 Participants and Context Material

Participants in this study were Informatics Engineering students of the Department of Electrical Engineering, Faculty of Engineering, State University of Malang, Indonesia. A total 25 students (64% male, 36% female) participated. This class is a regular class, and there were no significant age differences between students. Thus, data on age were not provided. In addition, none of the participants had any prior experience with the concept map method.

This study was conducted in the Database 1 course, which was delivered in Indonesian. The lecturer used presentation documents and distributed printed handouts to students. Following the offered experimental design, the material topic was divided into two parts: the original and additional parts. The presentation handout in the original material was composed of 532 words, while the additional material consisted of 829 words. A senior and experienced lecturer who had been teaching for 11 years was involved in this experiment to give a lecture and made an assessment.

4.2.2 Instruments

The effect of ESB on learning was evaluated using (1) test scores and (2) map sizes. Test scores were used to measure students' understanding and consist of pre-test, post-test, and delayed-test. In an effort to obtain feedback from users, this study involved a questionnaire regarding learners' perceptions of ESB.

Pre-test, post-test, and delayed-test were chosen to assess students’ understanding of SQL topics. Delayed-test was not only intended to investigate students' understanding, but also to express students' memory on the material topics. The lecturer designed evaluation questions with five answer choices. There were ten questions used to measure students' understanding consisting of 5 questions related to original part material and 5 questions related to additional part material. Pre-test, post-test, and delayed-test used the same questions that were delivered in random order.

Map measurement was performed based on propositions, which are the fundamental and smallest elements of the concept map that represent components of knowledge. The number of propositions was identified through the number of links connected to two concepts and forms a valid relationship. Proposition calculations were performed on all propositions made by each student, both scientifically correct and incorrect. This study considers all propositions with the reason they commonly describe student knowledge. Map size measurements evaluate the original and additional maps separately, then were analyzed statistically to identify their differences.

4.2.3 Experimental Settings

The experiment was carried out in a computer laboratory during one lecture session. Before the experiment was conducted, in a previous course meeting, participants had been given an introduction to concept maps. Furthermore, participants were also instructed to build concept maps on the introduction of a database system topic. This step was also intended to ensure that all personal computers were able to connect to the server and work appropriately. After the demonstration well-conducted, at the next meeting, they carried out the experiment. The experimental activities follow the timeline, as described in Table 1.

Table 1. The experiment schedule

Phase	Teacher's activity	Students' activity	Duration
1	Act as facilitator	Receive a pre-test	10'
	Give a lecture with original part material	Follow the lectures	25'
	Act as facilitator	Create a concept map based on the original material	15'
2	Continue a lecture with additional part material	Follow the lectures	25'
	Act as facilitator	Expand the previous concept map by referring additional material	15'
	Act as facilitator	Receive a post-test	10'
	Act as facilitator	Receive a delayed-test (1 week later)	10'

The total time of 100 minutes was required in one experiment session. One week after the experiment was finished, students were given a delayed-test to investigate whether they still have good memory related to the topic of the material or not. In this delayed-test, students were only asked to do post-test questions that were given at random. Delay tests did not involve delay map construction, therefore only measure students' understanding. The delayed-test was done without prior notice, so students did not have the opportunity to read the material first.

4.3 Results

4.3.1 Analysis of students' understanding

The pre-test was designed to measure the students' understanding of SQL topics before the intervention, and the post-test was used to investigate the students' understanding after the intervention. The delayed-test was applied to investigate students' retention regarding questions that have been given previously. Descriptive statistics of the pre-test, post-test, and delayed-test scores for the students are shown in Table 2. After giving lecture material and continued with the creation of concept maps and extended maps, the mean scores in the post-test seen to be increased. The Wilcoxon signed-rank test was used to compare the significance of the difference between pre-test and post-test scores. The results of the analysis reported that there were significant differences between pre-test and post-test scores ($Z = -4.314$; $p = .000 < .05$) with a large effect size of Pearson's r value ($r = 0.61$).

Table 2. Paragraph Remaining calculation example

Pairs	**N**	**Min**	**Max**	**Median**	**Mean**	**SD**
Pre-test	25	20	80	40.00	46.00	15.546
Post-test	25	50	100	90.00	80.00	15.275
Delayed-test	25	40	100	70.00	74.40	16.850

The delayed-test was done a week after the experiment was finished and without any prior notice. The results of the Wilcoxon signed-rank test were reported that there were no significant differences between post-test and delayed-test scores ($Z = 1,917$; $p = .06 > .05$) with a small effect size of Pearson's r was 0.27. The statistical analysis results stated that delayed-test scores achievement did not decrease significantly and had a small effect size. Figure 4 shows the average achievement of students' pre-test, post-test, and delayed-test scores.

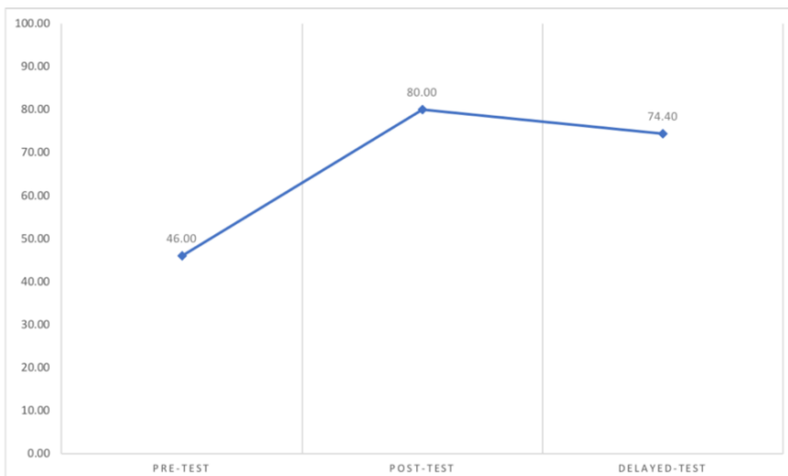

Figure 4. Average of pre-test, post-test, and delayed-test scores

4.3.2 Analysis of map size

The map size illustrates the broadness of the concept map represented by the number of definable propositions. The numbers of propositions for each student in the original map and additional maps were obtained from the system. Descriptive statistics of the number of propositions for original and additional maps are shown in Table 3. The average number of additional map propositions was higher than the original map. The results showed that with the same time allocation, the expansion of the concept map was able to produce a more extensive map size than making a map from scratch.

Table 3. Descriptive statistics of the number of propositions scores

Pairs	**N**	**Min**	**Max**	**Median**	**Mean**	**SD**
Original map	25	5	14	10.00	9.64	2.98
Additional map	25	8	18	12.00	12.36	2.66

The map size results represented the characteristics of an open-ended concept map that facilitates students to express their knowledge. Achievement of the individual map size scores on the original and additional maps is shown in Figure 5. A total of 4 students obtained the map size scores on the original map higher than the additional map; 3 students received the same score between the original and additional map; and 18 students achieved higher map scores higher than the original map. The results of giving the intervention reported that students were able to expand their previous concept maps.

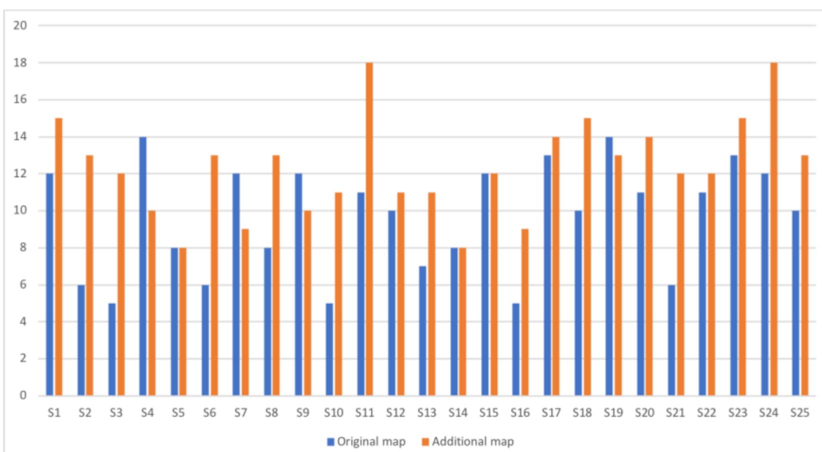

Figure 5. Average of pre-test, post-test, and delayed-test scores

The statistical analysis Wilcoxon signed-rank test was used to determine whether the map extensibility between the original and additional maps was significant. Based on a p-value threshold of 0.05, there was a statistically significant difference between both concept maps ($Z = -3.190$; $p = .001 < .05$) with Pearson's r was -0.45, showing a medium effect size. The analysis indicated that students were not only able to expand the existing concept map, but also reach a larger map size than the prior map.

4.4 Discussion

4.4.1 The effects of ESB on students' understanding scores

Constructing an open-ended concept map technique is consider appropriate because it shows the difference between the knowledge structures of the learners (Ruiz-Primo et al., 2001; Vanides, 2005; Taricani and Clariana, 2006) and able to recall the basic terms in learning (Clariana, 2010). Although some researchers reported that the open-ended approach is not able to achieve a maximum understanding score (Ruiz-Primo et al., 2001; Vanides, 2005), the expansion of the concept map through ESB showed a different findings. Pre-test and post-test scores reported that teacher explanations supported by ESB concept mapping could significantly increase students' understanding. Likewise, with the delayed-test results, students still have a good memory of the material that was taught a week ago. This finding evidenced through the delayed-test scores, which was not significantly different from the post-test, despite a decrease in the average value of the group.

The ESB strategy, had proven to be able to increase students' understanding regarding the material. The expansion of the concept map by linking new propositions to the existing map encourages students to improve their understanding. Students were asked to connect prior core concepts with new concepts. Thus, students can further increase focus and ignore other ideas that do not represent key concepts. Observations in the learning process reported that students who were still uncertain of the correctness of the propositions they had made would make use of the second teaching session to ask questions actively. Next, in the second concept mapping session, they had the opportunity to correct and add more new relevant propositions. This situation made ESB suitable for use to facilitate formative assessment in a classroom. As confirmed by Hartmeyer et al. (2018), the open-ended concept mapping technique most appropriate for the formative evaluation.

4.4.2 The effects of ESB on map size

In Phase 1 concept mapping, students were able to express their knowledge related to the material topics. The results of creating the original map show that each student could express their knowledge naturally, as indicated by the achievement of a varied number of propositions. Fletcher et al. (2018) argued that knowledge structure within groups illustrates variations of individual ideas according to their responsibility. Phase 2 is a crucial stage that illustrates the main activities of ESB concept mapping. At this stage, students were allowed to expand the original map by adding new relevant propositions.

The results reported that ESB could increase the original map size significantly. In making the original map in Phase 1, most students had not finished it completely. Phase 2 provided a valuable opportunity for students to review and improve their concept maps. As a result, the achievement on the additional map is higher than the original map. The number of concept map components defined by students illustrates the amount of information collected and elaborated by them (Clariana et al., 2013).

4.5 Conclusion

This study investigated the effects of EKB concept mapping on students' achievements, consisting of understanding and map size scores. The main contribution of the current study was to propose an ESB concept mapping approach and observed its effect on students' learning outcomes. ESB offers an expansion of concept maps by adding new propositions and linking them to prior existing maps to enhance meaningful learning. The ESB approach realized improved meaningful learning that was represented through the original map and additional map. Experimental results reported that ESB had a positive effect on students' learning outcomes. ESB had positive impacts on students' learning understanding measured by using a pre-test, post-test, and delayed-test scores. The findings also revealed that students' additional maps were able to achieve significantly increased map size scores compared to the original map. This study also emphasized that there was a correlation between the original map and the additional map on students' learning outcomes.

This study involved several limitations that should be considered for further works. First, this study was conducted in one experimental group. Future works should include the control group to investigate the performance of ESB. Second, the students who participated in this experiment were relatively small. Future studies should consider more significant participants to examine the effects of ESB on a more broad scale. Finally, the pre-test, post-test, and delayed-test questions were used to assess the students' learning understanding were also relatively small. In the future, more design questions will be able to reveal a more comprehensive understanding of particular topics.

Chapter 5

The effects of EKB concept mapping to improve students' achievements

Summary: KB map is a kind of re-compositional concept map, which is a subcategory of a closed-ended concept map. Through several practical uses, it has been confirmed that the KB map is effective in promoting learner's comprehension of a learning material. However, activities in KB yet promote students to represent their knowledge because what they are building is the teacher's knowing. This chapter introduces EKB, a new KB extension which allows the learner to expand the KB map using a open-ended technique. The performance of EKB was compared with ESB that also employed extended concept mapping design. A pre-test, post-test, map size, and quality of propositions were involved to evaluate students achievements. The findings show that both ESB and EKB are an extensible concept mapping design which facilitate enhanced meaningful learning. The results reported that EKB not merely outperformed ESB in terms of total understanding score, number of propositions, and quality of propositions but also had a more even distribution of mastery in all material subtopics.

5.1 Introduction

The expansion of the concept map encourages learners to increase their achievement through engagement in solving complex problems. An expanded concept map structure is efficient in organizing design work and building a pertaining knowledge base in a particular domain (Foley et al., 2018; Schwendimann and Linn, 2016). During the elaboration activity, learners are tightly involved in compound experiences that are related to one another. The map expansion facilitates learners to integrate knowledge in student-centered learning situations actively.

Extended concept mapping is composed of two interrelated activities. In the first activity, the learners are requested to construct the concept map (original map) as usual according to learning material (original material). Next, learners are given a new material (additional material) related to the original one, and then they are requested to extend the prior original map based on the additional material that would yield an additional map. Extended concept mapping activity facilitates enhanced meaningful learning that occurs when learners link new concept maps to existing ones. In this paper, the extended concept mapping refers to a composite of the original map and the additional (partial) map. As long as the maps are stored in separate tables, it is possible to evaluate the distribution of students' achievement for each section.

This study investigates the difference between the effects of the two different methods of the original map building, one is scratch-building, and the other is kit-building (Hirashima et al., 2015). The scratch-building or open-ended mapping is a usual method where a learner is allowed to make a node and link freely by him/herself. In the kit-building, a learner is provided a set of nodes and links and then requested to reconstruct a concept map using the components. The set of nodes and links are prepared by decomposing a teacher's map of a target learning material. Several kinds of researches have already confirmed that the kit-building is sufficient for a learner to promote comprehension following the teacher map (Hirashima, 2019; Pailai et al., 2017). This research examines that the concept map built by kit-building is useful as the original map to be extended by the learner.

In this study, a learner in the experiment group used kit-building to build the original map and used scratch-building to extend the original map. A learner in the control group used scratch-building both to make the original map and to extend it. The activity of the experiment group is called Extended Kit-Build (EKB), and the activity of the control group is called Extended Scratch-Build (ESB). We have already developed the ESB system (Prasetya et al., 2019) and confirmed that it is useful for learning (Prasetya et al., 2020). This study compared the performance of ESB and EKB to investigate the effect on students' achievements (Prasetya et al., 2021).

5.2 Methods

5.2.1 Participants and Context Material

The present study involved 55 Informatics Engineering students (65.45% male, 34.55% female) from the Department of Electrical Engineering, State University of Malang, Indonesia. There were no significant age differences between students; thus, data on age were not provided. All participants are novices in the context of using concept mapping. The test of homogeneity of variances was performed before determining the control and experimental groups and showed equal differences (p = .389 > .05).

This study was conducted in the Database 1 course, with the topic Relational Database. The material topic consists of two following subtopics: (1) original material: introduction to a relational database (consisting of 192 words) and relational keys (consisting of 139 words), (2) additional material: formal language (composed of 101 words) and commercial language (composed of 81 words). In the EKB, an experienced lecture provided the teacher's map for the original material includes ten propositions. The lecturer used a presentation and distributed printed handouts to students.

5.2.2 Instruments

Three measurements were involved in confirming the distribution of students' achievements in each subtopic: 1) understanding test; 2) map size; and 3) quality of knowledge structure scores. Test of understanding was carried out using pre-test and post-test designed by expert teachers. There were eight multiple-choice questions, and four questions represented each subtopic of materials. The teacher had marked each question, where four items were related to the original material, and four items were associated with additional material.

Measurement of the distribution of knowledge structure was based on the number of propositions in the original and additional maps. The number of concept map components illustrates the amount of information collected and elaborated by learners (Clariana, 2013). For each existing proposition, it was identified by referring to the appropriate subtopic of materials. The calculation of the number of propositions in the subtopic was done manually by the class teacher.

The existence of propositions in the concept map represents students' knowledge and understanding of a particular topic. However, relationships are still not clearly defined in terms of whether they are reasonable or scientifically meaningful (Vanides, 2005). Students' knowledge and understanding measurements were carried out based on the quality of propositions of the concept map. The quality of propositions scoring method proposed by Osmundson (1999) was used to examine the students' knowledge and understanding. Four levels of proposition scores were formulated, from incorrect relationships (score = 0 points) to most scientific understanding (score = 3 points). Two midpoints were representing practical understanding (score = 1 point) and correct with thin scientific understanding (score = 2 points). Referring to the individual proposition-based scores, the teacher could calculate to obtain the total group scores representing the quality of knowledge and understanding. Similar to the size calculation, the quality measurements evaluated the original and additional maps in the two groups, then analyzed and compared their differences. The proposition-based map scores were assessed by the teacher, who also taught in the classroom.

The normality distribution and homogeneity of variance were examined to determine whether the data could be analyzed using a parametric test. Since the data were not normally distributed, the analysis was performed using non-parametric statistical tests.

5.2.3 Experimental Settings

The experiment for both groups was carried out in a computer laboratory during one lecture session. Before the experiment was conducted, in a previous course meeting, participants in both groups had been given an introduction to concept maps, including usage practices. The experiment activities following the timeline in Table 4.

Activity in Phase 1 was started with giving the pre-test in both groups. Furthermore, the teacher delivered the subtopic 1 materials. Lecture activities were carried out face-to-face, and students took lectures as usual. After the first lecture, students in the control group were asked to create concept maps with a scratch-build approach, while those in the experimental group used the KB map. During the concept mapping activity, students were allowed to read the printed handouts.

Table 4. The experiment schedule

Phase	Teacher's activity	Control group's activity	Experimental group's activity	Duration
1	Act as facilitator	Receive a pre-test		10'
	Gives a lecture original material	Following the lecture		25'
	Act as facilitator	Create concept map using scratch-building	Create a concept map using kit-building	15'
2	Continues a lecture additional material	Following the lecture		25'
	Act as facilitator	Extend previous concept map using scratch-building (open-ended)		15'
	Act as facilitator	Receive a post-test		10'

In Phase 2, the teacher continuing lecturing on additional material (subtopic 2). The procedure and time allocation of the lecture were the same as in Phase 1. Furthermore, students in both groups were requested to expand their prior concept maps using the same open-ended approach. The students could add any concepts, links, and create propositions according to their understanding. Finally was the evaluation of students' understanding of the course material through a post-test.

5.3 Results

5.3.1 Analysis of students understanding

The pre-test was designed to diagnose whether students in both groups had an equivalent understanding. The Mann-Whitney U test was used to determine whether there were significant differences between the pre-test scores for both groups. Based on a p-value threshold of 0.05, the results in subtopic 1 (p = .532) and subtopic 2 (p = .594) indicated there was no statistically significant difference between students' scores in the control and experimental groups.

The post-test design was adopted to investigate the students' achievements after received the intervention. Table 5 presents the descriptive statistics of the post-test scores regarding material subtopics for two groups. The performance of students for the questions in the original material was almost the same. For questions in additional material, the experimental group's performance was superior to that of the control group.

Table 5. Descriptive statistics of the post-test scores in original and additional materials

Questions	**Group**	**N**	**Min**	**Max**	**Median**	**Mean**	**SD**
In original material	Control	27	75.00	100	100	95.37	9.90
	Experimental	28	75.00	100	100	96.43	8.91
In additional material	Control	27	25.00	100	75.00	66.67	18.34
	Experimental	28	50.00	100	75.00	78.57	17.63

The degree of differences between post-test scores attainment was further measured using the Mann-Whitney U test. Table 6 exposes the statistical analysis results of the post-test scores regarding material subtopics. For questions in the original material, there were no significant differences between the post-test scores of the two group experiments. Pearson's r value was -.057, which denoted a small effect size in the comparison result. For the questions in additional material, a significant difference was found with Pearson's r of -.305, indicating a medium effect size.

Table 6. The Mann-Whitney U test results of the post-test scores regarding material subtopics

Questions	**Group**	**N**	**Mean Rank**	**Sum of Ranks**	***U***	***Z***	***p***
In original material	Control	27	27.41	740.000	362.000	-.420	.674
	Experimental	28	28.57	800.000			
In additional material	Control	27	23.50	634.50	256.500	-2.260	.024
	Experimental	28	32.34	905.50			

Even though for questions in the original material, there were no significant differences, but the average mean of the experimental group was slightly higher than the control group. In addition, the comparison of the scores of the two groups also had effects, even in the small effects size category. Based on the results of the post-test scores, the experimental group achievement in the original and additional subtopics was more distributed than the control group.

5.3.2 Analysis of map size

Similar in post-test analysis, propositions in expansion activities consist of two parts: propositions on the original map (subtopic 1) and the additional map (subtopic 2).

Descriptive statistics of the number of propositions regarding material subtopics are shown in Table 7. There was an exciting pattern found in the obtained data. For the propositions in the original map, the average number of propositions of the control group was higher than the experimental group. However, for the propositions in the additional map, there was a drastic change, where the average number of experimental group propositions was more elevated.

Table 7. Descriptive statistics of the number of propositions in original and additional maps

Questions	**Group**	**N**	**Min**	**Max**	**Median**	**Mean**	**SD**
In original material	Control	27	11	33	17.00	18.04	5.10
	Experimental	28	13	18	14.00	14.07	1.44
In additional material	Control	27	1	11	6.00	5.30	2.49
	Experimental	28	5	21	11.00	11.54	4.32

Table 8 shows the statistical analysis results of the number of propositions regarding material subtopics. The results in the subtopic 1 indicated that the students in the control group achieved a higher number of propositions than those in the experimental group. There was a significant difference, with Pearson's *r* was -0.484, showing a medium effect size.

Table 8. The Mann-Whitney U test results of the map size regarding material subtopics

Questions	**Group**	**N**	**Mean Rank**	**Sum of Ranks**	***U***	***Z***	***p***
In original material	Control	27	35.80	966.50	167.500	-3.591	.001
	Experimental	28	20.48	573.50			
In additional material	Control	27	16.70	451.00	73.000	-5.155	.000
	Experimental	28	38.89	1089.00			

Consistent with the post-test attainment, contrary conditions were found in subtopic 2, where students' performance in the experimental group was superior for propositions in additional maps. There was a significant difference between the number of the proposition in the experimental group and the control group. Pearson's r value -.695 also reported there was a large effect size in the comparison analysis.

Regarding the size of the extended map (that is, the original map + additional map), the experimental group is superior to the control group in the total number of propositions. There was a significant difference ($Z = -2.001$; $p = .045 < .05$) between the mean of the total propositions in the control group (23.33) and the experimental group (25.61).

5.3.3 Analysis of map quality

Referring to the proposition-based scoring method, the lecturer could get the total concept map scores that describe the quality of individuals' knowledge structure. Descriptive statistics of the quality of propositions scores on material subtopics are shown in Table 9. An interesting finding is seen in achieving the quality of propositions on the original map. In the previous analysis of number of propositions, the control group's average score outperformed the experimental group using EKB. As for achieving the quality of propositions, the average score of students in the experimental group was approaching the control group.

Table 9. Descriptive statistics of the quality of propositions in original and additional maps

Questions	Group	N	Min	Max	Median	Mean	SD
In original material	Control	27	21	80	36.00	39.85	14.69
	Experimental	28	33	53	38.50	39.43	5.03
In additional material	Control	27	2	20	8.00	9.26	4.89
	Experimental	28	5	21	11.00	11.54	4.32

The degree of differences between the quality of propositions scores for both groups was measured using the Mann-Whitney U test. Table 10 depicts the statistical analysis results of the quality of propositions scores on subtopics material. In original map results, the mean rank control group was slightly higher than the experimental group, 25.72 and 30.20, respectively. Even so, there was no significant difference between the quality of propositions for both groups with Pearson's *r* of -0.140, indicating a small effect size.

Table 10. The Mann-Whitney U test results of the quality of propositions scores regarding material subtopics

Questions	**Group**	**N**	**Mean Rank**	**Sum of Ranks**	***U***	***Z***	***p***
In original material	Control	27	25.72	694.50	316.500	-1.038	.299
	Experimental	28	30.20	845.50			
In additional material	Control	27	14.33	387.00	9.000	-6.217	.000
	Experimental	28	41.18	1153.00			

The suspicion that students in the experimental group have stable performance was increasingly evident. Based on a *p*-value threshold of 0.05, there was a statistically significant difference between control and experimental groups on additional map. Pearson's *r* value -.838 also reported there was a large effect size in the comparison analysis.

5.4 Discussion

5.4.1 The achievement of students' understanding

The present study compared ESB and EKB concept mapping to reveal the distribution of students' achievement on the topic Relational Database. The EKB approach has proven to be able to maintain the superiority of a KB re-construction method. This finding is consistent with Hirashima's (2019) suggestion that the map rebuilding approach encourages learners to reach a maximum understanding of a particular subject. Statistical analysis results reported that groups that use EKB were not merely able to achieve higher average scores but also more equitable distribution in each subtopic of materials.

In Phase 1, the existence of the kit helps students to arrange concept maps in a structured way. In Phase 2, both groups were asked to expand concept maps, and no kit was provided for the experimental group. In principle, the kit is a key concept that uncovers and correlate new ideas in other subtopics. Although students in the experimental group add new concepts and links according to their understanding, the role of the core map structure in the previous phase was still felt. It was proven that the performance and distribution of understanding in the experimental group were superior.

5.4.2 The achievement of map size

A kit is a crucial component that plays an important role in re-constructional concept mapping. A kit is a collection of key concepts defined by the teacher (Hirashima et al., 2015), which are intended to assist students in building knowledge structures. The existence of a kit in Phase 1 triggers students to uncover key concepts in Phase 2 and connect them between subtopics. Therefore, experimental groups that use EKB could achieve a higher total map size scores and were evenly distributed across all subtopics materials.

The results of experiments on the original map reported that control groups that used scratch-building were able to achieve a higher number of propositions than experimental groups that utilized finite concepts and links. However, for the additional map, the control group could not maintain its achievements while the experimental group remains consistent. The additional map is a core component in extended mapping that describes students' enhanced meaningful learning (Novak and Cañas, 2008; Estes, 2004; Schwendimann and Linn, 2016). The EKB approach is proven to promote the attainment of a broader knowledge structure than ESB.

5.4.3 The achievement of map quality

The KB approach that uses kits is suitable to support extending activities. A kit represents key concepts defined by the teacher and is a crucial component that plays an essential role in concept mapping (Hirashima et al., 2015). The kit acts as a guideline to help learners in reconstructing the concept map according to the teacher's perception. The existence of a kit accustoms learners to uncover new key concepts and connect with prior knowledge. Kit in Phase 1 triggers students to reveal related ideas in Phase 2 and link them between subtopics. Therefore, experimental groups that use EKB could achieve higher map quality scores and are evenly distributed across all available subtopics materials.

5.5 Conclusion

This study compared the ESB and EKB concept mapping to investigate the distribution of students' understanding and breadth of knowledge structure. The distribution of attainment on original and additional materials was further investigated. The results reported that EKB not merely outperformed ESB in terms of total understanding scores, number of propositions, and quality of propositions, but also had a more even distribution of mastery in all material subtopics. The EKB map that used a kit component facilitates students to have a good memory and integrate one subtopic with other subtopics easily.

To acquire more reliable experimental results, further works should involve a higher number of participants and suggest several topics. Information related learners' behavior in creating concept maps will also be useful evidence. Future studies could include log data and analyze it to provide appealing details.

Chapter 6

Study on interactive learning content in blended learning

Summary: Blended learning has recently become an interesting issue again because it is considered as one of the right digital learning strategies in the post COVID-19 pandemic. The blended learning strategy is satisfactory when it is utilized in an interactive student-centered learning environment. As an interactive media that emphasizes a student-centered approach, the concept map has great potential for use in blended learning. While existing studies utilize concept mapping to promote students' understanding in blended learning, no effort has been made in applied concept mapping design with expanded features. This study sought to investigate the practical use of the extended concept mapping tool in a blended learning situation. The students in the experimental group used the ESB technique, and those in the control group used the whole-class discussion and summarization method. The results reported that the students in the experimental group outperformed the control group in terms of immediate-test scores.

6.1 Introduction

Blended learning combines the advantages of two different learning strategies: face-to-face classroom and electronic learning (e-learning). Blended learning is recognized as the most popular and appropriate strategy of instruction adopted by educational institutions due to its perceived effectiveness in providing flexible, timely, and continuous education (Rasheed et al., 2020). The blended learning approach is considered as practical solutions to facilitate learning processes that cannot be exclusively performed in the classroom, either because of work, location, or undesirable circumstances such as disasters and an outbreak of diseases.

Many researchers argue that the blended learning approach is more likely to be applied in the post-COVID-19 era (Yussoff et al.,, 2020). Blended learning enables the face-to-face learning process, which is proven to be able to control the learners' emotions, to run optimally while still paying attention to social distancing. Blended learning strategy is satisfactory if it is used student-centered interactive media and methods (Herlo, 2015). The media component has an essential role in appropriately delivering learning content.

Concept maps are powerful interactive learning media (Ibrahim, 2006) which emphasizes a student-centered approach (Kim, 2013). Concept maps have been widely applied in a challenging blended-learning environment. Previous studies agree that the concept map approach has positive effects on flexible blended learning (Ezequiel et al., 2019; Laer et al., 2019). While existing studies utilize concept mapping to promote students' understanding in blended learning, little effort has been made to implement extended concept mapping activities in blended learning.

The present study sought to investigate the practical use of ESB concept mapping in a blended learning environment. The blended learning approach is considered as an answer that offers practical solutions to facilitate learning processes that cannot be exclusively done in the classroom, either because of work, location, or undesirable circumstances such as disasters and an outbreak of diseases (Prasetya et al., 2020c). To examine its performance, ESB was compared to the usual mixed learning activity without concept mapping (Prasetya et al., 2020d). Students' understanding was applied to confirm the performance of both approaches, consisting of pre-test and post-test scores.

6.2 Methods

6.2.1 Participants and context of study

Participants of the present study were second-year informatics engineering students from the Department of Electrical Engineering, State University of Malang, Indonesia. Fifty-four students from two regular classes participated. Participants are familiar with using a personal computer and the Internet in electronic learning activities. This study was conducted in a homogeneous class ($p = .230 > .05$) based on a test conducted previously. Randomly, the first class was assigned as an experimental group and the second class as a control group.

The present study was conducted in the Database course with the Relational Database topic. Learning material was delivered in presentation slides using Indonesian. According to experimental design, learning material was divided into two parts: original and additional content. The original material consists of 10 slides (283 words), and additional material consists of 8 slides (237 words). A senior and experienced lecturer taught both the control and experimental classes.

6.2.2 Instruments

Pre-test and post-test were involved in investigating students' understanding of the material in the control and experimental groups. The pre-test was designed to measure the students' performance before the intervention, and the post-test was used to investigate the achievement after giving intervention. There are eight multiple-choice questions related to original and additional materials. Pre-test and post-test used the same questions that were delivered in random orders.

6.2.3 Experimental Settings

Before the lecture begins, the lecturer had prepared all the material in the electronic learning system that can be accessed online. This experiment was carried out on two homogeneous groups separately and with different treatments. Both groups apply the blended learning strategy, but the experimental group utilizes concept mapping while the control group without concept map. The experimental procedure consisted of two phases: Phase 1 and Phase 2, as shown in Figure 6.

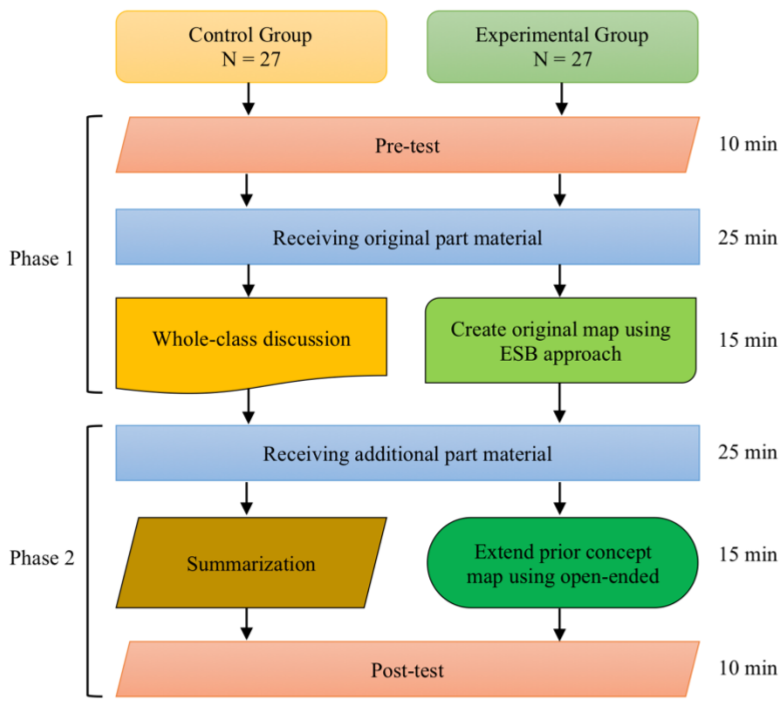

Figure 6. Experiment flow design

In Phase 1, the activity begins by giving a pre-test to measure initial skill before getting intervention. Furthermore, participants in each group received the original part material from the lecturer for 25 minutes. Next, students in the control group implement a whole-class discussion for 15 minutes, and the teacher acts as a facilitator. In the experimental group, students were asked to express their understanding of the original material into an open-ended concept map with the same time allocation.

In Phase 2, the teacher continued to deliver the additional part material with the same approach and allocation as before. After receiving the material, students in the control group were directed to make a summary of the material that they have learned. Meanwhile, students in the experimental group were requested to expand the previous concept map by adding ideas, relationships, and new propositions for 15 minutes. Finally, both groups get an immediate-test to evaluate achievement.

6.3 Results

The pre-test was designed to examine whether students in the control group and the experimental group had an equivalent understanding regarding related instructional design. Descriptive statistics of the pre-test scores for both groups are shown in Table 11. The mean rank of the control group was 48.61, while the experimental group was 47.69. The results stated that students in the control and experimental group had equivalent average achievement

Table 11. Descriptive statistics of the pre-test scores

Group	**N**	**Min**	**Max**	**Median**	**Mean**	**SD**
Control	27	37.50	75.00	50.00	48.61	10.01
Experimental	27	12.50	75.00	50.00	47.69	16.64

The Mann-Whitney U test was further applied to determine whether there were significant differences between the pre-test scores for both groups. Table 12 depicts the results of the comparison between the two groups. An examination of the findings for the pre-test of learners' understanding of the control and experimental groups did not show any statistical differences (Z = -172; p = .863 > .05). The result of Pearson's revealed that there was almost no effect size on the examination with r = -.023. The statistical analysis results reported that before getting intervention, students on the control and experimental groups had the same pre-test understanding achievement levels.

Table 12 The Mann-Whitney U test results of the pre-test scores

Group	**N**	**Mean Rank**	**Sum of Ranks**	***U***	***Z***	***p***
Control	27	27.15	733.00	355.000	-.172	.863
Experimental	27	27.85	752.00			

The post-test of understanding of instructional design was adopted to examine the students' achievements after the use of the concept maps. Table 13 shows the descriptive statistics of the post-test results for both groups. The findings stated that the different treatments in the two groups yielded increased achievement. Even so, the average post-test scores in the experimental group were higher than the control group, which was 81.02 compared to 74.07.

Table 13 Descriptive statistics of the post-test scores

Group	**N**	**Min**	**Max**	**Median**	**Mean**	**SD**
Control	27	50.00	100	75.00	74.07	13.84
Experimental	27	62.50	100	87.50	81.02	10.61

Figure 7 displays boxplot of pre-test and post-test scores for both groups. The achievement of pre-test scores in the control group appears slightly superior compared to the experimental group. The interquartile range (25-75%) on the post-test scores in the control group stated a considerable value, which means a lot of variation, but with a middle quartile, which tends to be low scores. In the post-test scores in the experimental group, the interquartile and middle quartile achievement was higher than the control group.

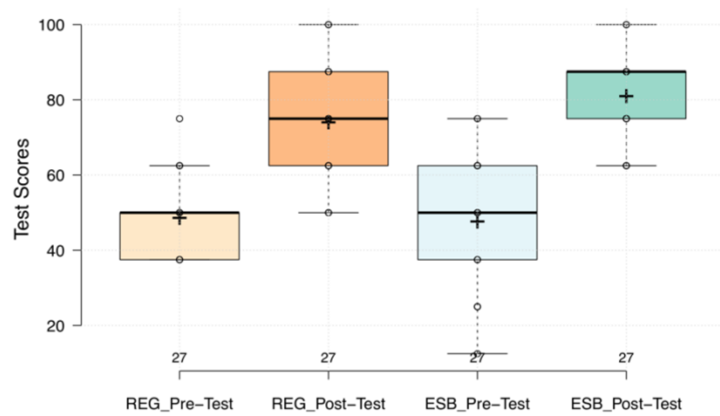

Figure 7. Boxplot of pre-test and post-test scores for both groups

The Wilcoxon signed-rank test was used to find out the differences between the pre-test and post-test for the control and experimental groups. The Wilcoxon signed-rank test is similar to a paired t-test but is used for non-normally distributed data such as this study. The results of the analysis in the control group indicated that there was a significant difference between the pre-test and post-test scores ($Z = -4.297$; $p = .000 < .05$). Cohen's Pearson's r correlation also indicated a large effect size, with values of -.585. The results of the statistical analysis in the experimental group also reported a significant difference between the pre-test and post-test scores of the experimental group ($Z = -4.484$; $p = .000 < .05$), with Pearson's r of -.610, indicating a large effect size.

The comparison of post-test achievements in control and experimental groups is presented in Figure 8. Boxplot of post-test scores shows that both groups were able to reach a maximum score of 100. However, the average students' achievement in the experimental group (81.02) was higher than the control group (74.07).

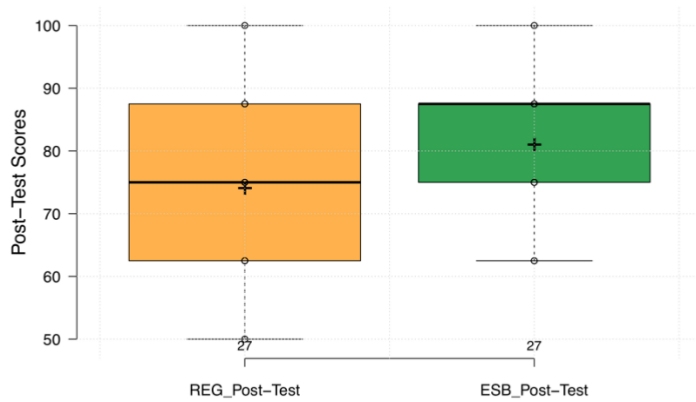

Figure 8. Post-test scores comparison on control and experimental group

Further analysis of post-test scores comparison was carried out by applying the Mann-Whitney U test. Table 14 shows the results of the comparison between the control and experimental groups. The results revealed that there was a significant difference in students' understanding between the control and experimental group (Z = -1.983; p = .047 < .05). Pearson's *r* = -.27 indicating a small effect size in terms of post-test achievement. The rank average of the post-test scores of the control group students was 23.44, while the students in the experimental group had 31.56.

Table 14. The Mann-Whitney U test results of the post-test scores

Group	**N**	**Mean Rank**	**Sum of Ranks**	***U***	***Z***	***p***
Control	27	23.44	633.00	255.000	-1.983	.047
Experimental	27	31.56	852.00			

To investigate the results of the students' understanding deeply, the post-test questions were classified into two parts: questions in original material and questions material. The Mann-Whitney U test results of the post-test scores regarding and not regarding the teacher's map in the first experiment are shown in Table 15.

Table 15. The Mann-Whitney U test results of the post-test scores in original and additional materials

Questions	**Group**	**N**	**Mean Rank**	**Sum of Ranks**	***U***	***Z***	***p***
In original material	Control	27	80.56	321.500	-.820	.412	27
	Experimental	27	85.19				27
In additional material	Control	27	67.59	273.000	-1.714	.087	67.59
	Experimental	28	76.85				76.85

For the questions in the original material, there was no significant difference between the control and experimental groups (Z = -.820; p = .412 > .05), with Pearson's r of -112, indicating a small effect size. The mean rank control group was 80.56, while the experimental group was 85.19. Similar conditions were also found in questions in additional materials. Statistical analysis showed that there was no significant difference between the control and experimental groups (Z = -1,714; p = .087 > .05), with Pearson's r of -333, indicating a small effect size.

Based on the statistical analysis results, the experimental group looks to have outperformed the control group in terms of the average understanding scores. In the context of questions in the original and additional materials, even though there was no significant difference, the mean rank score of students in the experimental group was superior to that of the control group.

6.4 Discussion

Constructing an open-ended concept map technique is consider appropriate because it shows the difference between the knowledge structures of the learners (Ruiz-Primo et al., 2001; Prasetya et al., 2020a), and could recall the basic terms in learning (Clariana, 2010). The ESB approach extends open-ended to improve an individual's knowledge structure and solve complex problems. The experimental results confirmed that the average score of students in the experimental group is superior to the control group. The achievement of experimental groups that use ESB remains consistent for the question categories of original and additional materials. Even though the test results state that there was no significant difference, the average score of the experimental group was higher.

The achievement of questions in additional material highlights that extending activities were approaching a significant contribution. In particular, the effect size on additional scores is larger than the original scores. This finding emphasizes that extending activity has a role in increasing students' understanding.

Concept maps describe active learning that facilitates students to relate important concepts and store longer in memory. Key concepts are essential points in the material compiled into useful information in the form of propositions. Expansion of the map provides the possibility of learners to review their prior knowledge, elicit missing ideas and relationships, and improve new experiences. The ESB strategy, which involved expanding concept mapping, had proven to encourage students to enhance their understanding in blended learning situations compared to those without concept mapping.

6.5 Conclusion

This study sought to investigate the practical use of the Extended Scratch-Build (ESB) concept mapping tool in a blended learning environment. The ESB approach is compared to blended learning strategies without concept mapping to find out its performance. The contribution of this study is to reveal the impact of extending concept mapping on learning outcomes as measured using pre-test and post-test scores. The results were reported that students who used ESB in blended learning obtained higher scores than those who did not utilize mapping activities.

Further studies should involve a more significant number of participants to examine the effects of ESB on a more broad scale. Also, questions used to confirm students' understanding need to be added.

Chapter 7

Conclusion

7.1 Summary of studies

Extended concept mapping is an activity for extending an existing concept map by adding new components based on the related information. Extended concept mapping is composed of two interrelated activities: original concept mapping and additional concept mapping. Design of extended concept mapping facilitates enhanced meaningful learning that occurs when learners link new concept maps to existing ones. In this dissertation, we introduce two extended concept mapping design: Extended Scratch-Build (ESB) map and Extended Kit-Build (EKB) map.

ESB is a design that extends the concept map using open-ended techniques. The extended concept mapping design on the ESB provides learners with the opportunity to review initial ideas and connections, eliciting missing ideas and relationships, adding new concepts and links, and revising knowledge integration. The experimental results prove that the students' achievement in the additional map is higher than the original map. Concept map activities with extended features also encourage learners to increase meaningful learning. Students who take advantage of ESB seem to have stronger knowledge transfer skills in solving new problems.

The EKB is a design that extends the previous existing KB map with open-ended technique. EKB is consistently able to maintain the excellence of KB method in achieving maximum students' understanding, and on the other hand makes it possible to reflect differences across students' knowledge structures. The use of KB's kit in original map creation encourages individuals to compose their understanding regarding the knowledge target. Furthermore, in the map expansion phase, EKB, which already has a solid KB structure, facilitates learners to produce a broad and quality extended concept map. Students who used EKB outperformed those used ESB in terms of test scores, map size, and quality of propositions.

Extended concept mapping is an interactive learning media that emphasizes a student-centered approach. Active media design is a crucial necessity to realize the success of the blended learning approach. Blended learning is a flexible platform that is currently very much needed, particularly to answer education problems in post-COVID-19 era. The utilization of the extended concept mapping to a blended learning situation shows a positive effect and was superior to the usual blended learning without concept mapping activity. The present design allows learners to be actively engaged and gain new valuable experiences.

7.2 Limitations of the study

The present study had several limitations that should be considered for future works. First, the number of participants involved in this experiment was relatively small. Future works should consider a larger group of participants to examine the effects of extended concept mapping design on a broader scale. Second, the number of pre-test and post-test questions used to investigate the students' understanding was also relatively small. In the future, more questions will be able to reveal a more comprehensive picture of students' understanding of particular topics. This study still focuses on investigating students' learning outcomes. However, it is also important to reveal information on students' behavior in creating a concept map. Future studies may involve log data and other instruments to explore students' activities

7.3 Future works

The extended concept mapping design in this study has shown initial positive results. For further research, we are planning to use the EKB concept mapping in Indonesia, particularly in State University of Malang. The use of EKB in a blended learning environment will be our first focus based on the fact that face-to-face learning is still not possible. To optimize the use of EKB in post-COVID-19, we have also designed other scenarios that are still employed the KB framework, which is recompositing and reviewing.

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