KB-Mixed: Reconstructional and Improvable Concept Map to Promote Learners' Comprehend, Knowledge-Building, and Creativity

Didik Dwi Prasetya[1,2], Tsukasa Hirashima[1], and Yusuke Hayashi[1]

[1]Learning Engineering Laboratory, Graduate School of Engineering, Hiroshima University, Japan
[2] Department of Electrical Engineering, State University of Malang, Malang, Indonesia
didik@lel.hiroshima-u.ac.jp

Abstract: Concept map has proven to be a useful tool for teaching, learning, and assessment in the education environment. However, the issue related to knowledge understanding and knowledge building in concept mapping is still to be a concern of many researchers. In this study, we propose a new extension of a reconstructional Kit-Build (KB) concept map which integrated with an open-ended construction style that we call KB-Mixed. Based on the literature review and measurements analysis, this improvable framework has the potential to enhance students' learning comprehend, knowledge building, and creativity by optimizing the advantages of open-ended and closed-ended concept maps.

Keywords: concept map, reconstruction, learners' comprehend, knowledge-building, creativity

1. Introduction

Concept map is a graphical tool to support teaching, learning, organizing, and representing knowledge that was introduced by Novak and Gowin [1]. Concept mapping is a technique for representing the structure of information and knowledge visually. Concept map is a diagram that visually depicts the relationships between concepts and ideas. The main purpose of concept mapping is a knowledge representation in the visual format in order to acquire an overview of a domain of knowledge [2]. According to Plotnick [2], information representation into visual form has several advantages: (1) visual symbols are quickly and easily recognized for a human being; (2) minimum use of text makes it easy to scan for a word, phrase, or the general idea; and (3) visual representation allows for the development of a holistic understanding that words alone cannot convey.

Concept maps consist of node (point or vertices) that represents concepts, and links (arc or lines) that represents the relationships between concepts [2]. The concept maps depict ideas as circles or boxes of some type, and relationships between concepts indicated by a connecting line linking two concepts. Words on the line, referred to as linking words or linking phrases, specify the relationship between the two concepts [3]. Concept maps refers to a knowledge representation form that shows individual concepts at nodes with linking words that connect two concepts and indicate the relationship between them, thus forming a simple phrase or proposition [4]. Propositions are statements about some object or event in the universe, either naturally occurring or constructed [3]. According to Novak [3], another characteristic of concept map is that the concepts are represented in a hierarchical fashion with the most inclusive, most general concepts at the top of the map and the more specific, less general concepts arranged hierarchically below.

Concept maps construction can be classified into two styles: (1) open-ended; and (2) closed-ended [5]. In the open-ended concept maps, learners may use any concepts and any linking words in their maps. The advantage of the open-ended style is that it gives full control to the learners to create concept maps base on their knowledge understanding. Thus, this approach facilitates knowledge building, in which learners can add, modify, or remove concepts and links as their needed. Based on these characteristics, many investigators refer to the open-ended style as a standard one from viewpoint of capturing learner's knowledge structure [6]. However, in the open-ended style, it will be more difficult to assess and provide feedback to learners because there will be many variations of the concept map. In contrast, a closed-ended style contains finite concepts and links provided beforehand. In this case, learners must use provided components to

construct their maps by connecting one concept to another. This approach also states that open-ended tend to be less facilitate the knowledge building situation. However, behind this drawback, the open-ended style allows automatic assessment and able to give feedback easily.

Concept maps were developed by Novak and Gowin based on the meaningful theory proposed by Ausubel [7]. Meaningful learning is a process of linking new information to relevant concepts contained in a cognitive structure. Cognitive structures are facts, concepts, and generalizations that students have learned and remembered. Meaningful learning occurs when a student chooses to relate new knowledge to prior knowledge. Meaningful learning requires individual to have a well-organized relevant knowledge structure in the particular area and strong emotional commitment to integrate new with existing knowledge [3]. In fact, when the learners build concept maps, meaningful learning will be facilitated [4]. However, depending on the strategy to be used, meaningful learning is very likely to be improved again. Kit-Build (KB) concept map proves a reconstruction strategy as a right approach to enhance meaningful learning, particularly related to learning performance.

2. Related Works

Concept maps are flexible tools because it can be implemented in a various fields and education levels, starting from preschool to higher education and corporate training [1]. The study of concept mapping had been widely employed and intended for various purposes.

Mlika et al. [8] examined a free and open-ended concept map to assess the utility of using mapping techniques in medical students environment. The study compared the experimental group who were tutored using concept maps and control group who learned without concept maps. The results showed that the students utilized concept maps in their learning were statistically significantly better than those of the students that were not tutored with this technique.

Hirashima [6] summarized the effects of reconstructional KB concept in many education purposes, including individually and in groups. Hirashima described a framework of KB map, practical uses in classrooms, validity of the automatic assessment of KB map, and reciprocal kit building as a mutual reconstruction of KB map in a collaborative situation. These results showed a positive impact and emphasized that KB map is a promising approach to practically use a concept map in the classroom.

Fischer [9] assessed the effectiveness of using mechanistic concept maps (MCM). MCMs are graphical diagrams created individually or collaboratively by a team to foster an inductive analysis of a particular problem. Fischer reported that experimental group got better reasoning skills and attitude comparing to the control group. Students in the intervention group also stated that MCMs more helpful in terms of conceptual learning than their own notes.

Referring to the related studies we have mentioned, we can emphasize the differences works with our proposed research. In this work in progress, we proposed a new extension of a closed-ended Kit-Build (KB) concept map that we call KB-Mixed. KB is a reconstruction concept map that requires a learner to reconstruct the original concept map made by the teacher [6]. KB-Mixed extends the existing KB framework by integrating the open-ended method to support knowledge building and enhance meaningful learning.

3. KB-Mixed Concept Map

KB-Mixed is a new extension of the Kit-Build (KB) concept map that integrates open-ended style. KB is one type of closed-ended style concept map was introduced by Hirashima [10]. KB works by providing nodes and links composed by the teacher beforehand, and request the learners to reconstruct the concept map.

The practical flow of KB map can be shown in Figure 1. According to Hirashima [10], practical use of KB framework consists of four main phases: (1) teacher or expert build a map called goal map; (2) kit generated by decomposing the goal map; (3) learners use the kit to reconstruct concept maps; and (4) assessment of learner map by comparing with the teacher map. Goal map building is a very vital stage and conducting by a teacher who understands the material well. The goal map itself should cover essential points in the content represented in interconnected propositions and form a concept map.

A learner map is (re)constructed by using the same nodes and links with the goal map. Therefore, KB systems can identify differences in propositions between learner and teacher based on the source and purpose of a link. Based on the identification of this link, Hirashima [10] proposed three link terms which included: leaving link (link does not use in the learner map), excessive link (link does not exist in the goal map), and lacking link (link does not exist in the learner map).

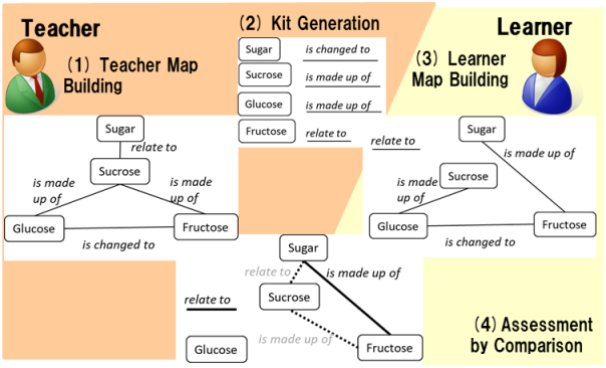

Figure 1. Practical flow of KB concept map

By design, KB is intended to realize automatic assessment of a concept map [10]. KB is more suitable for the knowledge-sharing situation than a scratch-build concept map. However, on the other hand, the scratch-build concept map is more ideal than KB because learners have various ways of understanding when they interpret material by themselves [11]. To answer this challenge we developed KB-Mixed that combines KB and open-ended or scratch-build concept maps. KB-Mixed is a combination of KB concept map and open-ended concept map. Thus, there are two interconnected phases concept map construction, as shown in Figure 2.

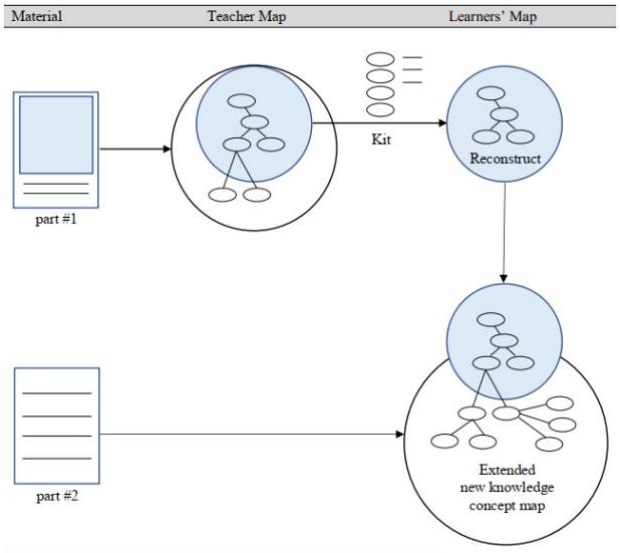

Figure 2. Design of KB-Mixed concept map

The main purpose of KB-Mixed is to facilitate both knowledge understanding and knowledge building that has been difficult to obtain by using either KB or open-ended concept maps. In the first phase, KB-Mixed runs the KB concept map, while the second phase utilizes the open-ended concept map. These two phases of construction are main characteristic of KB-Mixed to increase meaningful learning and promote learners' comprehend, knowledge-building, and creativity. As we mentioned, KB-Mixed employs KB framework to offer its advantages in improving learning performance. In facts, the prepared nodes and links approach as a scaffold encourages students to build a more structured concept map foundation. The existence of this good knowledge structure also motivates students to find cross-links and form hierarchical structures, which are the main components in creative thinking.

As with the KB concept map, the way KB-Mixed works begins with the teacher building a goal map. Based on the goal map that is composed of a learning material, the teacher will determine the key concept. This fundamental concept is the concepts of essence that will be decomposed into kits and given to learners. In creating the concept maps, students are allowed to open a handout because one of the objectives of this experiment is to support knowledge building.

According to the meaningful learning theory, KB-Mixed offers two facilitation, namely in 1st phase and 2nd phase. Thus, KB-Mixed has more significant potential to improve knowledge understanding, knowledge building, and creativity. Referring to these two phases, to support assessment, we can define two areas of concept maps: regarding the goal map and not regarding the goal map.

4. Analysis

In this study, we will involve three measurements analysis to investigate the KB-Mixed performances: (1) analysis of students' learning comprehend; (2) analysis of knowledge-building; and (3) analysis of students' creativity.

1. Analysis of students' learning comprehend

Analysis of students' learning understanding involve pre-test and post-test. The pre-test designed to examine whether students in the control group and the experimental group had equivalent knowledge regarding related instructional design. The post-test is designed in the same form as the pre-test and it will clarify whether the treatment is efficient or not by analyzing the difference between pre-test and post-test scores.

Pre-test and post-test use multiple choice questions created by the senior teacher. To get the objective data, pre-test and post-test questions are divided into two types: regarding goal map and not regarding the goal map. By separating these questions, we can mark and find out the

significance of the learning outcome, both when answering questions related to goal maps or not. To support this primary data, we also provide a Likert scale questionnaire related to knowledge understanding.

2. Analysis of knowledge-building

Knowledge-building is formally defined as production and continual improvement of ideas of value to a community [12]. In the context of this concept mapping, we define knowledge-building as the ability to visualize learners' ideas related to a particular topic. The assessment of the concept map will be conducted by the teacher class with reference to the rubric grading that has been formulated.

The assessment of the concept map is based on propositions by adopting the quality rating of propositions proposed by Osmundson [13] as displayed in Table 1. Propositions scores ranged from inappropriate or incorrect connections (score = 0 point) to most scientific understanding with the highest value (score = 3 points). There are two midpoints represent practical understanding (score = 1 point) and the scientific understanding of but has limited explanatory power (score = 2 points). Referring to the quality of the score propositions, the teacher can get the total concept map value that represents the students' knowledge structure.

Table 1. Quality rating of propositions

Score	Description of proposition	Example
0	Proposition does not make sense in any circumstance. Inappropriate.	Cells carry the brain
1	Proposition appropriate and correct. Limited in an everyday event.	Cells are part of the body
2	Proposition appropriate. Reflects scientific understanding, but has limited explanatory	Cells absorb nutrients
3	Proposition is explanatory, reflect a scientific understanding.	Cell produce carbon dioxide

To support the primary data of knowledge-building scores, we also provide a Likert scale questionnaire for the students. The questionnaire results can be confirmed to the quality rating of propositions to measure students' creativity.

3. Analysis of students' creativity

According to Novak [3], we use two features of concept maps that are important in the facilitation of creative thinking: (1) hierarchical structure; and (2) cross-links. In the hierarchical structure, the most general concepts will be located at the top, and the more specific are arranged hierarchically below. The hierarchical concept map describes structures that are good and easy to understand. Cross-links can be consider as a relationships between concepts in different domains of the concept map. Cross-links help us to identify how some domains of knowledge represented on the map are related to each other [3].

To measure the learners 'creativity, we adopted the Novak & Gowin's [1] structural method, as shown in Figure 3. We can see, there are four main components used to give a score: proposition, hierarchies, cross-links, and an example. For each valid component, we give the following points: 1 point per proposition, 5 points per hierarchies, 10 points per cross-link, and 1 point per example.

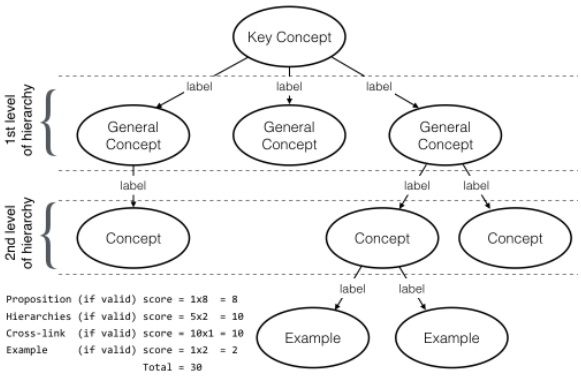

Figure 3. Novak & Gowin's structural method

The total score from the calculation of Novak & Gowin's structural method represents the learners' creativity. Expert judges and teacher class may be involved in assessing this method.

5. Conclusion

This work in progress provided a new approach of a combination of closed-ended and open-ended concept map style. We extend the existing reconstructional kit (KB) framework by adding the open-ended map construction that we call KB-Mixed. To confirm the KB-Mixed performance, we designed three types of measurement analysis: analysis of students 'learning comprehend, analysis of knowledge-building, and analysis of learners' creativity. Referring to the characteristics of KB-Mixed and clarification of the measurements used, KB-Mixed has the potential to

enhance learners' understanding, knowledge-building, and think creatively. However, experimental use and results of the analysis are necessary to be investigated more deeply. Therefore, we plan to do practical use several times by involving the control group as a comparison.

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References

[1] Novak, J. D., & Gowin, D. B.: Learning how to learn. Cambridge University Press. (1984)

[2] Plotnick, E.: Concept mapping: A graphical system for understanding the relationship between concepts. Syracuse, NY: ERIC Clearinghouse on Information and Technology. (1997)

[3] Novak, J. D., & Cañas, A. J.: The theory underlying concept maps and how to construct and use them. (2008).

[4] Cañas, A. J., & Novak, J. D.: Concept mapping using CmapTools to enhance meaningful learning. In Knowledge cartography (pp. 23-45). Springer, London. (2014)

[5] Herl, H. E., O'Neil Jr, H. F., Chung, G. K. W. K., & Schacter, J.: Reliability and validity of a computer-based knowledge mapping system to measure content understanding. Computers in Human Behavior, 15(3-4), 315-333. (1999)

[6] Hirashima, T.: Reconstructional concept map: automatic Assessment and reciprocal reconstruction. (2018)

[7] Ausubel, D. P.: The Psychology of Meaningful Verbal Learning. New York, Grune and Stratton. (1963)

[8] Mlika, M. B. Khelil, C. Amri, A. Mrabet & F. El Mezni.: USING FREEMIND SOFTWARE TO TEACH PATHOLOGY TO MEDICAL STUDENTS. Int. J. of Pedagogies & Learning, 12(1), 17-24. (2017)

[9] Fischer, K., Sullivan, A. M., Krupat, E., & Schwartzstein.,R. M.: Assessing the Effectiveness of Using Mechanistic Concept Map. (2019).

[10] Hirashima, T., Yamasaki, K., Fukuda, H., & Funaoi, H.: Framework of kit-build concept map for automatic diagnosis and its preliminary use. Research and Practice in Technology Enhanced Learning, 10(1), 17. (2015)

[11] Warunya, W., Jaruwat, P., Yusuke, H., & Tsukasa, H.: Comparison between Scratch-and Kit-Build concept map with several evaluation methods. SIG-ALST, 5(03), 54-59. (2016)

[12] Scardamalia, M. & Bereiter, C.: Knowledge Building. InEncyclopedia of education, Secondedition. New York: Macmillan Reference. pp. 1370–1373 (2003)

[13] Osmundson, E., Chung, G. K. W. K., Herl, H. E., & Klein, D. C.: Knowledge mapping in the classroom: A tool for examining the development of students' conceptual understandings. Report: CSE-TR-507. (1999)