Design and Development of Kit-Build Concept Map Authoring and Collaborative Support System

(キットビルド概念マップにおけるオーサリング機能と共同利用機能の設計・開発**)**

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Declaration of Authorship

I, Aryo Pinandito, hereby declare that I am the sole author of this dissertation. This is a true copy of the dissertation, including any required final revisions, as accepted by the examiners. Therefore, I declare:

- All direct or indirect sources used are acknowledged as references.
- This dissertation was not previously presented to another examination board and submitted for the requirement of any other degree.
- Other external sources are cited and acknowledged with bibliography appearing at the end of this dissertation.

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Abstract

Despite its notable contribution to learning outcomes, learning with concept maps was helpful, fun, and engaging, including learning with the Kit-Build concept map. Kit-Build concept map is a learning framework that incorporated concept map recomposition as its essential activity. While Kit-Build concept maps have promoted better learning performance, there are several challenges and difficulties in authoring concept maps for teaching and learning. Students learn through recomposing digital concept maps from a set of teacher's concept map components; hence, a teacher concept map is essential in Kit-Build. In composing a teacher concept map of Kit-Build, teachers should reflect the learning context and strategy, embody their purpose and intention, students' understanding level, and focus questions in concept maps manifestation. Hence, support to improve teacher and student productivity in composing concept maps and support for online collaborative learning with Kit-Build concept map becomes a requisite to revamp online education in this current pandemic situation. This study designs and develops a concept mapping support system that allows concept map authors to compose concept maps from learning material with a semi-automatic concept map generation approach. Additionally, the system functionality is further developed to support online collaborative concept mapping use, allowing teachers and students to learn and work collaboratively with concept maps in real-time. Investigation regarding the developed tool performance and its use in a learning environment is conducted through multiple experiments; involving both teacher and student to elucidate its impact on learning. The concept map authoring and collaboration support feature have been successfully developed in this study. Evaluation of the newly developed tool suggested that the authoring support tool could assist teachers in composing concept maps from English learning material reasonably. The findings also suggested that the support tool could improve concept mapping efficiency while maintaining concept maps of similar quality. Students and teachers found the authoring support tool beneficial and compatible with their work, rendering its potential for actual teaching and learning. A WebSocket-based collaboration system has been implemented and integrated with the concept map authoring tool regarding its use in a collaborative learning environment. The tool allowed users to be virtually connected with others when they compose concept maps. The implementation suggested that the system could successfully support real-time communication and collaborative concept mapping work of multiple users. An experimental use with students to use the online collaboration system to learn with concept maps suggested that collaborative learning with Kit-Build concept map online yielded better learning outcomes and better learning interaction than the traditional open-end concept mapping. Therefore, this study provided an insight on how Kit-Build concept map offered more significant benefits towards collaboration learning; thus, further recommends Kit-Build as a better approach to learning with concept maps.

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To all readers for reading this dissertation, I definitely hope you enjoy reading it.

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Donna, Kalya, Keindra.

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List of Publications

Journal Article

- Pinandito, A., Prasetya, D. D., Hayashi, Y., & Hirashima, T. (2021). Semi-automatic concept map generation approach of web-based kit-build concept map authoring tool. *International Journal of Interactive Mobile Technologies (iJIM)*, 15(08), 50-70. doi:10.3991/ijim.v15i08.20489
- Pinandito, A., Prasetya, D. D., Hayashi, Y., & Hirashima, T. (2021). Design and development of semi-automatic concept map authoring support tool. *Research and Practice in Technology Enhanced Learning*, 16(1), 8. doi:10.1186/s41039-021-00155-x
- Pinandito, A., Prasetya, D. D., Az-zahra, H., Wardhono, W., Hayashi, Y., & Hirashima, T. (2021). Design and Development of Online Collaborative Learning Platform of Kit-Build Concept Map. *JITeCS (Journal of Information Technology and Computer Science)*, 6(1), 50-65. doi:10.25126/jitecs.202161294
- Pinandito, A., Hayashi, Y., & Hirashima, T. (2021). Online Collaborative Kit-Build Concept Map: Learning Effect and Conversation Analysis in Collaborative Learning of English as a Foreign Language Reading Comprehension. IEICE Transactions on Information & Systems, E104-D(7), 981-991. doi:10.1587/transinf.2020EDP7245

International Conference Article

- Pinandito, A., Az-zahra, H. M., Hirashima, T., & Hayashi, Y. (2019). User experience evaluation on computer-supported concept map authoring tool of kit-build concept map framework. In *2019 international conference on sustainable information engineering and technology (siet)* (p. 289-294). doi:10.1109/SIET48054.2019.8986005
- Pinandito, A., Wulandari, C. P., Prasetya, D. D., Hirashima, T., Hayashi, Y. & Az-zahra, H. M. (2020). Students' acceptance towards kit-build concept map authoring tool in supporting learning of english reading comprehension. In *Proceedings of the 5th International Conference on Sustainable Information Engineering and Technology (SIET '20)*. Association for Computing Machinery, New York, NY, USA, 158-164. doi:10.1145/3427423.3427464

International Conference Poster Article

- Pinandito, A., Hayashi, Y., & Hirashima, T. (2020). Online collaborative kit-build concept map. In H. J. So (Ed.), *Proceedings of the 28th international conference on computers in education. asia-pacific society for computers in education.*
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Chapter 1

Introduction

Computer and mobile devices have become an enabler to greater access to learning contents in distance learning. In a situation where learning activities are shifting to online learning, the need for online—and mobile—learning platform and infrastructure becomes imminent to deliver digital learning content and media remotely and seamlessly (Drolia et al., 2020; Ivanova et al., 2020).

One example of learning media other than textbooks and lecture notes for learning is concept map. Despite the simplicity in its graphical form, concept map can been put into various uses, such as dialogue, collaboration, discussion, and feedback; enriching the learning environment, especially for learning. A concept map can also be identified as a tool, artifact, or scaffold to mediate discussion and negotiation between two or more different views (Saeidifard et al., 2014). Elaborating concept map into learning activities could help students depict and explore their understanding (Stoica et al., 2011; S.-Y. Wu et al., 2016), optimizes their learning as it may influence students' self-efficacy and self-regulation during learning (Chularut & DeBacker, 2004); thus, improve their learning achievement (Astriani et al., 2020; Chiou, 2008; Joshi & Vyas, 2018; Machado & Carvalho, 2020; Saeidifard et al., 2014; Taie, 2014; Tseng, 2020). Their interaction and learning performance could be improved if the activities were supported by a computer-supported concept mapping tool (Joshi & Vyas, 2018). Thus, learning and its assessment through interactive activities (Ma & Shi, 2016) could be conducted with more fun and engaging (Lai et al., 2020).

Several studies about learning incorporated concept mapping with digital concept map as an effective learning activity that encouraged a better learning interactivity (Leauby et al., 2010; Ma & Shi, 2016) in addition to its use in assessing and predicting student understanding (Daley et al., 2007). Further development of learning with digital concept maps could bring forth a learning framework that can quickly and easily assess students' understanding (Hay, 2007), such as Kit-Build concept map (Hirashima et al., 2015).

Positive learning effects have been confirmed in several studies on various subjects and activities that used Kit-Build in which students can learn through recomposition of a Kit-Build concept map kit (Hayashi et al., 2020; Pailai et al., 2017; Prasetya et al., 2020; Sadita, Hirashima, et al., 2020). Kit-Build concept map delivers its concept map recomposition activity with a computer-based concept mapping tool. Students can use their personal computer or tablet devices to learn with Kit-Build. With the provided concept map analysis tool, Kit-Build could help teachers or instructors to quickly gain insight into the development of students' knowledge and evaluate their teaching (Pailai et al., 2017) through its concept map recomposition and comparison analysis features (Hirashima et al., 2015).

In contrast to composing a traditional open-end concept map, students compose their concept maps by recomposing a concept map kit; hence, the teacher concept map is essential in Kit-Build (Pailai et al., 2017). Moreover, recomposing a concept map from components could help students focus more on concepts and ideas represented by the components (Pinandito et al., 2020).

Other studies suggested that composing a good concept map from learning materials was difficult and time-consuming (Andoko et al., 2020; Duarte et al., 2017; Machado & Carvalho, 2020; Pinandito et al., 2019; Sue et al., 2007). The main drawback of learning with Kit-Build concept map is that teachers should prepare a concept map before using the map to teach and decomposed the map into a Kit-Build kit and let the students recompose a concept map from it. Preparing concept maps prior to teaching has been an obstacle for teachers to adopt Kit-Build as their teaching strategy. Prior research suggested that concept mapping activity put additional cognitive load for both student and teacher (Hwang et al., 2014; Katagall et al., 2015). Teachers might already have other academic-related loads other than teaching and the concept map being made should represent the learning material adequately and correspond to the teaching strategy.

The process of segmenting and structuring knowledge into a concept map requires expertise and adequate proficiency in the subject or problem domain (Duarte et al., 2017). The process requires higher cognitive load in a situation where the problem space is more extensive, i.e., in a situation where the concept map authors were overwhelmed by the amount of information they have or when they were asked to construct several concept maps in a limited amount of time (Furtado et al., 2019). When students were requested to compose a concept map of a learning material from scratch, they took a considerable amount of time to comprehend, identify key ideas and concepts, identify relationships among ideas, and reorganize their understanding before they could pour their knowledge and understanding into a concept map. Moreover, in the situation where the time to compose the map is short, they would put their effort more on how to compose a concept map than put their focus on understanding the material (Pinandito et al., In press 2021). Hence, a useful support for efficient concept map composition and authoring—for both teacher and student—becomes necessary.

Learning through collaborative interaction is also considered important because it could benefit students socially, psychologically, and academically (Laal & Ghodsi, 2012). Interactions in collaborative learning include students' participation and social interaction (Stegmann et al., 2007) where learning becomes an act of rewriting knowledge than merely receiving the information uncritically; hence, meaningful learning (Gray, 2019). When meaningful interaction is developed, students' knowledge and understanding shall improve through the interactions made during learning (Woo & Reeves, 2007) and concept map has the potential to support it (Akinsanya & Williams, 2004; Daley et al., 2016; Romero et al., 2017).

Collaboratively constructing knowledge, exchanging ideas, embodying one's understanding, or sharing past experiences with concept maps could promote not only meaningful learning (Sharan, 2015), but also memory retention (Collins & Nyenhuis, 2020; Fonteles Furtado et al., 2019; Funaoi et al., 2011). Activities involved in composing concept maps also help students enhance their critical thinking skills (Latif et al., 2016; Tseng, 2020), develop deeper, higher-level cognitive processing (Pinandito et al., In press 2021; S.-Y. Wu et al., 2016), and meaningful learning (Carr-Lopez et al., 2014; Prasetya et al., 2020; Vanhear, 2012). Furthermore, Kit-Build concept map in collaborative learning has been suggested to foster better interaction and meaningful discussion (Sadita, Hirashima, et al., 2020; Wunnasri et al., 2018a).

Recently, due to the 2019 Corona Virus Disease (COVID19) pandemic situation, many education systems were forcefully shifting from offline to online learning; transforming the interaction style between teacher and student in learning activities, and induced collaborative learning difficult. Learning in a virtual, online-based learning environment, becomes more challenging than before; forbidding a direct face-to-face communication in almost every aspect of interaction (Mahyoob, 2020). It is tedious to maintain a straightforward and natural interactive learning activity similar with what can be conducted in offline classrooms. In such an offline classroom, there is no time and space separation to maintain good interaction that involves emotion, empathy, and physical activity. Learning technology, which supports online learning, needs to tackle or at least lessen the problems (C. Angeli et al., 2003; Bannan-Ritland, 2002).

The needs of online collaborative concept mapping system is shoved by the situations where distance learning is inevitable (Al Lily et al., 2020; Amir et al., 2020; Armstrong-Mensah et al., 2020; Moallem, 2003). Subsequently, support for online collaborative learning also becomes necessary, including support for online collaborative learning with Kit-Build concept map. However, the current system and authoring tool of Kit-Build concept map does not support online collaboration. Even though previous studies suggested that incorporating Kit-Build in collaborative learning promoted better learning and discussion, the collaboration was conducted offline. Each discussion group use only one device to compose concept maps collaboratively and discuss the maps in a face-to-face manner. Hence, the existence of collaboration system for online learning with Kit-Build concept map that supports real-time composition and discussion becomes necessary.

Despite the promising benefits of using concept maps in collaborative learning, realizing the ability to interact and discuss using concept maps in online settings is challenging. The concept mapping technology being used needs to provide seamless transition between offline and online, maintain the discussion and interaction style natural; hence, meaningful learning in online collaborative learning with concept maps. With the currently available computer and Internet technology, it is possible for the concept maps be authored, distributed, and used in digital form online.

This study designed and developed a concept map authoring tool that adopted semi-automatic concept map generation to support efficient concept map composition for learning. The tool's functionality is also further extended to support collaborative learning with concept maps online. The research questions of this study are described in its own chapter. Multiple experiments are conducted to answer the research questions and the discussion regarding support for authoring process with semi-automatic concept map generation and support for online collaborative learning were discussed in two chapters before the conclusions to the research questions were drawn in chapter 6.

Chapter 2

Related Works

2.1 Kit-Build Concept Map

In learning, learners may have different ways to acquire a deep and meaningful understanding of learning material. Mind mapping or concept mapping is often chosen as one of strategies to outline, sort, categorize, or organize ideas inside the materials. Despite a little differences between mind map and concept map in terms of its tree structure, these mapping activities allow learners to quickly capture, identify, or even generate creative and unique ideas with more freedom and creativity. The strategy on how learners do the concept mapping would make them become more effective readers and knowledge creators (Novak, 2010; Novak & Cañas, 2008). Not only concept maps helped student and teacher gain clearer understanding of learning material, but the constructed map would also guide their learning sequences (Novak & Cañas, 2007).

By the definition, concept map is a graphical diagram that depicts concepts and meaningful relationships between concepts. A keyword or short phrases usually represent a concept in a concept map. A relationship is usually visualized by a line—or a link—that connects two concepts. Usually, the link is labeled with a short phrase or label that explains meaningful relationship between the concepts and every connected link in a concept map represents the relation between its two connected concepts.

A concept map is connected. It comprises several interconnected propositions in which each proposition has two connected concepts by one link to express a meaningful relationship or knowledge between connected concepts. Each concept and link in a concept map uses succinct nouns or phrases as its label to represent knowledge. A formed proposition in a concept map should have a meaningful statement (Cañas et al., 2005) and semantically self-explanatory.

Concept maps can be used and applied in many different ways, from regular note-taking to assisting discussion of a problem-solving activity. Organizing knowledge in a concept map with digital technologies allow teachers and students to easily create, modify, and arrange their concept maps. Furthermore, learning with digital concept map have known to improve student's engagement in constructing knowledge, hence more dynamic and interactive learning (Daley et al., 2007), and lead to a higher level of cognitive thinking (Koh et al., 2010).

Kit-Build concept map (Kit-Build) is a learning framework that incorporated a highly directed concept mapping activity in its learning strategy (Hirashima et al., 2015); adopted the Novakian concept map style into computer-based concept mapping activity for easy assessment of one's understanding. In learning with Kit-Build concept map, concept map recomposition is one important key activity. Instead of adopting an open-ended concept mapping approach, Kit-Build applies a closed-end concept mapping approach in which students compose a concept map from a pre-defined set of concept map components. One other way to call an open-ended concept mapping activity is scratch-mapping or scratch-building. In scratch-mapping, students have their freedom to express their creativity in composing a concept map. Nevertheless, composing a concept map with Kit-Build not only helps student focus and understand better, but its recomposition activity also guides student comprehends things that their teacher wants them to understand. The set of components, which the students use to recompose a concept map, is called a kit; hence, the name Kit-Build and kit-building activity. The general flow of learning activities with Kit-Build concept map is shown in Figure 2.1.

In the current practices, teachers and students compose a concept map with a computer-based concept mapping tool that is specifically made for Kit-Build. With the tool, teachers can create a concept map, decompose the map into kit, and let students recompose the kit into a concept map. Several kits can be made from either partial or full decomposition of the teacher concept map. With the provided concept mapping tool, the decomposition process can either be performed automatically or manually. Because the students compose their concept maps from the same components as teacher concept map, student concept maps can be compared directly with teacher concept map. The tool can also help teachers depict the gap between their expectation

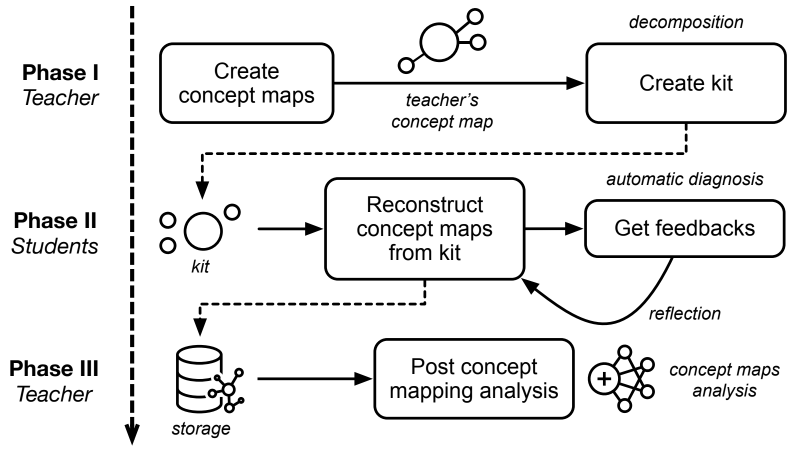


Fig. 2.1 General flow of learning with Kit-Build concept map.

and student understanding quickly and easily (Hirashima et al., 2015; Pailai et al., 2017).

In learning with a closed-end concept mapping approach, such as Kit-Build, student learn by the given kit of a teacher concept map. Teachers as the domain expert create a concept map—a goalmap—representing of what the students have to achieve and understand. By composing a concept map from kit, student has less freedom to put their knowledge or add more information into their concept map other than what have been provided by the kits. The kit from which the students recompose into concept maps, force them to reflect their thinking deeply. Therefore, despite the limitation, the kit as well as its composing teacher concept map play the essential role in learning with Kit-Build concept map.

Studies regarding the practical use of Kit-Build in the elementary school science class (Sugihara et al., 2012) and English as a Foreign Language (EFL) studies (Alkhateeb et al., 2016; Andoko et al., 2020) suggested that Kit-Build concept map have many positive impacts towards learning. Additionally, the Kit-Build concept map can be incorporated into a collaborative learning environment to facilitate students' discussion in sharing their knowledge and understanding (Sadita, Furtado, et al., 2020; Sadita, Hirashima, et al., 2020; Wunnasri et al., 2018a).

2.2 Developing EFL Reading Comprehension Skill with Kit-Build Concept Map

In most practical use of Kit-Build concept map, students learn from text-based learning material. One of several learning subjects, which can be learnt with Kit-Build concept map, is EFL reading comprehension (Alkhateeb et al., 2016; Andoko et al., 2020). In learning EFL reading comprehension with Kit-Build, the concept maps serves as a learning supplement for the material. Its use in supporting reading-intensive learning, as in EFL reading comprehension, appears to be highly effective. The visual representation and the recomposition of a teacher concept map's kit help students focus more on the key topics and ideas of the text, thus aiding them to comprehend the text better (Alkhateeb et al., 2015). The kit, in which the students recompose a complete concept map, should possess all of the critical parts of a reading. Therefore, it is necessary for teachers to create a good concept map since the students focus on the ideas and relationships depicted by the kit. Additionally, this explains why teacher's concept map is essential in learning with Kit-Build.

In a experimental setting, using Kit-Build concept map to practise EFL reading comprehension helped the students retain their knowledge better than a traditional selective underlining method (Alkhateeb et al., 2016). Another Kit-Build concept map learning strategy with source connection capability helps students comprehend an English reading better than using a traditional text-summarization approach (Andoko et al., 2020). Recomposition and review strategies of EFL reading comprehension with Kit-Build concept map helped students better learn and understand English reading comprehension texts. Hence, the use of the Kit-Build concept map to support the learning process of EFL reading comprehension is promising.

In practising EFL reading comprehension with Kit-Build concept map, students try to comprehend the readings and express their understanding by reconstructing a concept map kit representing the text. When a teacher compares the maps, the parts that are different depict students' misunderstanding or misconception about the reading. Hence, the teacher can explain to the students and discuss the problematic parts in more depth using a more comprehensive concept map.

In an EFL learning strategy that uses Kit-Build concept map, many readings were used. Thus, many concept maps, which represented the readings, also have to be recomposed by the students for practices. In Kit-Build, teachers have the responsibility for creating the initial Kit-Build concept map.

Teachers have to prepare a concept map sophisticating enough to represent the reading before students use the map to help them learn and comprehend the reading. The lack of understanding on how to properly create a an adequate concept map could result in a concept map that is difficult to interpret and review (Veronese et al., 2013). Therefore, teachers should carefully craft and compose a concept map that helps students comprehend the reading better.

It is common to use many readings for practicing EFL reading comprehension with the Kit-Build concept map. The consequence of using many readings to learn EFL reading comprehension is that many concept maps also have to be created. The concept map creation activity becomes a burden for some teachers and increases the cognitive loads of their current academic workload (Harrison & Gibbons, 2013). While it is difficult to carry out, concept mapping takes a significant commitment of time and effort to produce a good concept map (Alkhateeb et al., 2016; Harrison & Gibbons, 2013; Torre et al., 2007; Tseng, 2020).

2.3 Support in Authoring a Kit-Build Concept Map

2.3.1 Concept Mapping with Kit-Build Concept Map Tool

Theoretically, concept map and its composition activity are boundary objects that mediate the relationship between two or more different perspective (Pennington, 2010). In learning, concepts map mediates the perspective of students and teacher for a subject or learning material. In harmony with the theory of boundary objects (Star & Griesemer, 1989), student and teacher can cooperate and collaborate for a specific task or purposes by interacting with concept maps.

A concept map can be created or constructed in various ways. The way on how concept map being used for particular purposes has been developed into frameworks in the fields of health care (Leyns et al., 2018; Risisky et al., 2008; Trochim & Kane, 2005) and education (Gouli et al., 2003; Hirashima et al., 2015). The construction method may vary from merely using paper and pencil to using software or other advanced tools to construct them.

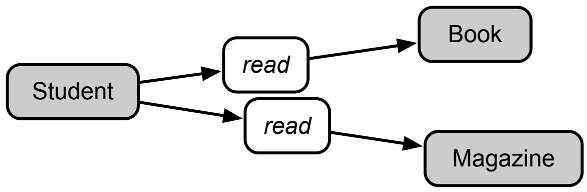
The use of digital technologies raises the potential in enhancing the teaching and learning process. Technologies in concept mapping allowed the students to easily create, modify, and arrange their concept map (Erdem et al., 2009; Leauby et al., 2010); improving student's engagement in constructing knowledge, making online learning more interactive and dynamic (Daley et al., 2007), while performing a paperless concept mapping activity.

Several studies have been developing computer-based concept mapping tools that allow people to draw a digital concept map using a computer or tablet instead of traditionally using paper and pencil (Daley et al., 2007; Erdogan, 2009). One popular tool to construct and share concept map-based knowledge model is CmapTools that is developed by the Institute for Human Machine Cognition (IHMC) (Cañas et al., 2004). Even though the way on how they interact with the digital concept map may differ, the resulting concept map would be fundamentally the same.

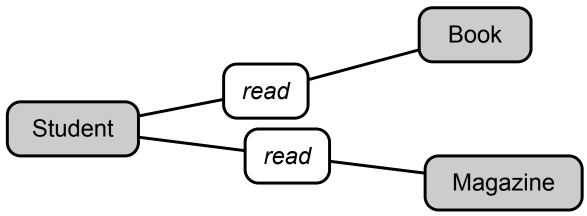
Kit-Build concept map also uses a computer-supported tool in its learning environment with concept maps. However, several differences make the Kit-Build concept maps differ from other concept maps. For example, in the Kit-Build concept map, one relationship can only connect to two concepts, and the propositions made with the link can either be directed or non-directed. Additionally, recent extension to the Kit-Build concept map authoring tool incorporated artificial intelligence to extract concepts and relationships from texts (Pinandito et al., 2021) and the extension could support both teachers the students identify concepts and relationships from text more efficiently. Even though the tool is not specifically built to support learning with Kit-Build concept map, the visual style of concept map components and its concept mapping activity of the authoring tool refer to the Kit-Build concept map framework style.

One concept map is usually visualized by a collection of concepts that semantically linked. A relationship or link—represented by linking words or phrases—represents semantic relationship or association between two connected concepts or ideas. There is no standard way on how ideas were expressed and organized in a concept map. Even though concept maps tend to be organized hierarchically, from most general or inclusive concepts to most specific concepts (Novak & Cañas, 2007). The way on how concept maps read are likely progressing from top downward and from left to right. In a concept map, a meaningful statement, which is represented by two or more concepts connected by linking words or phrases, is called a proposition. However, for simplicity and its practical implementation reason, one proposition in Kit-Build concept map can only be represented by one linking word or phrase as shown in Fig. 2.2. Hence, the difference between Kit-Build concept map and Novakian concept map.

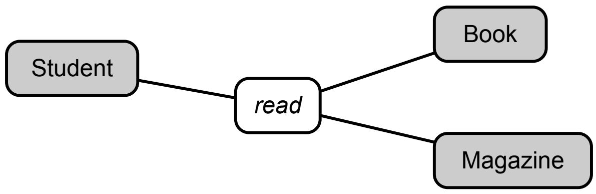
"A student read a book and a magazine."



(a) Directed multi-relationship proposition in Kit-Build



(b) Undirected multi-relationship proposition in Kit-Build



(c) Undirected multi-relationship proposition

Fig. 2.2 Representation of a directed and undirected multi-relationship proposition in Kit-Build concept map

In a traditional concept map composition activity, ideas have to be identified from learning material and be realized into concepts. Logical relationships among concepts should also be identified as links where a proposition is made when a link is connected to at least two relevant concepts. In Kit-Build, the task for identifying concepts from learning materials is called segmenting task while associating relationships between relevant concepts to form several propositions into a complete concept map is called structuring task (Hirashima et al., 2015). The current Kit-Build concept map tool supports these traditional concept map composition activity in the digital form.

The style of concept map in the Kit-Build concept map refers to Novakian concept map style. Even though there is no standard way to represent concepts and links in a concept map, it is common to visualize concepts in a concept map with labeled rectangles and visualize a link representing a relationship between concepts with a labeled node. The relationship between two concepts is usually visualized by a solid line and described by a relevant link positioned in between. Propositions in Kit-Build concept map are represented with visual representation as shown in Fig. 2.2.

In the original Novakian concept map, one source concept can have several similar relationships with two or more other concepts with only one link. To some extent, relationships in a Kit-Build concept map may be represented by both directed and undirected connections between links and concepts. The directional arrow can be omitted when the proposition can be read in both directions or have bidirectional meaning. Another reason to omit the direction is to simplify the concept maps; reducing cognitive load to think about direction. However, in a multiple proposition where one link is linked to several concepts, directed connection is necessary. Directed connection helps readers avoid misconceptions or ambiguity.

Assessment multi-relationship propositions is difficult due to ambiguity that arise from undirected multiple relationships. For an example, the undirected multiple-proposition, as shown in Fig. 2.2b, can be correctly understood as "a student read a book" and "a student read a magazine." The propositions can also be correctly understood as "a book is read by a student," and "a magazine is read by a student." However, if direction of a proposition is omitted as in Fig. 2.2c, the proposition might incorrectly be understood as "book read magazine" or "magazine read book".

Multi-relationship propositions in Kit-Build concept map can be accommodated by duplicating the link node and forming several single propositions from the same link nodes as depicted in Fig. 2.2a and Fig. 2.2b. Duplication or separation of link in a multi-relationship proposition is helpful to avoid ambiguity and misconceptions that occur where direction is omitted.

Regardless the directional problem, a multi-relationship proposition as shown in Fig. 2.2c cannot be formed with Kit-Build concept map. Directed and undirected proposition is an option when composing concept maps with Kit-Build concept map tool. With this single proposition mechanism of a link node, teachers can now use either directed or undirected concept maps without worrying about misconception problem that occur in undirected multi-relationship proposition.

A fully decomposed teacher concept map means all links from two associated concepts of said concept maps are disconnected; leaving just the concept and link nodes as a set of concept map components or a Kit-Build concept map kit. Even so, teachers have full control in decomposing their concept maps into kit by using the provided Kit-Build concept map tool. Ondemand structural analysis feedback can also be given during concept map composition or recomposition.

Kit-Build concept map authoring tool is implemented as a web application that utilize Hypertext Markup Language 5 (HTML5) and Javascript technology. A modern web browser that supports HTML5 and Javascript, such as Google Chrome or Mozilla Firefox, can be used to run the authoring tool. However, Internet connection is necessary as the authoring tool user interface is served by a web server through the Internet. Nevertheless, once the tool is loaded, almost all of the internal authoring process is performed locally. The only client-server communication during the composition is reading or writing concept map-related data to database.

2.3.2 Semi-automatic Concept Map Generation with Concept Map Mining

Despite all of the advantages of using concept maps, there are challenges and difficulties in the creation process. How a concept map is composed is subject to its creator purpose and subjectivity. The mental knowledge model of the creator could be transferred to a manually composed concept map. However, the manual concept map composition activity is often perceived as inefficient and a fully automatic approach is difficult to imitate the transfer (Presch, 2020).

Reconstructing a reading's knowledge structure in a concept map format is difficult since it requires a higher level of thinking to discover key ideas of a learning material (Cañas et al., 2017). However, it is possible to discover facts, relationships, and assertions in textual data with help from text mining and Natural Language Processing (NLP) (Hayama & Sato, 2020; Hearst, 1999) to support concept mapping composition activities within a short time. NLP can analyze the information of a human language and help the computer understand or communicate with humans (Collobert et al., 2011; Manning & Schütze, 1999).

An automatic generation of concept maps with information retrieval techniques is called Concept Map Mining (CMM) (Villalon & Calvo, 2008). CMM involves three main tasks, including concept identification, relationship identification, and topology identification (Villalon & Calvo, 2008), to extract concepts and relations and summarize the results into a concept map. Additionally, CMM involves NLP and text mining techniques in part of the automated process (Presch, 2020).

Several studies about the automatic generation of concept maps from texts has been conducted. Most of them incorporated NLP, machine learning, and other linguistic techniques to process the text to identify the necessary concepts and relations (Nugumanova et al., 2015; Qasim et al., 2013; Wafula, 2016; Zubrinic et al., 2012). Nonetheless, a concept map is context-dependent and subject to the author's purpose and preference. Thus, automatically generating a concept map that satisfies subjective results without human interference is considered difficult. The generated concept maps still have issues regarding coverage, accuracy, readability, and suitability (Atapattu et al., 2017). Prior study demonstrated that a semi-automatic approach yielded a better concept map than a full-automatic approach in comparison to a manually composed concept map as gold standard (Presch, 2020). Hence, semi-automatic concept map generation approach could bridge the gap between manual and fully-automated concept map composition.

This research extends the previous Kit-Build concept map tool's functionality with an authoring support function. Instead of fully automating the generation process, the tool adopts a semi-automatic approach with CMM to support teachers. The tool's support function extracts keywords and relation words or phrases from text as concept and relation candidates. Every proposition in a concept map has fundamental purpose and meaning in contrast to an individual concept or relation node. In addition to providing keywords as suggestions to concepts, the authoring tool being developed in this study also provided assistance at proposition level. The tool suggested subject-relation-object triples to the author as the candidates of concept map propositions that were not explicitly provided in prior studies (Hayama & Sato, 2020; Presch, 2020). This study targeted English teachers as its users who use Kit-Build in teaching EFL reading comprehension and the experiment was also more robust due to the use of multiple texts and uses. The general concept mapping activity with the designed authoring tool is shown in Figure 2.3 and the interface where users interact with the suggestions during the concept map composition is shown in Figure 2.4.

In addition to the regular concept mapping activities with the current Kit-Build concept map tool, teachers can get suggestions from the tool to quickly identify concepts and propositions of learning material. When a text material is loaded, the NLP toolkit annotates the text and extract keywords from it. An unsupervised method to extract keywords from a text document, Rapid Automatic Keyword Extraction (RAKE), is used in the extraction process. RAKE measures the importance of a keyword to the document based on its composing words' degree and frequency (Rose et al., 2010). Each identi-

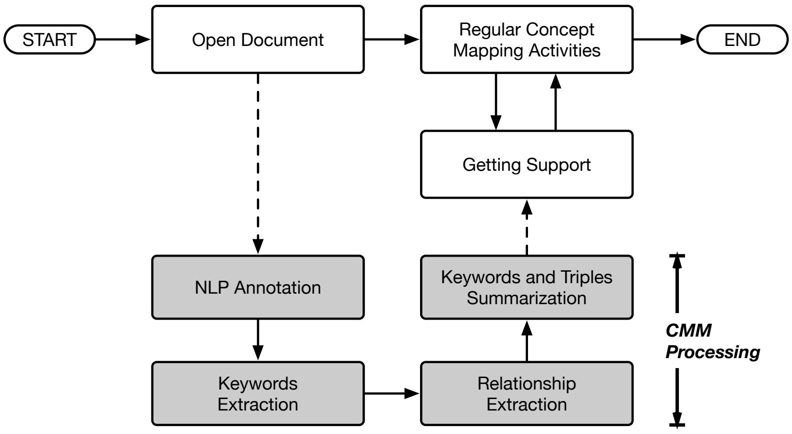


Fig. 2.3 Concept mapping activities and support processing flow

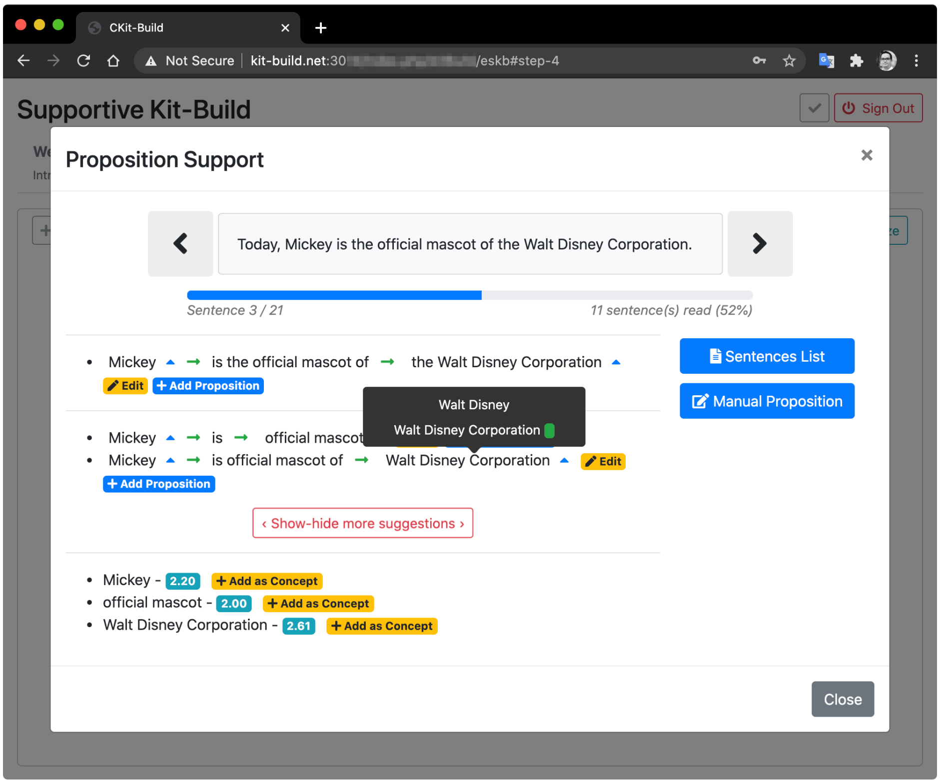


Fig. 2.4 Example of the concept map authoring tool support dialog; suggesting proposition triples and concepts of a sentence.

fied keyword's weight is computed with Term Frequency-Inverse Document Frequency (TF-IDF) technique. The computed weight determines the keyword importance level of the text. Similarities among keywords are calculated to avoid suggesting similar keywords and minimize redundancy. The NLP toolkit used to annotate the text material in this research is the Stanford CoreNLP (Manning & Schütze, 1999).

Concepts of a concept map are commonly represented by nouns or noun phrases relevant to a particular context. Relationships between concepts may be represented by linking verbs or linking phrases between two concepts of a sentence. Both noun phrases and verbs are two useful Part of Speech (POS) tags to identify concepts and relationships of a sentence. In CMM, the POS tags can be obtained from the NLP toolkit's POS-tagging annotation. Some other useful NLP annotations provided by the Stanford CoreNLP toolkit include tokenization, sentence splitting, lemmatization, dependency parsing, coreference resolution, and Open Information Extraction (Open IE). Additionally, the Stanford CoreNLP toolkit also offers some customization for the annotations.

Identifying an accurate and meaningful relationship between a link and two concepts plays an essential role in composing a concept map proposition. The Stanford CoreNLP's Open IE annotation extracts triples representing tuples of subject, relation, and relation-object of a text. The Open IE annotation corresponds to the open domain relation that captures the relation phrases expressed by the combination of verb-nouns patterns (Fader et al., 2011) and a natural logic classifier (G. Angeli et al., 2015). However, many sentences use a combination of verb-noun phrases instead of a single verb to depict a meaningful relationship between subjects and objects. Merely relying on a single verb to express a meaningful relationship is sometimes inadequate. A simple regular expression pattern can be applied to a sentence's POS tags sequence to identify verbs and verb-noun phrases as another potential candidate of propositions. The extraction process that uses regular expression patterns to extract relationships from a sentence is called Syntactic Relationship Extraction (Fader et al., 2011). The pattern's use can also reduce the number of uninformative relationships of a sentence (Fader et al., 2011) and improves the extraction performance (Patel et al., 2018).

2.3.3 Concepts Extraction and Prioritization

Concept's labels in a concept map are commonly specified from a document keywords as they most likely represent the document's topics or main ideas. There are many ways to determine keywords for a text document, but most existing approaches use manual assignments by experts or defined manually based on the concept map's authors' judgment. However, with the NLP and text mining techniques, it is possible to extract keywords from a text document based on statistical approaches.

Most concept labels in a concept map are nouns or noun phrases. Therefore, it is evident that one approach to extracting concepts from a text is by capturing all of the nouns and noun-phrases tagged from NLP's annotation process. However, not all nouns or noun-phrases are essential to consider to put into a concept map. Subject to using the concept maps, a concept label should be non-trivial and essential.

The relevance of words or keywords to a document can be measured by their frequency of appearance (Salton & Buckley, 1988). The term TF-IDF is a popular algorithm in calculating the weight of terms or keywords to a document. The TF-IDF weight (w_{ij}) of a term i in a document j can be computed from the number of occurrences of the term in the document (tf_{ij}), the number of documents containing the term (df_i), and the total number of documents (N) in a corpus as in (2.1).

$$w_{ij} = tf_{ij} \times log\frac{N}{df_i} \tag{2.1}$$

The similarity between two keywords can also be computed by finding the cosine similarity ($cos(\theta)$) between vectors of two keywords ($\vec{d}_j$,$\vec{d}_k$) composed of n unique words from both vectors. The similarity value could be calculated based on the TF-IDF weight of the composing words in each keyword (w_{ij}, w_{ik}) as in 2.2.

$$cos(\theta) = \frac{\vec{d}_j.\vec{d}_k}{|\vec{d}_j|.|\vec{d}_k|} = (\sum_{i=1}^{n} w_{ij}w_{ik}) \cdot (\sqrt{\sum_{i=1}^{n} w_{ij}^2}\sqrt{\sum_{i=1}^{n} w_{ik}^2})^{-1} \tag{2.2}$$

An unsupervised method for extracting keywords from a text document, namely RAKE, measures the importance of a keyword to the document based on its composing words' degree and frequency (Rose et al., 2010). The degree of a word is defined as the frequency of words appear in the keyword candidate list plus its frequency of co-occurrence with other words in the candidate list. The score of a keyword (S_R), which composed of n words, can be calculated as a sum of the ratio of each composing word's degree ($deg(w_i)$) and its frequency of appearance ($freq(w_i)$) in the candidate list as in (2.3). Important keywords can be selected from top T scoring keywords from the list or by setting a minimum keyword score. When working with keywords on a single document, RAKE is also more computationally efficient than a graph-based ranking approach, such as TextRank (Rose et al., 2010).

$$S_R = \sum_{i=1}^{n} \frac{deg(w_i)}{freq(w_i)} \tag{2.3}$$

2.3.4 Relationship Extraction

In the extraction process of propositions from a text, a CMM system should identify concepts and relationships (links). Identifying an accurate and meaningful relationship between a link and two concepts plays an essential role in forming a concept map proposition. A concept map proposition can be represented as a triple of concept-link-concept or a set of subject-relation-object in Open IE. The Open IE annotation process of Stanford CoreNLP annotates and extracts triples from a text, representing a subject, relation, and relation object (G. Angeli et al., 2015). The Open IE annotation corresponds to the open domain relation that captures the relation phrases expressed by the combination of verb-nouns patterns (Fader et al., 2011) and a natural logic classifier (G. Angeli et al., 2015). The triples resulting from the syntactic relationship extraction process serve potential candidates for concept map propositions.

Relationships in a complete sentence were mostly constructed by verbs. However, many sentences use a combination of verb-noun phrases instead of a single verb to depict a meaningful relationship between subjects and objects. Therefore, identifying relationship by relying on a single verb is insufficient to identify one good and meaningful relationship. A simple regular expression pattern can be applied to a sentence's POS tags annotation sequence to identify verbs and verb-noun phrases as a potential relationship candidate for propositions in a concept map. The extraction process that uses the pattern to extract relationships from a sentence is called the syntactic relationship extraction (G. Angeli et al., 2015). The extraction pattern is given by 2.4.

$$V|VP|VW*P \tag{2.4}$$

where

V = verb particle? adverb?
W = noun | adjective | adverb | pronoun | determiner
P = preposition | particle | information marker

Furthermore, the pattern could reduce the number of uninformative relationships extracted from a sentence (Fader et al., 2011) and improve the extraction performance (Patel et al., 2018).

The computed distance between two vectors of keywords represents the similarity level between keywords. The similarity among two keywords or phrases using cosine similarity measure can be determined by (a) calculating the keywords' TF-IDF value with (1), (b) transforming the keywords into vectors space model, and (c) computing the distance of both vectors with cosine similarity measure as in (2).

2.4 User Acceptance and User Experience Evaluation

The term User Experience (UX) design is often used confusedly with the term User Interface (UI) design. UX is the practice of making products (Hudson, 2008). UX does encompass not only the usability or pragmatic quality, how to carry out tasks effectively and efficiently, how to carry out tasks effectively and efficiently, but also emotional or hedonic quality (Laugwitz et al., 2008). Providing services from the perspective of the consumer should be addressed to improve users productivity; thus improving the usability (Az-zahra et al., 2015; Pinandito et al., 2019).

Due to enormous use of digital concept maps in many different fields, understanding how users are experiencing while using computer-based concept map tools become essential, especially in learning and education fields. If UX level of concept mapping tools were evaluated and understood, further improvement could be conducted to more specific UI/UX areas, thus promoting their experience in constructing concept maps.

2.4.1 User Experience Questionnaire as a Tool to Evaluate User Experience

User Experience Questionnaire (UEQ) encompasses both classical usability aspects in terms of efficiency, perspicuity, and dependability; and UX aspects in terms of originality and stimulation. UEQ was developed to answer the requirements of UX evaluation instruments that capture a comprehensive impression of user's experience in a quick, immediate, and simple assessment. The result is a semantic differential with 26 items that takes approximately 3-5 minutes to take out in UEQ.

Like most UX measurements, the result obtained from the measurement itself is not the goal. Nonetheless, it has other natural backgrounds as a basis for quantitative measurements (Schrepp et al., 2017b). Similar with UEQ, its applications can be applied into several scenarios to answer several problem backgrounds, i.e., continuous improvement by conducting UX measurement of a new product, comparison with other competitor products, evaluation of product's adequacy in terms of user experience, thus establishing room for product improvements.

UEQ uses six quality measure scales, i.e., stimulation attractiveness, perspicuity, efficiency, dependability, and novelty. The attractiveness scale is depicting the general impression of the product, whether the users like the product or not. The attractiveness scale is further categorized into two quality aspects, i.e., pragmatic and hedonic. Perspicuity, efficiency, and dependability describe pragmatic quality aspect that is oriented to product use (goal-oriented). On the other hand, stimulation and novelty are the hedonic quality aspect that is not oriented to product use (non-goal-oriented).

UEQ is originally written in German. UEQ has been translated into more than 20 languages, including Bahasa Indonesia. The UEQ has two versions, i.e., the long and short version. The long version consists of 26 statement items while the short version only has eight statements taken from the long version, i.e., obstructive/supportive, complicated/easy, inefficient/efficient, confusing/clear, boring/exciting, not interesting/interesting, conventional/ inventive, and usual/leading edge. The short version of UEQ only measures pragmatic and hedonic quality.

The short version of UEQ, User Experience Questionnaire-Short (UEQ-S), was developed in a situation where filling out the entire UEQ statements is too time-consuming. However, there are situations where UEQ-S is applicable. First, data are collected shortly after the user had finished using the product and going to leave from using it. Therefore, user impressions have to be quickly captured. Otherwise, they are going to refuse in giving feedback. Second, in a situation where the UEQ questionnaire was given along with another questionnaire, and it is impossible to be given separately as the user may refuse to fill too many questionnaires. Lastly, UEQ-S also applicable in a situation where UEQ questionnaire is given in experimental settings where participants were asked to judge the user's experience of several products or variants of a product in one session or the product variation are presented to them in random order one after another (Schrepp et al., 2017b). In such situations, the number of items must be kept to a minimum. Otherwise, the participant will be stressed. Thus, the quality of the answer will quickly decrease. The UEQ-S evaluation items and quality scales are shown in Table 2.1.

2.4.2 Technology Acceptance Model

Technology Acceptance Model (TAM) was first introduced by Davis (Davis, 1989) to identify factors that affect users' acceptance in adopting new technology. Davis proposed TAM based on the users' social psychological factors rather than on the technological aspect of the technology itself. The TAM

Table 2.1 UEQ-S Evaluation Item and Quality Scale

Item No.	Evaluation		Quality Scale
	Negative	Positive	
1	obstructive	supportive	pragmatic
2	complicated	easy	pragmatic
3	inefficient	efficient	pragmatic
4	confusing	clear	pragmatic
5	boring	exciting	hedonic
6	not interesting	interesting	hedonic
7	conventional	inventive	hedonic
8	usual	leading edge	hedonic

model is coming from the Theory of Reasoned Action (TRA) and the Theory of Planned Behavior (TPB) that focused on a link between intention and behavior, in which intention is being predicted by attitudes (Ajzen & Fishbein, 2000; Nistor et al., 2019).

Intuitively speaking, the easier the use, the technology will be more acceptable for users. Perceived Usefulness (PU) and Perceived Ease of Use (PEOU) are two beliefs that are well-known in the TAM (Davis, 1989; Davis et al., 1992). The former referred to what extent a technology subjectively perceived to be useful for users to improve their productivity and efficiency (Mun & Hwang, 2003). The latter referred to what extent users subjectively perceived the ease of use of a technology (Davis, 1989; Davis et al., 1992). The TAM model has been extensively adopted and extended to over 4,000 times by various researchers (Hong & Yu, 2018), including technology acceptance from the perspective of educational technology.

2.4.3 Compatibility, Habit, and Enjoyment as Factors that Influence User Acceptance in Learning

Some researchers argued that the variables involved in the TAM are a subset of the Innovation Diffusion Theory (IDT) (Shiau et al., 2018). IDT is a concept to explain the importance of innovation in the development of science or technology in society (Rogers, 2010). Compatibility is one of the main characteristics in IDT, which measures "the degree to which the innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters" (Choshaly, 2019; Rogers, 2010; Shiau et al., 2018). Additionally, researchers have been demonstrated to include compatibility with their proposed model. The inclusion shows positive effects on behavioral intention through perceived usefulness and ease of use (Choshaly, 2019; Crespo et al., 2013; Gagnon et al., 2012; Shiau et al., 2018).

From the Theory of Interpersonal Behavior (TIB) (Triandis, 1980), habit is traditionally defined as "behavior that has become automatized" (Gagnon et al., 2012). Regarding the literature, the adoption of new technology will complement users' habits when they experience the necessary knowledge about the purposes of using the technology and by what means they can achieve the goals (Alsharo et al., 2020). Furthermore, habit is activated by the task's goals for which the system is used in response to a specific learning purpose. Habit is used as a construct in research conducted by (Hubert et al., 2017). He proposed that variable habit has a significant positive relationship to perceived usefulness and perceived ease of use, which are the primary constructs of TAM, and acts as a principal predictor of future behavior intention of using a technology (Alsharo et al., 2020; Rafique et al., 2020). This research puts habit into consideration as the tool provides an automated extraction and identification of concepts and propositions from English texts.

Enjoyment is defined as: "the extent to which the activity of using the system is perceived to be enjoyable in its own right aside from the instrumental value of the technology" (Davis et al., 1992). Enjoyment is classified as a type of intrinsic motivation. Intrinsic motivation refers to "the performance of an activity for no apparent reinforcement other than the process of performing the activity per se" (Mun & Hwang, 2003). Intuitively speaking, in the context of technology acceptance, enjoyment can lower the cognitive burden when using technology. Users are more likely to adopt a technology if they experience enjoyment from using it (Park et al., 2012). Previous research has proven that perceived enjoyment positively affects perceived usefulness and perceived ease of use and plays a significant role in the acceptance of educational technology (C. T. Chang et al., 2017; Granić & Marangunić, 2019; Park et al., 2012).

2.5 Support in Collaborative Learning with Kit-Build Concept Map

Kit-Build concept map has been practically used in several kinds of learning environment and studies about Kit-Build showed its positive impact towards students understanding (Alkhateeb et al., 2015; Andoko et al., 2020) and memory retention (Fonteles Furtado et al., 2019; Funaoi et al., 2011). Employing Kit-Build concept map in a collaborative learning environment allows students to share their knowledge and understanding (Sadita, Hirashima, et al., 2020; Wunnasri et al., 2018a, 2018b). However, many concept map authors have limited experience in composing concept maps; resulting in vague concept maps with many abstruse propositions and issues. Having a meaningful discussion with partners is often selected as a brisk and appropriate way to clarify problems and potentially deepen one's understanding of said topic or issue. Thus, comprising collaborative learning with concept maps could potentially improve not only the learning but also the interaction (Gao et al., 2007).

Kit-Build has several implementation for its concept mapping tool. The initial implementation of Kit-Build concept map uses Flash for the user interface and Ruby as its backend processing for the storage system and learning analysis (Hirashima et al., 2015; Sugihara et al., 2012; Yoshida et al., 2013) before the following studies about Kit-Build uses Unity platform to make the system portable, cross platform, and be able to run on wide-range tablet devices (Pailai et al., 2017; Sadita, Hirashima, et al., 2020; Wunnasri et al., 2018a). Even though the system cannot directly support the discussion and collaborative concept mapping work from within the application itself, students could learn collaboratively and reciprocally compose concept maps with their partners offline.

Completely redesigned the Kit-Build concept mapping tool into a HTML5 web application yields a new Kit-Build concept mapping experience that runs on almost every modern web browsers and devices (Pinandito et al., 2019, 2020); thus, covers a wider range of computer platforms—including mobile devices—to run the Kit-Build system. However, the former Kit-Build system, which is built on Flash, has become obsolete since support for Flash has been officially ended on all web browser by December 31, 2020; leaving Unity and HTML5 as the two main platforms of Kit-Build system that were actively used in classroom. The latter study also extended the tool's functionality with semi-automatic concept map generation feature to support the concept map composition process.

The Kit-Build system, which uses HTML5, has become the preferred platform to substitute the previous Kit-Build concept map system that uses Unity. Both systems can be used on many different platforms, but one that uses HTML5 have a faster development time, more responsive, utilizes less resources, and has better compatibility towards new technology and future web standards. The drawing canvas of the HTML5 Kit-Build system uses the Cytoscape.js Javascript library for graph analysis and visualisation of Kit-Build concept map (Franz et al., 2016). The development in this study focused on extending the HTML5 Kit-Build concept map system; allowing real-time distance collaboration in learning with Kit-Build concept map.

2.5.1 Real-time Web-based Application with Socket.IO and Node

Many applications could benefit from real-time functionality, especially for multi-user applications that support collaborative work; ensuring effective interaction and smooth communication among collaborators. Different techniques were elaborated to support the collaborative work. Prior to HTML5, developing web application with multimedia features was confined. A web page has to embed Java applet, Flash, or Silverlight technology to deliver rich contents over the Internet (Garaizar et al., 2013). Prior to WebSocket and HTML5, developers have to go "native" to a particular platform and utilize the exposed network Application Programming Interface (API) to build collaborative concept mapping programs with real-time communication capability (Elorriaga et al., 2013). Nevertheless, WebSocket and HTML5 technologies were introduced to leverage new standard in delivering contents and Internet applications with better accessibility (Elkabani et al., 2015) and interactivity (Ringe et al., 2015). Furthermore, HTML5 technology is designed to support multi platforms (Curran et al., 2012; Holzinger et al., 2012) and provide full native support for 3D and multimedia contents (Garaizar et al., 2013).

WebSocket protocol is not a new technology. It was was introduced as one of HTML5 technology standard for active content delivery over the Internet through full-duplex communication channels (Hu & Cheng, 2017). Delivering real-time information and constant changes to a client, such as collaborative working systems (Maanpää, 2019; C. Wu et al., 2019; Zhao et al., 2013) and online games (Miu et al., 2020; Sugiyanto et al., 2019), requires a persistent socket connection between client and server. In a classic client-server web application, real-time complex communication was difficult to achieve without having users constantly poll requests to retrieve the updated information (Stratmann et al., 2011). As WebSocket usability and performance becomes much better (Mardan, 2018), many native real-time applications were advancing towards real-time web application (Liu et al., 2018) and shifting from request-based information generation approach to actively pushing information to users. Prior study have implemented the WebSocket on a virtual whiteboard for real-time online interaction experience across multiple users. Real-time communication with WebSocket was claimed to have lower latency than a regular Hypertext Transfer Protocol (HTTP) communication with a web server (Ringe et al., 2015).

Socket.IO (Mardan, 2014) is a Javascript library that provides abstraction layer to bidirectional communication between server side and client side that uses WebSocket technology. Socket.IO leverages WebSocket with long polling fallbacks through its unified API (Cadenhead, 2015). It requires a Node-based HTTP server to run and a client set up to connect and communicate. Usually, a server running Socket.IO uses Express framework to simplify server side programming in Node; hence, server side code becomes more flexible, more robust (Cadenhead, 2015), and run faster on large number of concurrent requests (Greiff & Johansson, 2019; Liu & Sun, 2012). Node itself is a platform that is built on Chrome's JavaScript runtime to build high performance and scalable network applications.

Socket.IO serves as a communication relay that maintain persistent connections of its clients. It has two components for both the client and the server. Communication between client and server is handled through corresponding event handler on each side. Socket.IO provided an interface—a Javascript IO object—for use in both server side and client side to send messages or attach event handlers to process incoming messages (Rai, 2013). In this wise, web applications could simply use the IO object instance to send messages and listen to incoming messages.

2.5.2 Collaborative Learning of EFL Learners with Kit-Build Concept Map

Kit-Build concept map is a learning framework that uses concept maps as its learning strategy. The framework incorporates a computer-supported concept mapping tool that allows teachers to assess students' understanding by comparing teacher and students' concept maps more efficiently (Pailai et al., 2017). Kit-Build concept map primarily adopts a closed-end concept map approach where students' concept maps are limited to the provided components (Hirashima et al., 2015). In Kit-Build concept map, a set of concept map components from which the students will recompose is called a kit.

In composing a closed-end concept map, the students cannot freely compose their concept maps with their own words or ideas as opposed to composing an open-end concept map from scratch. The concept map recomposition activity of a Kit-Build kit is referred to as kit-building. The kit, from which students compose their concept maps, can be obtained from the teacher's concept map decomposition. The decomposition of teacher's concept maps can be performed automatically by the Kit-Build concept map tool or manually by the teachers. As the students compose their concept map using the same components as their teacher's concept map components, the comparison can be automatically carried out by the concept mapping tool (Hirashima et al., 2015). Thus, their misunderstanding or misconception can be inferred from the different parts between teacher and students' concept maps.

Learning the EFL reading comprehension with Kit-Build concept map was shown to be one beneficial learning strategy to learn with concept maps. One practical use of Kit-Build concept map is supporting the learning of EFL reading comprehension. Practising with many readings is a common way to improve learner's language skills. Collaboratively learning with others has also been known to more beneficial than learning individually. Collaborative learning promoted active learning, knowledge-sharing, and self-discovery of learners due to the interaction during the collaboration process (Ibrahim et al., 2015). Therefore, in the context of collaborative learning of EFL reading comprehension, one understanding of a reading text can be shared through the interaction and discussion during collaboration, hence improved comprehension (Stegmann et al., 2007).

The nature of interaction varies in different learning environments and settings, either in a direct—face-to-face learning environment or in an online class at a distance. Regardless of the settings, the environment needs to stimulate learners' curiosity to promote meaningful collaborative learning; hence more productive activities and improved learning (Hirumi, 2002). Therefore, to support collaborative learning with Kit-Build concept map and also supporting distance communication, the Kit-Build concept map tool has been extended with real-time synchronization of concept mapping capability and text-based communication features. This study tries to discover whether composing concept maps with Kit-Build concept map helps students better understand the reading than composing concept maps from scratch in an online collaborative learning environment.

2.5.3 Kit-Build Concept Map Authoring Tool in Collaborative Learning

In learning with the current Kit-Build concept map tool, a single user can only create or compose one concept map at a time. Even though the tool has been applied in collaborative learning, it cannot be operated by more than one student to work on the same concept map at the same time (Sadita, Hirashima, et al., 2020; Wunnasri et al., 2018a). Moreover, it was impossible to use the current tool to collaboratively work on a single concept map from two different computers simultaneously. As the need for a collaborative Kit-Build concept mapping arises, an extension to the existing Kit-Build concept map tool that supported collaborative work was implemented.

The new implementation of Kit-Build concept map tool allowed multiple users to work with a concept map from different computers collaboratively and simultaneously. Any changes over one drawing canvas will immediately be reflected to the other participating users; hence, a real-time collaborative concept mapping environment is created. A similar concept mapping tool has been developed in another study (Farrokhnia et al., 2019). The tool also allows several users to compose a concept map at the same time collaboratively. However, the tool does not support the recomposition of concept maps, and it has no comparison analysis features as in this study new collaborative Kit-Build concept map authoring tool.

The tool has been developed with web technologies, hence accessible from modern web browsers that support HTML5 and Javascript. The tool is expected to run on most computers and mobile devices with access to the Internet despite the requirements that have to be met for a smooth and seamless concept mapping experience. An example of the newly developed online collaborative Kit-Build concept map tool, which shows a student's concept map during collaboration, is shown in Fig. 2.5.

In supporting communication in collaborative work of concept mapping, the online collaborative Kit-Build concept map tool provided two kinds of text-based communication channels as shown in Fig. 2.5 for students to communicate and discuss their concept maps with others. The discussion data for analysis were obtained from these channels. One of the communication channels, which is located on the right side of the screen, is a general discussion channel. Messages sent from this channel will be broadcasted to other participants who joined the collaboration. The other type of communication channel is linked to a concept or link node; hence, one communication channel for each concept and link node. The node-linked communication channels were designed to facilitate discussion of a particular idea or relationship attached to the corresponding concept or link nodes. Additionally, notifications and indicators will be displayed over a concept or link node when a new message arrives. These communication features are useful for facilitat-

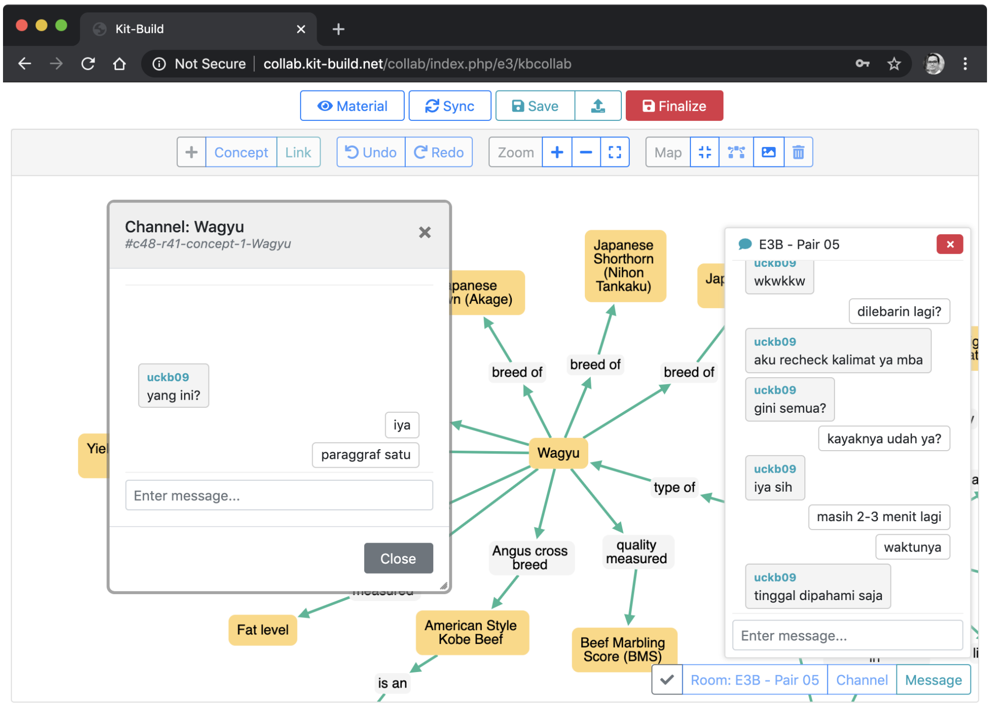


Fig. 2.5 Communication in Online Collaborative Kit-Build Concept Map Tool

ing communication among users and keeping the discussion in control when discussing many different topics or ideas simultaneously.

Chapter 3

Research Questions

One of the aims of this study focused on assisting teacher and student compose concept maps from learning material with Kit-Build concept map authoring tool with semi-automatic concept map generation approach. The second aim of the study focused on supporting online collaborative learning with concept maps by developing the concept mapping system to support real-time communication and collaboration in concept map composition activity. Several research questions were defined and be addressed in this study to evaluate the impact of the newly developed system towards its use in learning environment. The study will be organized into two sections, the first section discussed the design and development of concept map authoring support tool while the second section discussed the design and development of concept mapping tool for online collaborative learning with concept maps. Depending on the focus of the study, the defined research questions were organized into the respective sections accordingly.

3.1 Design and Development of Concept Map Authoring Support Tool

This research presents the design and development of a semi-automatic support function that extends the previous Kit-Build concept map authoring tool to aid teachers in creating concept maps from English reading materials. The design of the generation approach of a concept map authoring tool, which adopted the CMM method and text mining to generate concept maps of EFL reading comprehension texts semi-automatically is presented and evaluated.

The designed authoring support tool semi-automatically generates the concept maps by suggesting keywords and proposition triples for the teachers to choose, modify, and incorporate the suggestions into their concept maps. However, before the tool is considered to be used practically with Kit-Build, the performance of the authoring support system has to be evaluated. Therefore, the accuracy of the suggestions yielded by the system, and how the tool is perceived, need to be discovered.

Thus, teachers could compose concept maps for use with Kit-Build more efficiently than composing the concept maps manually. The new tool implements the NLP, CMM, and several text mining methods to extract and suggest relevant items of reading material to teachers. Currently, teachers have to create concept and link nodes, connect the nodes to make propositions, and arrange the propositions manually. With the proposed concept map authoring tool, teachers can get suggestions of keywords and propositions to be included in their concept maps. This research puts the tool into a trial with English teachers to evaluate how the tool's support function affects teachers' concept mapping activities in terms of efficiency and concept map quality.

The following research questions were addressed in this study:

RQA-1: With the designed extraction approach towards EFL reading comprehension learning strategy with Kit-Build, how is the accuracy of the suggested keywords and proposition triples of the authoring support tool?

RQA-2: Will the developed concept map authoring support tool perceived to be useful for assisting teachers in composing concept maps from EFL reading comprehension texts and support their teaching activities with Kit-Build concept map?

RQA-3: Will the concept map authoring support tool, which generates concept maps semi-automatically, could improve the concept mapping efficiency in terms of the yielded number of propositions?

RQA-4: Will using the authoring support tool yields concept maps of better quality than a manually composed concept map?

RQA-5: How will the teachers perceive the usefulness of the concept map authoring support tool to create concept maps of English reading materials for teaching?

As a part of Kit-Build concept map learning framework, a computer-based concept map authoring tool is developed and used for learning. Additional support features have also been incorporated into the basic functionality of the authoring tool by suggesting keywords and propositions. The suggestions were obtained from the extraction process of English-based general reading material. The tool can also provide several feedbacks and critiques based on the map that is being constructed. This study also investigates how students would experience the authoring tools to compose a concept map with and without semi-automatic generation support. Finding how the students experience the tool could promote better experience and performance in constructing concept maps. The UX analysis will be performed to find whether a concept map authoring tool, which incorporates keywords and propositions suggestions and feedbacks, would give better experience over the basic version that has no such supports and functionalities.

With the new support feature can put a different interaction with the tool during concept mapping. It is interesting to analyze the students' intentions and perceptions of whether they accept using the Kit-Build concept map authoring tool as a learning media that supports them in studying learning materials with concept maps. TAM has been profoundly used to measure and depict users' acceptance of new systems or technologies, including education and learning technologies Salloum et al. (2019). A critical review of TAM revealed that including additional factors an extension to the original model can provide a broader view and better explanation regarding factors that might contribute to the acceptance of a specific technology Teo (2009). This study also aims to investigate the validity of TAM in an educational setting and the extent to which the external variables to the model will impact the students' acceptance towards the Kit-Build concept map authoring tool.

The following research questions regarding user experience and user acceptance in using the concept map authoring support tool are also addresed:

RQA-6: Will the developed concept map authoring support tool provides better experience towards concept mapping than the existing authoring tool?

RQA-7: How is the user acceptance model with TAM for the developed concept map authoring support tool?

RQA-8: Among several factors that could possibly influence the acceptance model, what are the factors that contributed to the acceptance of using the developed concept map authoring support tool?

3.2 Design and Development of Support Tool for Online Collaborative Learning with Concept Maps

Previous studies suggested that posing concept maps in collaborative learning could improve students' learning and productivity C.-C. Chang et al. (2017); Gao et al. (2007). Learning with Kit-Build concept map in collaborative learning environment also yielded similar benefits towards learning Sadita, Hirashima, et al. (2020); Wunnasri et al. (2018a). However, how Kit-Build concept map could perform similarly in online collaborative learning has yet to be discovered. This study took the online collaborative Kit-Build concept map tool into a trial to investigate the use of Kit-Build concept map in online collaborative learning of EFL reading comprehension and discover whether it helped the students comprehend the readings better from online discussion and collaborative recomposition of concept maps. Comparative analyses with a traditional online collaborative concept mapping approach were presented in this study regarding the learning effect and students' conversation during collaboration.

This study presented the design and development of Kit-Build concept map collaboration system where students and teachers could collaborate and discuss learning materials with Kit-Build concept map from distance. Preliminary evaluation towards the prototype of the online collaboration system is also presented to portray the usability of the system in supporting collaborative learning. Therefore, to guide this study, the following research questions were addressed:

RQB-1: How is the design of a system that enables the current Kit-Build concept map system supports online real-time composition and discussion of concept maps?

RQB-2: How is the students' attitude towards the system usability in supporting collaborative learning with Kit-Build concept map?

RQB-3: How the use of Kit-Build concept map in an online collaborative learning environment of EFL reading comprehension, which uses concept maps composition as its learning strategy, affects student comprehension as opposed to the regular open-end concept mapping?

RQB-4: How is the discussion during online collaborative work with concept maps with and without the Kit-Build method?

Chapter 4

Concept Map Authoring Support Tool with Semi-Automatic Concept Map Generation

4.1 Study 1: Design of Semi-Automatic Concept Map Generation with Concept Map Mining Approach

4.1.1 Methodology

This study focused on supporting teacher's concept map composing activity in a semi-automatic way. Support was given in the form of recommendations of concepts and propositions extracted from English texts. The extraction process adopted the CMM method that involved NLP and text mining techniques. In addition to presenting the design of the extraction process, the accuracy of the yielded recommendations was analyzed and evaluated.

The Kit-Build concept map authoring tool was designed to be used computers or tablet computers. The current Kit-Build concept map authoring tool is implemented in HTML5 and Javascript technology. The support feature extended the current authoring tool and could also be run on the same platforms. Users could use the tool with the new support feature with their personal computers or tablet devices. This study extended the current Kit-Build concept map authoring tool's functionality by adding a recommendation system as an authoring support feature and enriched the way teachers composed and improved their concept map. The support function recommended keywords and proposition triples while also allowed modifications made to the suggested items.

The design and development of the authoring support function are shown in Fig. 4.1. Before the design and development of the support function were conducted, a preliminary study regarding Kit-Build concept map framework, CMM, and the Stanford CoreNLP toolkit was carried out to identify and analyze how CMM and the NLP toolkit were able to extract concepts and propositions from English reading texts. How teachers get assistance from the support function was designed following the strategy of learning EFL reading comprehension with Kit-Build concept map.

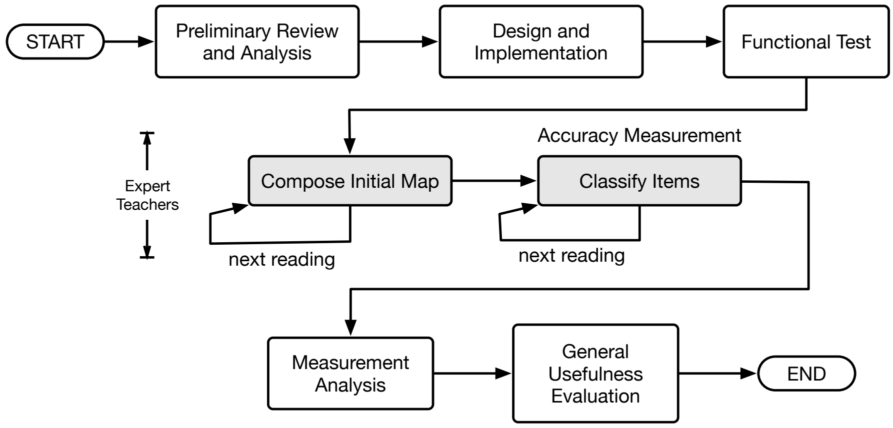


Fig. 4.1 Research Methodology

Review and analysis of the current Kit-Build concept map tool were carried out to identify how the authoring support function could be integrated into the current Kit-Build concept map tool, thus resulting in a general requirements specification. The support system architecture, activities, and text processing were designed according to the requirements specification. After all of the designs were implemented into the target program and prototype, several tests were carried out to ensure the system work as designed, thus yielded the expected outcomes.

The support system performance regarding support function accuracy was evaluated using several English reading comprehension materials. Several English teachers evaluated the system and composed concept maps using the support function of the authoring tool. The yielded suggestions of the support function were evaluated and classified by the teachers per their initial concept maps to measure the accuracy of suggested items. Additionally, the evaluators were given a questionnaire and requested to evaluate the tool's support function regarding their perceived usefulness in contrast to the traditional concept mapping approach with Kit-Build concept map.

EFL Reading Comprehension Learning Strategy

The concept mapping strategy that was applied to this study consisted of several steps. First, teachers created a concept map that sophisticatedly represented the reading and decomposed the map into a set of concept map components (Kit-Build kit). The map would be used in the next phase of learning with Kit-Build concept map framework, where students reconstructed the map to express their understanding regarding the reading. One sophisticating concept map should have enough relevant concepts and relationships to represent the content. The map should not be too general to represent the text with merely a small number of concepts and relationships or be overwhelmed with many complicated concepts and unnecessary relationships that might confuse the students.

During the comparison analysis phase, students' concept maps were compared with a teacher concept map. The comparison identifies their misconceptions or misunderstanding regarding the reading pointed by the different and missing parts. The teachers were then further explaining the reading and refining their concept map to a more detailed concept map that better cover the missing and different parts. In this learning strategy of EFL reading comprehension with Kit-Build concept map, teachers composed their concept map at least twice, i.e., during the initial concept map composing activity and during the refinement of their initial concept map. Therefore, the authoring support features were expected to support their composing activity in these two situations.

Support Function Evaluation

To evaluate the support system's performance, three English teachers were selected as expert evaluators based on their expertise in using concept maps in teaching EFL reading comprehension. They were requested to compose their initial concept maps of a sophisticated level based on Mueller's concept map rubric by using the system with support function (Mueller, n.d.). Upon reviewing several publicly available concept map evaluation rubrics, they had agreed that Mueller's concept map rubric was compatible with the strategy of learning EFL reading comprehension with Kit-Build concept map; hence, used in this research.

Fifteen reading comprehension texts of Barron's Test of English as a Foreign Language (ToEFL) iBT learning materials (Sharpe, 2013) were selected to evaluate the accuracy performance of support function. During their initial concept map composing, teachers were requested to use the authoring tool's support features to get recommendations of keywords and proposition triples. They were given a tutorial and practicing to use the concept map authoring tool.

A recommendation system's accuracy can be evaluated from the Positive Predictive Value (PPV) and the True Positive Rate (TPR). In information retrieval, PPV and TPR are generally called by precision and recall, respectively. PPV considers both true-positive items (t_p) and false-positive items (f_p), while TPR considers both true-positive items and false-negative items (f_n). PPV or precision was calculated with (4.1), while TPR or recall was calculated with (4.2).

$$PPV = \frac{t_p}{t_p + f_p} \tag{4.1}$$

$$TPR = \frac{t_p}{t_p + f_n} \tag{4.2}$$

In evaluating the suggested keywords and proposition triples' accuracy, the teachers were asked to identify and classify every keyword and triple from the suggestion list for its relevance and appropriateness to their concept maps. The support function accuracy performance of this study was measured by F-measure (F_1). F-measure is commonly used to evaluate the performance of information retrieval systems such as search engines, machine learning models, and natural language processing. Both precision and recall values were considered in calculating the system's accuracy performance. The F-measure is formalized in (4.3).

$$F_1 = 2 \cdot \frac{PPV \cdot TPR}{PPV + TPR} = \frac{t_p}{t_p + \frac{1}{2}(f_p + f_n)} \tag{4.3}$$

True-positive items (t_p) were defined as the number of suggested items and were used as part of their concept maps, either with or without slight modifications. The modifications may include adding or renaming part of the concept's or link's label; or altering the suggested triples. On the contrary, false-positive items (f_p) were defined as the number of suggested items not used in their concept maps. Part of their concept maps, which were not suggested by the support tool and had to be created manually, were identified as false-negative items (f_n). True-negative items were irrelevant in this study, because the system did not suggest the items or used in the concept map.

In this study, the support system was used in two concept mapping activities. First, it was used during the initial concept map composing; and second, it was used during the refinement of teachers' concept map. As the purpose of both concept mapping activities was different, the accuracy of the suggestions might differ. Thus, suggested concepts and propositions, which were not included in teachers' initial concept maps but potentially used to refine the concept maps, were classified differently. These potential suggestions were classified as false-positive potential (f_{pp}). Therefore, false-positive potential items were counted as false-positive and true-positive for the initial and the refinement concept mapping, respectively. The precision value of the support function for the initial concept mapping was calculated with (4.4), and the precision value for the refinement concept mapping activity was calculated with (4.5).

$$PPV = \frac{t_p}{t_p + (f_{pp} + f_p)} \tag{4.4}$$

$$TPR = \frac{t_p + f_{pp}}{(t_p + f_{pp}) + f_n} \tag{4.5}$$

4.1.2 Result and Discussion

Architecture Design of Authoring Support Processing Flow

The system was built on top of web technologies, thus accessible from most computers and mobile devices with access to the Internet. A web server served the application interface and provided the data API to communicate with the database. Both the NLP toolkit and Web API transferred the data in JavaScript Object Notation (JSON) format through the HTTP. The processing layer of the support system is depicted in Fig. 4.2.

The support system processing logic was integrated into the Kit-Build concept map web application. The essential part of the processing layers was the NLP toolkit and served by the Stanford CoreNLP server. The toolkit preprocessed, parsed, and annotated the text input. The Stanford CoreNLP annotated the English input text with tokenization, sentence splitting, lemmati-

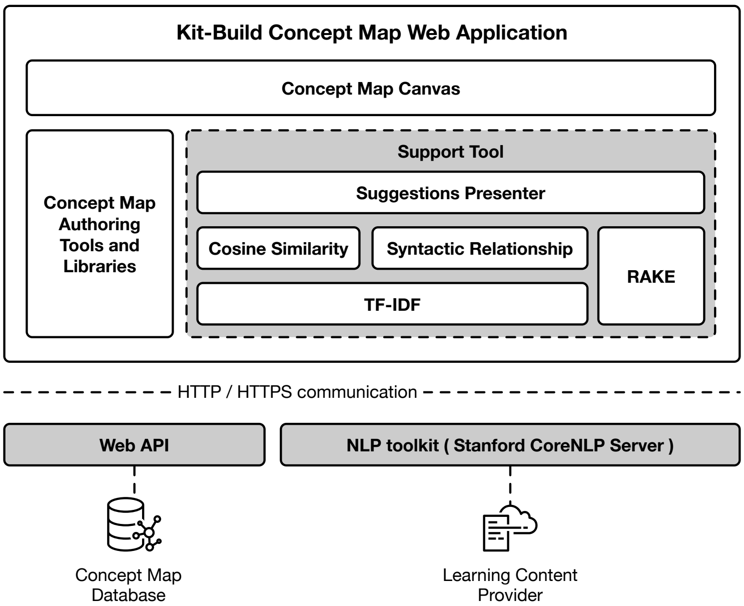


Fig. 4.2 Processing architecture layer of concept map support system.

zation, part-of-speech (POS) tagging, dependency parsing, coreference resolution, and open information extraction. The POS tagging annotation identified and labeled noun and noun-phrases for keyword identification processing. Each identified noun or noun-phrase was calculated for its weight by the TF-IDF method. Similarities among keywords can be computed with the cosine similarity measure. RAKE ranked the identified keywords according to the text.

The Stanford CoreNLP also yielded Open IE triples that already in a subject, relation, relation-object format. All triples, whose subject or relation-object has a strong similarity to the extracted keywords would be suggested to the teachers. However, teachers can also opt to see all of the Open IE annotated triples. The Syntactic Relationship Extraction process extracted possible relationships and triples based on the regular expression patterns as in 2.4. According to the review of the annotated text, some of the Open IE annotation results were unsatisfactory. Several triples resulting from the Open IE annotation were considered unnecessary, and verb-based linking words cannot be properly identified. Thus, the Syntactic Relationship Extraction (SRE) was incorporated to identify verb-based relationships of a sentence.

The system's suggestion processing flow in recommending the keywords and proposition triples and the relevant application layers that process the document text is shown in Fig. 4.3. The processing flow was initiated when teachers opened a text file. The processing flow was divided into two parts to optimize the processing time. The first part—the text pre-processing—ran immediately after the NLP toolkit had finished annotating the text. The pre-processing extracted essential keywords from the text and calculated the similarity among keywords. The second part ran during sentence navigation and processed the currently selected sentence.

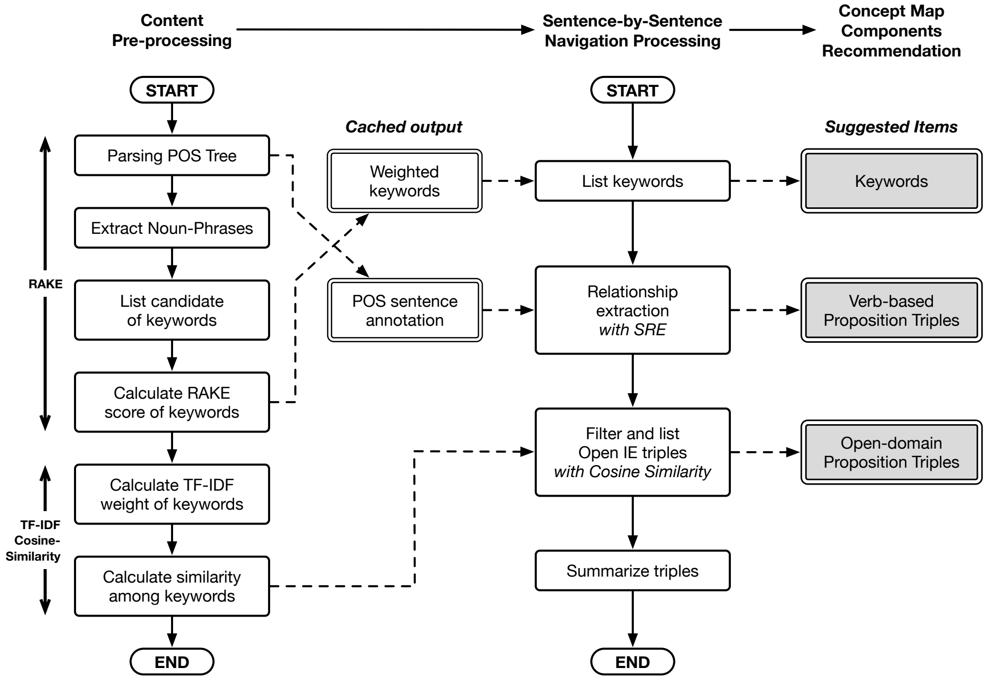


Fig. 4.3 Recommendation processing flow

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Implementation Result

The support system's interface and functionality were mostly implemented in web programming languages. The Web API was implemented in the PHP Hypertext Preprocessor (PHP) programming language. The cosine similarity, RAKE, SRE, and TF-IDF processors were implemented with Javascript and ran client-side. The graph visualization of the concept map used the Cytoscape.js library (Franz et al., 2016) with several plugins added.

The keywords and proposition triples were suggested by the system on a sentence-by-sentence basis, which means that the suggestions reflected a sentence selected by the teacher. The suggestions were presented to the teacher in a support dialog, as depicted in Fig. 2.4. Using the support dialog, teachers can navigate the text to get suggestions for another sentence. Teachers could modify the triples and put the desired keywords into the canvas from the suggested keywords and proposition triples. They can also modify the propositions, organize the concept map layout, and alter the map's visual appearance with the existing simple concept map composing tool.

The propositions were suggested into three sections. Each section represented the suggestions from RAKE, SRE, and Open IE. The topmost part, which consisted of three suggested proposition triples, was obtained from the SRE method. The center part, which consisted of one suggested proposition triple, was obtained from the filtered Open IE method. Lastly, three keywords were suggested from the RAKE approach. The label of a proposition triple's subject and relation object can be modified or replaced with any suggested keywords. Thus, forming a more appropriate proposition before incorporated the triples as part of the concept map. Keyword added to the canvas would represent a concept in the concept map. Additionally, teachers could compose a proposition triple manually.

Initial Concept Mapping Using the Authoring Support Tool

The system evaluation involved 15 EFL reading texts. According to the evaluation result, on average, the support tool suggested 157 keywords, 85 proposition triples of the SRE approach, and 62 proposition triples of the optimized Open IE. The SRE method extracted and recommended verb-based proposition triples according to the POS pattern of a sentence (Fader et al., 2011), while Open IE triples corresponded to open domain-based relations (G. Angeli et al., 2015). If all said keywords and propositions were visualized into a concept map, a relatively huge concept map would be generated, and evaluating such a concept map would be challenging. As generating proper and satisfying concept maps was difficult to achieve, the semi-automatic approach proposed was presumed a better approach than a fully-automated or manual approach, at least in this study.

On average, the EFL readings used to evaluate the support features were composed of 719 words and 34 sentences with a standard deviation of 50 words and six sentences, respectively. The description of the EFL reading comprehension text used in the evaluation of the tool, the number of sentences (n_s), the number of suggested keywords (n_k), the number of suggested propositions from the syntactic relationship extraction (n_{ps}), and the number of suggested propositions from the filtered open IE triples (n_{po}) are shown in Table 4.1.

During the initial concept mapping activities, teachers created 15 sophisticating concept maps—one concept map for each reading, resulting in con-

Table 4.1 Number of suggested keywords and proposition triples of the readings

ID	Title	n_s	n_k	n_{ps}	n_{po}
T1	Beowulf	39	159	82	57
T2	Building with Arches	34	151	88	58
T3	Civilization	24	150	81	48
T4	Exotic and Endangered Species	45	168	83	63
T5	Four Stages of Planetary Development	38	141	89	49
T6	Geothermal Energy	33	148	70	58
T7	Looking at Teathre History	29	155	97	26
T8	Organic Architecture	34	168	90	76
T9	Paleolithic Art	29	141	84	49
T10	Piaget's Cognitive Development Theory	41	139	119	49
T11	Resources and Industrialism in Canada	23	175	64	107
T12	Rising Sea Levels	38	195	80	85
T13	The Evolution of Birds	35	144	84	55
T14	The Hydrologic Cycle	38	156	71	68
T15	Thermoregulation	33	169	87	82

cept maps composed of 35 concepts and 36 propositions on average. Composing concept maps with such numbers of concepts and propositions was not an easy task. Moreover, teachers were requested to compose many concept maps in a relatively short time. The descriptive statistics of the expert teacher's initial concept maps during authoring support system evaluation are shown in Table 4.2.

Table 4.2 Descriptive statistics of expert teacher's initial concept maps

ET	n	Average		Minimum		Maximum		s.d.	
		C	P	C	P	C	P	C	P
ET#1	15	29.47	29.87	20	19	61	61	9.912	10.449
ET#2	15	43.87	43.33	25	24	89	90	14.773	15.230
ET#3	15	31.27	35.67	17	24	43	58	7.698	9.5196
Overall		34.9	36.3	17	19	89	90	12.896	13.204

ET: Expert Teacher; C: Concept; P: Proposition

Support Function Accuracy Performance Measurement

Three expert teachers classified the suggestions into a statistical confusion matrix, representing instances in the predicted classes and instances in the actual classes based on their initial concept maps. Each suggestion is classified into one of true-positive, false-positive, false-negative, or true-negative class. The classifications process was also carried out to all groups, i.e., RAKE keywords, SRE propositions triples, and filtered Open IE triples.

The number of relevant (true-positive (t_p)), potentially relevant (false-positive potential (f_{pp})), irrelevant suggestions (false-positive (f_p)), and non-existing suggestions (false-negative (f_n)) of one of the experts are shown in Table 4.3. The classifications were carried out to the suggested keywords, proposition triples of SRE, and proposition triples of Open IE. These values will be used to calculate the support system accuracy from their precision and recall value.

The summary of the support system performance and the standard deviation value of the concept mapping support tool are shown in Table 4. The table depicts the system's average precision, recall, and F-measure values for 15 EFL reading comprehension texts of three raters. For the suggested keywords, the support system has a relatively low precision but high recall value. However, triples obtained from the SRE and Open IE approach have low pre-

Table 4.3 Classification of Suggested Items of a teacher

ID	Keywords				Verb-based Triples				Open-domain Triples			
	t_p	f_{pp}	f_p	f_n	t_p	f_{pp}	f_p	f_n	t_p	f_{pp}	f_p	f_n
T1	130	17	12	3	41	17	22	17	31	11	12	29
T2	67	63	20	2	28	29	28	6	25	11	22	14
T3	58	84	8	3	26	41	9	22	12	17	18	24
T4	68	86	16	4	46	18	21	6	17	31	13	8
T5	46	82	13	1	34	27	27	10	17	18	16	10
T6	68	68	11	1	29	19	20	16	17	20	19	17
T7	54	82	19	5	17	50	24	13	7	18	0	16
T8	43	111	15	2	20	30	34	19	12	37	24	22
T9	64	62	14	4	32	28	27	2	13	20	14	5
T10	43	82	14	4	22	65	31	17	15	27	7	26
T11	53	116	4	0	17	40	7	11	44	14	43	10
T12	70	112	15	3	49	7	20	24	52	2	25	23
T13	53	86	4	6	21	47	16	16	18	26	11	18
T14	63	89	6	4	18	31	16	25	15	26	19	28
T15	74	92	3	3	32	41	13	9	24	26	31	10

cision and recall value. A low precision value indicated a high number of false-positives; similarly, a low recall value indicated a high number of false-negative items, depicting few suggestions were used in the initial concept maps. A low recall value indicated that many parts of their concept maps have to be created manually. It can also be said that the system could not suggest satisfying proposition triples for use in the teachers' initial concept maps.

The support system's accuracy performance can be depicted from the F-measure value, which is the harmony between precision and recall values. According to Table 3, it can be seen that the system has the lowest F-measure average performance of 42%, 14.9%, and 19.2% in terms of keywords, open domain-based triples, and verb-based triples, respectively. The highest F-measure average performance is 55.9%, 40.3%, 44.8% for the keywords, open domain-based triples, and verb-based triples. Supposing the same suggestions were used to refine the concept map, the F-measure performance improved for a maximum of 95.1%, 69.4%, 76.7% for the keywords, open domain-based triples, and verb-based triples, respectively.

When teachers created their initial concept maps, all false-positive potential items were regarded as false-positives items, resulting in a larger number of false-positive items, thus lowering the system's precision value. In composing the initial concept maps, they created one sophisticated concept map rather than directly composed a very detailed and huge concept map. Thus, it was expected that a lower number of true-positive items was noticed in their initial concept maps. However, in another use of the support function where they refine their concept map, false-positive potential items were potentially useful to refine the concept map and could be regarded as true-positive items; hence, improved precision.

Usefulness Evaluation

A questionnaire based on the TAM questionnaire was given to the expert teachers to get their usefulness impression regarding the support tool. The questionnaire consisted of 5 questions on a 7-Likert scale, which has a Cronbach alpha value of 0.84, indicating good reliability. The questionnaire was given in comparison with the manual concept mapping approach. Their responses to the questionnaire are shown in Fig. 4.4.

According to the questionnaire result, as shown in Fig. 6, none of them gave neutral or negative feedback regarding the usefulness. They agreed that the authoring support tool would enhance the effectiveness and increase their

Table 4.4 Support Tool Accuracy Performance

Suggestion Type	n	Precision		Recall		F-measure	
		mean	s.d.	mean	s.d.	mean	s.d.
Expert Teacher #1							
potential suggestions (f_{pp}) are counted as false-positives (f_p)							
Keyword	15	0.405	0.129	0.953	0.0283	0.559	0.112
Open domain triple	15	0.333	0.121	0.541	0.169	0.403	0.119
Verb-based triple	15	0.347	0.131	0.667	0.148	0.448	0.132
potential suggestions (f_{pp}) are counted as true-positives (t_p)							
Keyword	15	0.926	0.0359	0.98	0.0113	0.951	0.02
Open domain triple	15	0.694	0.112	0.71	0.107	0.693	0.063
Verb-based triple	15	0.73	0.085	0.815	0.0866	0.767	0.068
Expert Teacher #2							
potential suggestions (f_{pp}) are counted as false-positives (f_p)							
Keyword	15	0.294	0.108	0.925	0.0368	0.436	0.116
Open domain triple	15	0.13	0.115	0.184	0.127	0.149	0.121
Verb-based triple	15	0.145	0.0904	0.311	0.109	0.192	0.102
potential suggestions (f_{pp}) are counted as true-positives (t_p)							
Keyword	15	0.931	0.0385	0.973	0.02	0.951	0.025
Open domain triple	15	0.519	0.122	0.497	0.138	0.502	0.12
Verb-based triple	15	0.668	0.074	0.696	0.0774	0.676	0.049
Expert Teacher #3							
potential suggestions (f_{pp}) are counted as false-positives (f_p)							
Keyword	15	0.278	0.0842	0.916	0.0458	0.42	0.102
Open domain triple	15	0.207	0.107	0.331	0.123	0.243	0.097
Verb-based triple	15	0.219	0.0486	0.535	0.17	0.306	0.069
potential suggestions (f_{pp}) are counted as true-positives (t_p)							
Keyword	15	0.896	0.0424	0.972	0.0163	0.932	0.024
Open domain triple	15	0.758	0.0817	0.649	0.113	0.694	0.082
Verb-based triple	15	0.749	0.076	0.784	0.106	0.761	0.07

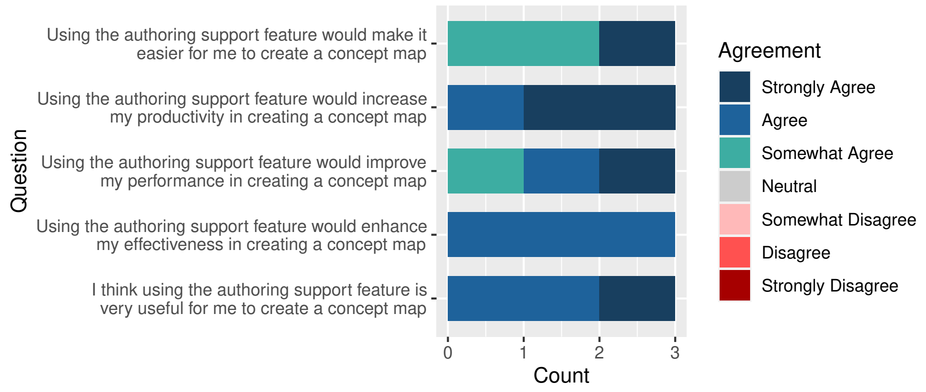

Fig. 4.4 Expert teacher's perceived usefulness of using Kit-Build concept map authoring tool with support function

productivity in creating concept maps from text learning materials; thus, they thought the support tool was very useful. However, two of them somewhat agreed that the authoring support feature would make them easier in composing concept maps because the way they composed their concept maps with the authoring support tool was more complex than a manual composition. Their responses regarding the support tool's usefulness were in line with the tool's usability level, as presented in (Pinandito et al., 2019). Hence, improvement in usability could improve the usability of the authoring support tool. Nevertheless, it can be said the developed Kit-Build concept map authoring tool was useful in assisting teachers in composing concept maps from English texts.

4.1.3 Limitation and Future Work

The result of the proposed semi-automatic concept map generation showed a promising result to be used in the actual EFL learning environment with Kit-Build concept map. Thus, practical use and trial of the authoring support tool with EFL teachers for use in EFL reading comprehension learning will be the future work of this study.

The concept map generation approach does not elaborate on teachers' logic and thinking while composing their concept maps. Following the teachers' logic in determining which concepts and relationship triples are important and genuinely relevant to the topic is important could improve the suggestions' accuracy. Discovering factors that influence how teachers compose their concept maps is also one important aspect of suggesting more accurate extraction and further improving the suggestions. Specifying the context of learning and adapting the automatic generation approach to conform to the learning context could potentially yield better relevance keywords and propositions; hence, more accurate and better components to suggest.

Technically, the extraction approach applied does not elaborate coreference and semantic resolution in which they may improve how the system resolves pronouns and identify similar words in a text. Elaborating coreference resolution could improve the extraction approach. Incorporating semantic approach and additional processing to support ill-structured English sentences are several other potential future works of this study towards a better concept map generation process. Even though the extraction approach in this study was not specifically designed and limited for EFL reading comprehension use, it is also possible to use the tool to extract concept map components from another English text. However, it might yield inaccurate and unexpected results.

4.2 Study 2: The Effectiveness and Efficiency of The Developed Concept Map Authoring Support Tool

4.2.1 Methodology

Context and Participants

This research aimed to trial the utilization of Kit-Build concept map authoring tools to assist teachers to create concept maps on Phase I of the Kit-Build concept map framework. The context of this research is to support English teachers in creating concept maps from English reading comprehension texts as concept mapping with Kit-Build is shown to promote the students' comprehension and understanding of its contents. The reading comprehension texts, which were used in the experiment, were structured English readings.

The participants consisted of 47 English teachers and tutors who voluntarily participated in the experiments. They mainly teach English in high school or university in Malang, East Java, Indonesia and they have experience in teaching English reading comprehension with concept maps. The participants consist of 29 (62%) female teachers and 18 (38%) male teachers. The participants' ages range from 20 to 39 years old, with 48% of participants between 20 and 29 years old, and the remaining 52% between 30 and 39 years old. The participants were invited with an online registration form to give their consent to participate in the experiments. They also provided their contact information for communication purposes regarding the experiment. They also describe their experiences in English teaching and concept mapping over the past few years.

The reading passages used in the experiments were obtained from the ESL Fast website, an online English learning website that provides free English readings with a certain level of difficulties (ESL Fast, n.d.). This research uses two reading passages for the experiment. Both of the passages are intended for intermediate English learners. The selected passages are composed of about 300 words or 1800 Latin characters without any graphics or images.

Experiment Design

The concept mapping tools require a web browser and a network connection to a serving webserver to run. The tool is designed to run natively on modern web browsers with Javascript and HTML5 capabilities. Another requirement was that the computer screen from which the web browser ran needed to have a minimum resolution of 1024×768 pixels. Hence, all the tools' features and the concept mapping canvas can be shown on a single screen without scrolling the window.

In this research, all participants were English teachers or tutors. Most of them were new to the Kit-Build concept map framework and its authoring tool. A pre-task was given to the participants two weeks before the experiments to introduce the tool online. All participants were asked to create a concept map based on a pre-made concept map with the online tool. The online tool has the same functionalities as those used in the experiment. A user manual was also given as a guide for them to try and familiarize themselves with the tool.

All participants necessarily prepared their computers based on the specified requirements to minimize problems during experiments. They were requested to connect to the Internet, install an updated web browser, and enable the browser's Javascript processing capability. Even though all participants' computers were connected to the Internet, the experiments were carried out on a local area network.

Before they carried out the experiment activities, the teachers were introduced to the Kit-Build concept map framework and the concept mapping tool used to create a concept map with Kit-Build. There was also a short training session for about one hour, where they created a concept map with the tool. This training session was necessary to discover and solve technical issues with the tool, which they might experience or had encountered previously, before conducting the actual concept mapping activities where measurements were taken into account. A demographic questionnaire was also given to all participants at the end of the training session.

There were two types of tools used in the experiment. The first tool was a concept mapping authoring tool that provides the basic concept map creation functionalities; this tool is further referred to as the Scratch tool (SC). The other concept mapping tool has the same functionality as SC but has additional support and feedback functionalities. The second tool, which has the support function, is referred to as the Supported tool (SP).

This research's experiment was designed so that all participants experienced both concept mapping methods with the tool, i.e., with or without the support function. However, the order in which they used the tool's support function may have affected their concept mapping activities and further affected the resulting concept maps. When teachers created their second concept map for a particular text with a different method, they had known the contents, and they had made one concept map from the previous session. A learning effect is presumably affected their second concept maps. Hence, it was necessary to divide the participants into two groups, i.e., Group A and Group B. The group determined the order in which they used the tools' support function. However, to ensure that all participants experienced the same order of concept mapping methods, it was necessary to also use another text to create a concept map in the opposite order of concept mapping method. The concept mapping flow of this research is shown in Figure 4.5.

Two English reading texts, which were considered similar in terms of their contents and length, were used to discover whether the texts affected their concept mapping activities, thus affecting the resulting concept maps or not. For the first text, Group A began to create the concept map with SC and followed with SP. The other group (Group B) began with SP and then followed with SC. For the second text, both groups created a concept map using the tools in the opposite order. Hence, all participants performed the concept mapping activities using the support functions in both different concept mapping orders. In this way, each concept map was made from a different text, with different tools and order.

In the experiment's concept mapping stage, all participants created concept maps from two English readings, and four concept maps were created in total by each participant. Each concept map had a 25 minute time alloca-

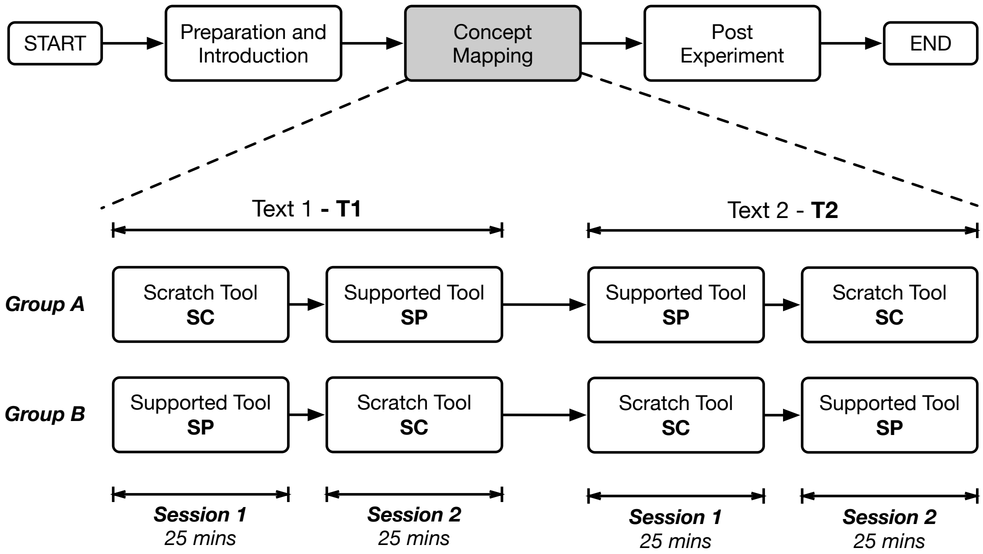

Fig. 4.5 Experiment design

tion. They read the text, created the concept map, and reviewed their concept map in the 25 minute allocated time. During the allocated time they were able to read the text while doing the concept mapping to reduce their load in remembering the text's contents. A five minute break was also given between each concept mapping session. Finally, at the end of the experiment, a set of questionnaire was given and short discussion with the teachers about Kit-Build, the Kit-Build concept map authoring tool, and how Kit-Build can benefit learning, was carried out.

Measurement and Data Analysis

At the end of each concept mapping session, the teachers were requested to finalize and save their concept maps. The metadata of the completed concept maps was recorded in the database, including concept labels, link labels, propositions, and their position over the canvas. Additionally, their activities were logged; hence, the concept map can be reconstructed and shown later for analysis, grading, and evaluation.

This research evaluated the Kit-Build concept map authoring tool based on the teachers' resulting concept maps. Comparisons with the teachers' concept maps were carried out to discover whether the tool's support function affected teachers' concept mapping efficiency. Three kind of parameters were specified to measure and analyze teachers' productivity in creating concept maps with the concept mapping tools, i.e., the tool type, the session, and the text. The tool type determines the support function's availability. The session describes the order of the concept mapping method in which teachers used the support function. They either used the supported tool first, then the scratch tool, or they used the tools in the opposite way. The text parameter represents the texts that teachers used to create the concept maps. Analysis of the resulting concept maps was carried out according to the specified parameters to evaluate the concept mapping tool.

A concept map scoring rubric was used to evaluate and grade the maps. The Mueller's concept map rubric (Mueller, n.d.), which has continuous rating scales to measure the legibility, accuracy, completeness, and sophistication of a concept map, was chosen to measure the quality of the concept maps. The rubric does not include concept map size as one of its scoring factors in determining a concept map's quality. Thus, the overlap with the analysis of concept map size could be avoided.

All created concept maps were rated by three expert teachers who were selected based on their expertise and experience. They needed to have taught English reading comprehension with concept maps for at least two years. Before performing the grading process, the raters had a quick overview of all of the resulting concept maps from the experiments. They constructed a rationale of the Mueller's rubric as objective criteria in grading all the concept maps. The rationale was intended to make the judgment in grading the concept maps among raters consistent. An inter-rater analysis was carried out to the scores before further analysis to evaluate the scores' reliability among different raters. Some examples of the rationale items, which were made from the Mueller's concept map rubric of this research, are shown in Table 4.5.

4.2.2 Results and Discussion

Concept Mapping Efficiency

The number of propositions determines a concept map's size even though it is arguable whether larger concept maps are able to cover more information and knowledge. Every proposition implies knowledge or information from the learning material that teachers want to convey. Hence, the amount of information and knowledge a concept map contains is represented by the quantity of the propositions. In the experiment, teachers took the same amount of time to create their concept maps in all the concept mapping sessions. Hence, the efficiency of concept mapping activities can be described by the concept maps' size.

Table 4.5 Example of Mueller's concept map scoring rubric rationale.

Score	Rationale
Legible—easy to read and free of spelling errors	
2 (No)	Spelling errors less than 30%
Accurate—concepts used accurately	
4 (A few inaccuracies)	Less than 20% of inaccuracies
Complete—sufficient number of relevant concepts and relationships	
0 (Limited use of concepts/ relationships)	The concepts cover less than 20% of relevant idea, regardless its relationship correctness.
Sophisticated—finding meaningful connections between relevant concepts	
7 (Some meaningful connections made)	More than 10 correct and relevant relationships identified, nicely arranged elements, easy to understand propositions, almost cover all of important ideas from the text.

Teachers who participated in the experiments numbered 47 persons, however five teachers' data were omitted from analysis because the teachers did not follow the standard procedures, or their data were found to be incomplete or missing. The descriptive statistics of the size of teachers' concept maps from each concept mapping session are shown in Table 4.6. The predicted concept maps size is visualized in Figure 4.6. The data are grouped based on the texts (T1 and T2), the sessions (S1 and S2), and the tools (Scratch and Supported).

According to Table 4.6, the average size of a concept map made with the supported tool (SP) is larger than those made with the scratch tool (SC) for all texts and sessions. The gap between the map size of the two different tools becomes more apparent in the sessions that used the second text (T2). Hence, concept mapping activities that used SP yielded larger concept maps.

A comparison analysis was carried out to discover the variables that affected the size of a concept map. This research's experiment specifies three independent variables, i.e., the tool, the text, and the concept mapping session, for analysis. The tool variable represents whether teachers use the support function (with SP) or not (with SC) during concept mapping sessions.

Table 4.6 Descriptive statistics of concept map size.

Text	Session	Tool	n	Mean	Std. Dev	Median
T1	S1	Scratch	21	14.43	2.46	14
T1	S1	Supported	21	16.95	1.94	17
T1	S2	Scratch	21	16.38	2.54	16
T1	S2	Supported	21	20.67	2.80	20
T2	S1	Scratch	21	15.52	2.60	15
T2	S1	Supported	21	20.33	2.74	20
T2	S2	Scratch	21	16.42	2.09	17
T2	S2	Supported	21	21.10	2.64	21

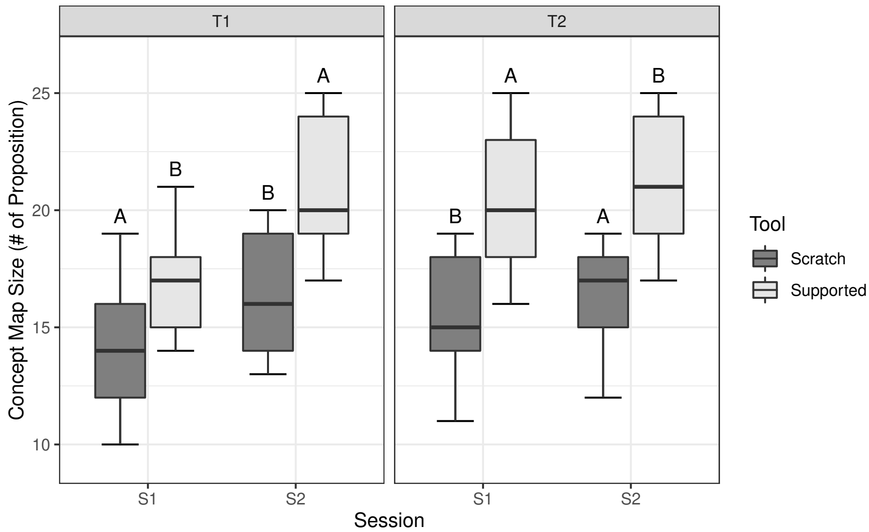

Fig. 4.6 Predicted concept map size based on the Text, Session, and Tool

The session variable represents the order in which teachers used the tools to create concept maps.

The experimental data conformed to Levene's homogeneity test. However, some proposition data violated Shapiro-Wilk normality tests, thus failing to conform to classical statistical assumptions. Therefore, in addressing the first research question, whether the developed concept map support tool could improve teachers' concept mapping efficiency in terms of the yielded number of propositions, analysis was carried out with the non-parametric Generalized Linear Model (GLM) instead of using three-way Analysis of Variance (ANOVA) to discover factors that influence a concept map size. The GLM analysis result of the experiment data is shown in Table 4.7.

Table 4.7 Generalized Linear Model analysis result.

	Estimate	Std. Error	t-value	p-value	Sig.
(Intercept)	14.43	0.54	26.52	2.00×10^{-16}	***
Session	1.95	0.77	2.54	1.21×10^{-2}	*
Tool	2.52	0.77	3.28	1.27×10^{-3}	**
Text	1.10	0.77	1.42	0.16	
Session:Tool	1.76	1.09	1.62	0.11	
Session:Text	-1.05	1.09	-0.96	0.34	
Tool:Text	2.29	1.09	2.10	3.72×10^{-2}	*
Session:Tool:Text	-1.90	1.54	-1.24	0.22	

*** p-value < 0.001, ** p-value < 0.01, * p-value < 0.05

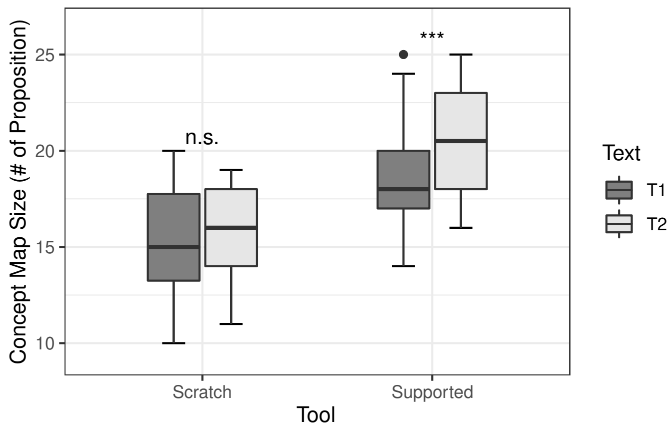

Fig. 4.7 Concept map size to Tool and Text (with Session combined)

According to the GLM analysis results, both tool and session variables significantly affected a concept map size. On the contrary, the text had no significant influence on concept map size. Additionally, interaction between tool and text variables was shown to affect concept map size significantly. To clarify the GLM analysis result, a non-parametric Kruskal-Wallis test was used to evaluate the group data individually. The individual Kruskal-Wallis tests described which factors influence the concept map size and which situations. The concept map size from two different tools and two different texts was compared to clarify the interaction between tool and the text. The result of the individual Kruskal-Wallis analysis with a significance level (α) of 0.05 is shown in Table 4.8. The predicted concept map size with tool as the predictor and the sessions combined is shown in Figure 4.7.

Table 4.8 Kruskal-Wallis Rank Sum test results.

Grouping		Response	Predictor	p-value	Sig.
T1	S1	Proposition	Tool	1.83×10^{-3}	**
T1	S2	Proposition	Tool	6.97×10^{-5}	***
T2	S1	Proposition	Tool	1.27×10^{-5}	***
T2	S2	Proposition	Tool	5.05×10^{-6}	***
T1	Scratch	Proposition	Session	0.02	*
T1	Supported	Proposition	Session	7.42×10^{-5}	***
T2	Scratch	Proposition	Session	0.26	
T2	Supported	Proposition	Session	0.34	
S1	Scratch	Proposition	Text	0.163	
S1	Supported	Proposition	Text	1.75×10^{-4}	***
S2	Scratch	Proposition	Text	0.95	
S2	Supported	Proposition	Text	0.62	

*** p-value < 0.001, ** p-value < 0.01, * p-value < 0.05

According to the Kruskal-Wallis test result shown in Table 4.8, it can be clarified that the tool significantly affected the concept map size in all sessions. The session was found to significantly affect concept map size made for Text 1 (T1). On the contrary, the session insignificantly affected the concept map size for Text 2 (T2). In other words, the order in which teachers used the tool affected their concept maps size only for T1. However, when the text was analyzed as the predictor, it only influenced the concept map size when they first created their concept map with SP.

According to Figure 4.7, the concept maps made with SP were larger than the concept maps made with SC. When teachers used SC, there was only a slight difference in the concept map size between T1 and T2. To show the interaction between tool and text that influenced the concept map size, the concept map size between two different tools and two different texts were compared with two Mann-Whitney U tests. The result of the Mann-Whitney U test of the number of propositions between T1 and T2 for SC was not significant (p-value = 0.34). On the contrary, when teachers used SP, the concept maps made for T1 were smaller than T2 to some extent. The result of the Mann-Whitney U test of the number of propositions between T1 and T2 when they use SP was significant (p-value = 0.0035). While those results could be some special characteristic of T1 when processed by the support function of

SP, the difference in said Mann-Whitney U tests explains the interaction between tool and text that influence the concept map size. Changes in the text only affected the concept map size when they use SP but not SC.

One plausible reason that explains the interaction was the teachers might have experienced problems in using the tool as they might still be learning to fully take advantage of SP when they first created their concept maps of T1. The difficulties in using SP to compose concept maps were also reported by another study that evaluated students' experience with Kit-Build concept map authoring tools. To some extent, the supported tool is more difficult to use than the scratch tool (Pinandito et al., 2019). Hence, the gap between concept map size made with both tools on S1 of T1 shows a lesser difference than the other sessions.

Even though both T1 and T2 were considered similar, the concept map size might differ when teachers created concept maps with SP. Teachers' unfamiliarity with the support function might also have resulted in the smaller concept map size made with SP. However, according to the data, this phenomenon was happening when teachers used the supported tool to create a concept map for the first time, i.e., in S1. Overall, the results show that concept mapping with SP is more efficient than SC in yielding larger concept maps.

Quality Aspect

To address the second research question, whether using the developed concept map support tool could yield concept maps of better quality than a manually composed concept map, three expert raters graded the concept maps with a rationale of Mueller's concept map scoring rubric. The descriptive statistics of the concept maps' score and the inter-rater agreement analysis results of the scoring of all three raters are shown in Table 4.9. According to the extended scale interpretation of Kappa categories to Kendall's coefficient of concordance W (Levitan et al., 2008), raters' concordance in scoring the concept maps was not always strong, but also substantial (Kendall W > 0.60). The Levene's test, which evaluated the homogeneity of variance, showed a non-significant result (p-value = 0.2245 > 0.05). The Shapiro-Wilk's normality test of each group setting also showed non-significant results (p-values > 0.05). Therefore, the Levene's and Shapiro-Wilk's test results to the map score data indicated that the concept maps' score data conformed with the classical homogeneity and normality assumptions.

Table 4.9 Descriptive statistics of concept map score.

Text	Session	Tool	n	Mean	s.d.	Kendall W	p-value
T1	S1	Scratch	21	13.60	0.93	0.83	2.34×10^{-4}
T1	S1	Supported	21	14.75	0.68	0.74	1.28×10^{-3}
T1	S2	Scratch	21	14.24	0.79	0.81	3.66×10^{-4}
T1	S2	Supported	21	14.76	0.87	0.80	4.04×10^{-4}
T2	S1	Scratch	21	15.02	0.88	0.77	7.10×10^{-4}
T2	S1	Supported	21	15.33	0.62	0.70	2.70×10^{-3}
T2	S2	Scratch	21	15.24	0.91	0.86	1.31×10^{-4}
T2	S2	Supported	21	15.75	0.60	0.67	4.64×10^{-3}

According to Table 4.9 and Table 4.10, the average score of concept maps made with SP was slightly better than concept maps made with SC. The visual comparison between concept map scores made with SP and SC for each experiment setting is shown in Figure 4.8. The star annotation over the plot denotes its significance level of comparison analysis between scores for concept maps that were made with SC and SP with independent T-tests. The result of the T-tests is shown in Table 4.10. Even though SC and SP's average map scores were statistically different in some situations, the differences were small and they were at the same category level of quality. For instance, when the teachers created their concept maps of T2 on S2, the average score of concept maps when they used SC and SP was 15.24 and 15.75 respectively. Even though the standard deviation is low enough for the results to be significant, the score difference between concept maps that were made with SC and SP were not so interesting as a learning achievement. The results implied that the concept maps at a similar level of quality. Furthermore, it can be said that creating concept maps with SP can result in concept maps of a similar quality with SC.

Teachers' Response to the Authoring Support Tool

To address the third research question regarding teachers' perceived usefulness to the concept map authoring support tool to create concept maps of English reading materials for teaching, a set of questionnaire was given to the teachers. They responded to the questionnaire after they had finished all the concept mapping activities. Part of the questionnaire, which captured their perceived usefulness to the authoring support tool, was adapted from

Table 4.10 Independent T-test result of concept map score between scratch tool and supported tool.

Text	Session	$\bar{x}$ Scratch	$\bar{x}$ Supported	p-value	Sig.
T1	S1	13.60	14.75	5.78×10^{-5}	***
T1	S2	14.24	14.76	0.048	*
T2	S1	15.02	15.33	0.187	n.s.
T2	S2	15.24	15.75	0.039	*

*** p-value $<$ 0.001, ** p-value $<$ 0.01, * p-value $<$ 0.05, n.s. p-value $>$ 0.05

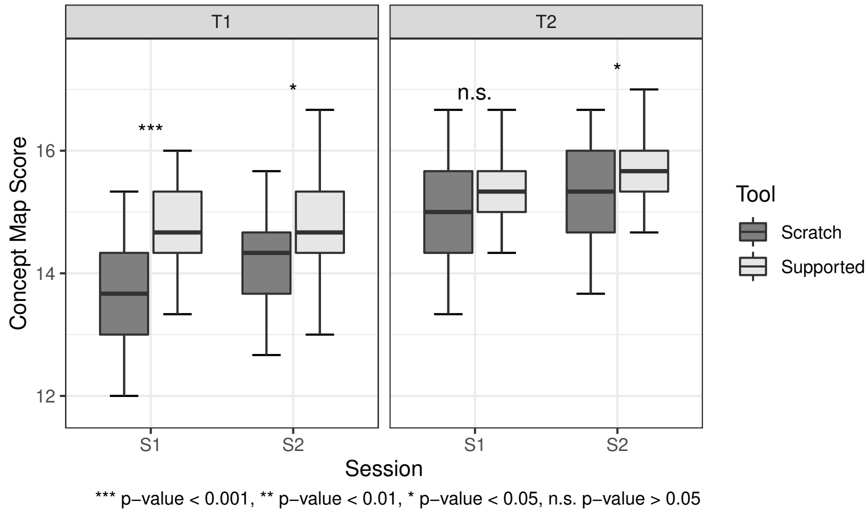

Fig. 4.8 Predicted concept map score based on Text, Session, and Tool

the questionnaire of TAM. The questionnaire consisted of five 7-Likert scale questions and the internal consistency (Cronbach's α) of the questions towards Perceived Usefulness factor was 0.84; indicating good reliability. The summary of their perceived usefulness response to the authoring support tool is shown in Figure 4.9. The numbers inside the stacked bar chart denotes the number of teachers who responded their agreement of a particular level to the respective questions.

According to the result, there was a small percentage of teachers that think neutrally whether using the authoring support tool is easier than not using it to create a concept map. Small numbers of teachers thought neutrally if using the support tool would increase their productivity in creating a concept map. Even though several teachers did express their disagreement whether using the tool would improve their performance in creating a concept map, the overall impression was positive. Most of the teachers perceived that the

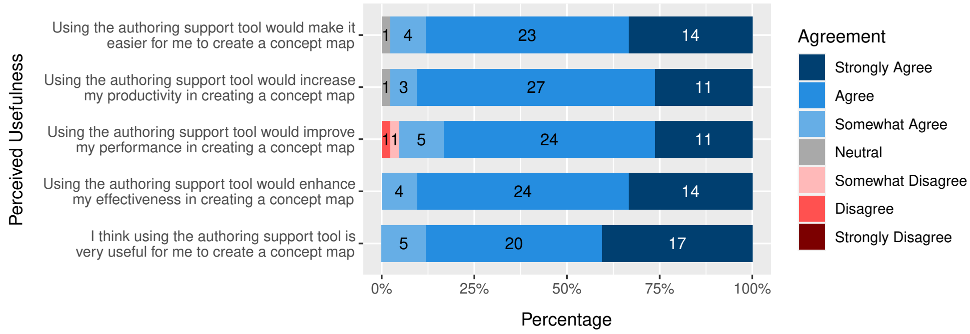

Fig. 4.9 Teachers' perceived usefulness regarding assistance from the authoring support tool

authoring support tool was useful in assisting the concept map composition activity of English reading material.

4.2.3 Limitation and Future Work

The impact of teacher experience and personality influencing the quality of concept maps for Kit-build has not been investigated, and it will be a target of future research. Teachers who are not familiar with concept maps and do not use concept maps in their teaching might have difficulties in creating concept maps and fail; hence, the limitation of use of the tool. However, based on the authoring support method of this study, a support tool for beginner teachers to compose a concept map will be developed as a new future work.

This research took the EFL reading comprehension as its learning context. It uses two similar EFL reading comprehension passages as input. However, actual passages of a general EFL reading comprehension may vary. It cannot be said that teachers' concept mapping ability improved when they used the supported tool to create concept maps from English readings. Nevertheless, the trial data analysis shows the tool's potential to improve teachers' productivity in concept mapping. Additionally, the tool's support function can process any English texts even though some limitations exist to get a satisfactory result and the effect of the authoring support tool on teachers purpose and subjectivity is a target for future work of this study.

An analysis regarding the tool's suggestions should be conducted in the future. Evaluating the quality of the suggestions could discover how the suggestions affected teachers' concept mapping activities, thus discovering how they relate to the concept maps. The support function performance analysis may contribute towards the study in automatic concept map generation and improve the user experience of computer-enabled concept mapping activities.

4.3 Study 3: User Acceptance and User Experience

4.3.1 Methodology

This study evaluates how is the user would experience a computer-based concept map authoring tool to aid users in constructing a concept map of a learning material. How would adding an authoring support feature provide better experiences than the basic version of the authoring tool is investigated.

There are two types of tools that were evaluated in this research, one is the tool that has only basic concept map functionality to construct a concept map, and another one is the tool that has construction support and feedback features enabled in addition to the basic functionality features from the first tool. An experiment was designed and conducted to evaluate the tools. Participants were asked to create a concept map using both tools from an English reading. The experiment flow conducted in this research is shown in Fig. 4.10. The experiment has a similar flow with one that conducted to English teachers, but this study was conducted with students.

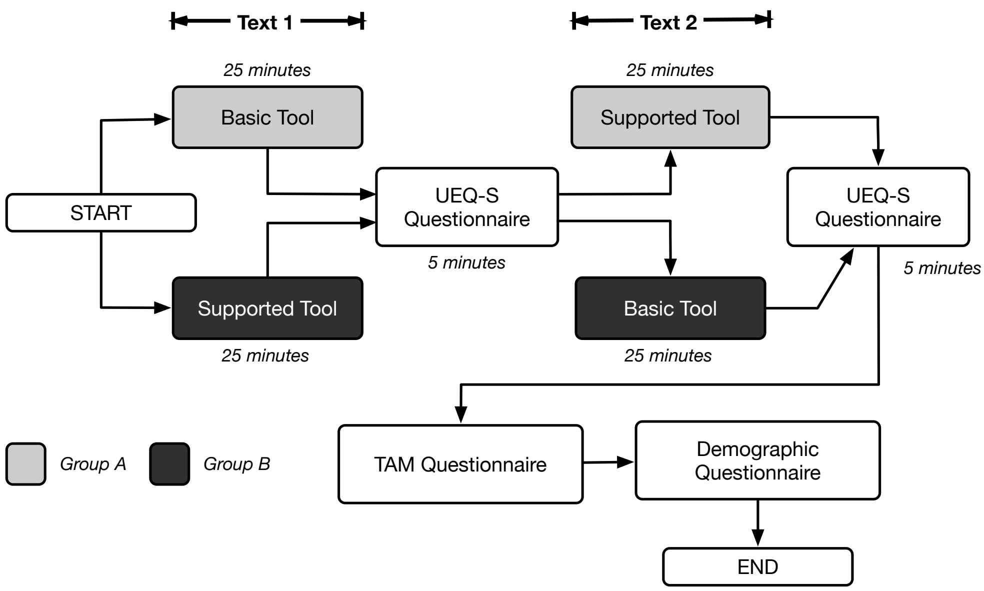

Fig. 4.10 Experiment Flow for User Experience and User Acceptance

Students of Group A first composed the concept maps with the basic authoring tool while students of Group B used the supported authoring tool on the first session. On the next concept mapping session, they composed another concept map with the opposite type of authoring tool. Thus, all the students experienced concept mapping with both tools. Each UEQ-S questionnaire was given to the students after they have finished composing concept maps with each tool type. Hence, the UEQ-S questionnaire could depict their perceived experience with the tool they had used recently.

This research uses UEQ-S—the short version of the UEQ—due to its quick and simplicity in capturing user impression in experiencing the tools. After they had completed constructing the concept map with the tools, they were asked to answer the short-version of the UEQ questionnaire (UEQ-S) in Bahasa Indonesia for the respective type of KB-Map tools that were previously used. At the end of the experiment, they were also asked to fill a post-questionnaire and answer several questions related to how they are thinking about the tools. They are also asked to evaluate both tools in terms of the quality of concept map drawn, the concept map fitness in re-describing the material, and the user-friendliness of the tools in concept mapping. Additionally, at the end of the experiment, the particpants were also asked to fill the TAM questionnaire regarding the supported version of the authoring tool to depict their acceptance regarding the tool.

Data Collection, Context, and Participants

The participants create two concept maps from one English general reading material. The English reading material used in the experiment is an English essay taken from ESL Fast website. The reading text contains around 350 words or 2000 characters without graphical contents. One concept map is created by using one type of tool.

The participants were undergraduate students who enrolled in User Interface Interaction Design course at Information System department. They were on the 3rd-year of their study. They were also participating in the experiment on their late study of the semester to promote their practical evaluation experience in evaluating the interaction design of computer software. In this case, the computer software is the two versions of KB-Map concept map authoring tools. Even though this research uses an English-based reading material in the evaluation process, there was no consideration for a specific English skill level for the UX analysis requirements. However, in order to depict participant's English capability, a question about the score of ToEFL Institutional Testing Program (ITP) or another equivalent English test score was given in the demographic questionnaire.

The participants were taken from two classes of User Interface Interaction Design course. The total number of students who participated in this research is 73. The students were selected by using purposive sampling method to ensure their homogeneity, thus simplifies the treatment in the experiment. Assuming that all students on both classes have a similar skill level, they were randomly divided into two groups regardless of their age and gender. The differences between groups differed in the order of using the tools to construct the concept maps. The first group constructs the concept maps in the following order: the basic version and then the supported version while the other group experiences the opposite. The time given for them to construct one concept map is 25 minutes. During the map construction process, they were allowed to read the text. They were asked to construct a concept map from the text in such a way that they were supposedly able to comprehensively describe the contents of the text by using the map. Several concept map scoring and evaluation rubrics were used as criteria in determining the success or failure of participants in carrying out the given task.

The TAM questionnaire to investigate the students' acceptance regarding the Kit-Build concept map authoring tool consisted of fifteen 7-Likert scale questionnaire items representing the four main TAM variables, i.e., PU, PEOU, Attitude Towards Using (AT), and Behavioral Intention (BI). Eleven additional questionnaire items were added to represent the three external variables defined in this research, including Compatibility (C), Habit (H), and Enjoyment (E). The additional variables represent external variables for the proposed model. Samples of the TAM questionnaire items used in this research are shown in Table 4.11. The term Kit-Build in the TAM questionnaire items refers to the Kit-Build concept map authoring tool.

Analyzing the UEQ-S Result

There are several steps taken to analyze the answers from the UEQ in this research. First, the questionnaire answers were collected by assigning a value of 1 for the leftmost scale to a value of 7 for the rightmost scale option. The data were processed using the provided UEQ-S analytic tool as in (Schrepp et al., 2017b). Inconsistent data and outliers were discarded during the analysis process using the tool. The tool will adjust the score value for every statement answer from 7 Likert scales to -3, which represent the most negative value and +3 for the most positive value. The average score for pragmatic, hedonic, and overall quality parameters was calculated to all participants. Any score values between -0.8 and 0.8 represent a neutral evaluation of the

Table 4.11 Sample of items on the TAM questionnaire

TAM Internal Variables
Perceived Ease of Use (PEOU4): I think using Kit-Build is easy
Perceived Usefulness (PU5): I think using Kit-Build is very useful for me to create a concept map
Attitude towards Using (AT4): In my opinion, the use of Kit-Build will have a positive impact.
Behavioral Intention (BI1): Assuming I had access to Kit-Build, I intend to use it
TAM External Variables
Compatibility (C2): The use of Kit-Build is compatible with my work habits
Habit (H3): I often use software as tools in my work
Enjoyment (E2): The use of Kit-Build to create a concept map is more exciting rather than dull

The term *Kit-Build* refers to the Kit-Build concept map authoring support tool.

corresponding scale. Score values higher than 0.8 represents a positive evaluation, and vice versa, score values of less than -0.8 represents a negative evaluation.

In addition to the average calculation, the confidence interval and scale consistency were also computed. The confidence interval measures the precision of the estimation of the mean. The smaller the confidence interval value, the higher is the precision of the estimation, thus, the more the results can be trusted. The alpha-coefficient measures consistency scale. The alpha value is measured by the correlation of items per scale aspects. It is also assumed that a scale should show an alpha value higher than 0.7 to be considered as sufficiently consistent. If the alpha-coefficient value shows a massive deviation from a reasonable target value, i.e., 0.7, this can be an indication that some items of the scale for the given context were interpreted unexpectedly.

The average calculation result can be compared with the result of another system that had previously been evaluated. Currently, the UEQ benchmarking data were sourced from 4,056 persons from 280 studies concerning different products, e.g., business software, web pages, online stores, and social networks. However, these benchmarks data are based on the full UEQ instead since there is not enough data were available for the short version of UEQ.

The short version of UEQ itself was published in 2017. The benchmarking result put all the quality aspect of the evaluated system into the category of excellent, good, above average, below average, or bad (Schrepp et al., 2017a).

User Acceptance Analysis with Technology Acceptance Model

The proposed model in this research is adapted from the original TAM. The conceptual model was proposed based on the presented literature review, including Compatibility (C), Habit (H), and Enjoyment (E) variables toward PU and PEOU. The proposed model of TAM in regards to the Kit-Build concept map authoring tool for this research is depicted in Figure 4.11.

In accordance with the literature review and alongside with the original TAM, the proposed model in this study will test the following eleven hypotheses:

H1: Perceived Usefulness will significantly influence students' Attitude to use KB to create a concept map.

H2: Perceived Ease of Use will significantly influence students' Attitude to use KB to create a concept map.

H3: Perceived Usefulness will significantly influence students' Behavioral Intention to use KB to create concept map.

H4: Students' Attitude towards use of KB will significantly influence their Behavioral Intention to create a concept map using KB.

H5: Perceived Ease of Use will significantly influence students' Perceived Usefulness to use KB to create a concept map.

H6: Students' work Compatibility will significantly influence students' Perceived Usefulness in using KB to create concept map.

H7: Students' work Enjoyment will significantly influence students' Perceived Usefulness in using KB to create a concept map.

H8: Students' Habit in using tools to create concept map will significantly influence students' Perceived Usefulness.

H9: Students' Habit in using tools to create concept map will significantly influence students' Perceived Ease of Use.

H10: Students' work Enjoyment will significantly influence students' Perceived Ease of Use in using KB to create a concept map.

H11: Students' work Compatibility will significantly influence students' Perceived Ease of Use in using KB to create concept map.

The term KB in the defined hypotheses refers to the supported Kit-Build concept map authoring tool instead of the Kit-Build method.

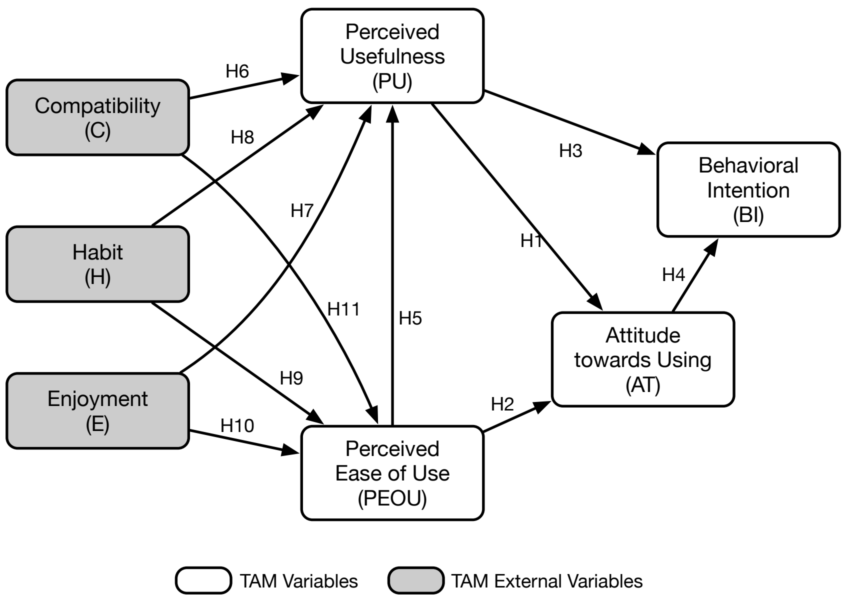

Fig. 4.11 The TAM model with three proposed external variables.

Table 4.12 TAM questionnaire Cronbach's Alpha

TAM Variables	Items	Cronbach's Alpha	Reliability
PEOU	4	0.85	Good
PU	5	0.83	Good
AT	4	0.85	Good
BI	2	0.91	Excellent
C	4	0.79	Acceptable
H	4	0.87	Good
E	3	0.9	Excellent

C: Compatibility; H: Habit: E: Enjoyment

Before analyzing the students' response data, the questionnaire items' internal consistency was validated by calculating each variable Cronbach's alpha to depict its reliability. The summary of the reliability analysis of the items in the questionnaire is presented in Table 4.12. The results indicated that the alpha of PU was 0.83, both PEOU and AT were 0.85, BI was 0.91. Whereas, additional variables' alpha, such as Habit (H) and Enjoyment (E) fall between 0.8 to 0.9, hence indicating good reliability. However, Compatibility (C) has an alpha of 0.79 that indicates its reliability was still acceptable. An alpha higher than 0.9 indicates excellent reliability. The resulting alpha implies that the responses towards a set of questions for all variables are reliable. Hence, the response data can be analyzed to evaluate and test the hypotheses further.

4.3.2 Result and Discussion

User Experience Measurement

In the experiment, 73 students participate in evaluating the tools. However, 12 participants were found to be inconsistent. Thus, their data were omitted from the analysis, remaining 61 usable data. Most participants were male (62.3%), and the remaining 37.7% were female. The age of all participants was between 19 to 21 years old. Based on the questionnaire given, the students are doing 8 out of 11 (σ = 2.2) different types of activities while using the internet using a web browser in the past month. This means that most of them are fluent in using a web browser in their daily activities. Thus, they should not encounter a significant problem while interacting with the tools to construct a concept map because the tools are built using web technologies that run on top of a web browser. The participants current average ToEFL ITP score is 480. The score means that in such an English reading comprehension they are usually able to understand the descriptions of relatively simple processes and narration in texts with high-frequency vocabulary, recognize paraphrased information, understand the meaning conveyed by the most common conjunctions, and connect meaning across some simple sentences that contain high-frequency vocabulary (ETS, 2012).

Based on participants data of UEQ-S questionnaire, Group A and Group B consists of 29 and 32 participants respectively. Both groups are different only in terms of the order on how they use the tools. As shown in Fig. 3, Group A uses the basic version of the tools during the first attempt of concept map construction while Group B uses the supported version. On the second attempt, the tool type was reversed where Group A uses the supported version while Group B uses the basic version to construct a concept map from the same reading. The UEQ-S questionnaire data from both group were processed further using the provided UEQ-S analysis tools.

Table 4.13 shows the analysis result of a mean average score with a 95% confidence interval of pragmatic quality, hedonic quality, and overall UX scale. On the pragmatic quality scale, the highest score was obtained from Group B who used the basic version of the concept mapping tool (1.617) and followed by Group B who uses the supported version of the tools (1.438). For the same scale, Group B scores 1.328 and 1.259 for the basic version and the supported version of the tools respectively. For the hedonic quality scale, the highest score values obtained from the supported version of the tools from Group A (1.397) even though the score of Group B for the same tool version

Table 4.13 UEQ-S Score

Quality Scale	Group (Tools)	UEQ Score	UX Eval.	Benchmark
Pragmatic	A (Basic)	1.328	Positive	Above avg.
	A (Supported)	1.259	Positive	Above avg.
	B (Basic)	1.617	Positive	Good
	B (Supported)	1.438	Positive	Above avg.
Hedonic	A (Basic)	1.078	Positive	Below avg.
	A (Supported)	1.397	Positive	Above avg.
	B (Basic)	1.219	Positive	Above avg.
	B (Supported)	1.383	Positive	Above avg.
Overall UX	A (Basic)	1.20	Positive	Above avg.
	A (Supported)	1.33	Positive	Above avg.
	B (Basic)	1.42	Positive	Above avg.
	B (Supported)	1.41	Positive	Above avg.

are quite similar (1.383). The basic version of the tools has a score of 1.219 and 1.078 from Group B and Group A respectively. For the overall scale of UX, the highest score obtained Group B for the basic version of the tools (1.42). Group B also score 1.41 for the supported version. Group A has a better score for the supported version (1.33) than the basic version of the tools (1.20). However, the overall score for all of the tools being evaluated is higher than 0.8, which means that both tools have positive UX.

Also based on the scores of pragmatic quality scale as shown in Table 4.13, participants from both Group A and B think that using the basic version of the concept map tools would yield a more suitable concept map than the supported version. Based on the hedonic quality scale score result, participants from both groups feel that the supported version of the concept map tools is more attractive as it offers a different approach to construct a concept map. However, for the overall UX quality scale, participants from Group A think that the supported version of the tool is better than the basic version, but the participants from Group B said the opposite. The result differences in the overall UX quality scale may be caused by the order on how they were impressed by both tools. After they were experiencing the first tool, there is a learning effect that may affect their thinking to construct a concept map from one same text that they had previously created. The good and below average benchmark result might indicate that UX improvements were needed for those quality aspects.

In general, the pragmatic quality average score of all participants show that the basic version of the tool has a better score than the supported one. Based on the UEQ-S item score result in Table 4.14, all participants think that creating a concept map using the basic version is clearer (1.6/1.3) and easier (1.5/1.1) than the supported version. However, the basic version of the tool is considered less efficient (1.2/1.4) and less supportive (1.5/1.6) than the one that has proposition support features. Both groups agree that using the basic version of the tool are easier and clearer but less supportive and less efficient. Both groups also agree that providing support features, by means in the current way of interaction design to the tool, are more supportive but also more complicated.

Table 4.14 UEQ-S Mean Score

UEQ-S Item No.	Mean Score					
	Support Tool			Basic Tool		
	Group A	Group B	All	Group A	Group B	All
1	1.6	1.5	1.6	1.4	1.7	1.5
2	0.9	1.3	1.1	1.4	1.7	1.5
3	1.3	1.6	1.4	1.1	1.4	1.2
4	1.2	1.4	1.3	1.4	1.8	1.6
5	1.3	1.1	1.2	0.9	1.0	0.9
6	1.5	1.5	1.5	1.2	1.4	1.3
7	1.3	1.4	1.4	1.0	1.2	1.1
8	1.5	1.5	1.5	1.1	1.3	1.2

As depicted in Table 4.14, the average score from all participants shows that the hedonic quality of the supported versions of the tool has a higher score over the basic tool for all hedonic items. The supported version is more interesting (1.5/1.3), more exciting (1.2/0.9), more inventive (1.4/1.1), and more leading-edge (1.5/1.2) than the basic one. Therefore, both groups agree that the tool with support features has better UX in hedonic quality. Even though all hedonic item score values for the supported tool is better than the basic tool, the UEQ-S item for a boring-exciting evaluation score, the least among all hedonic item scores. This opens an opportunity to improve UX by providing a more exciting user interaction design to the tools.

Table 4.15 Summary of Hypotheses Tests

Hypotheses	Estimate	*p-value*	Intercept	R^2
H1: PU ⟶ AT	0.712	***	1.694	0.466
H2: PEOU ⟶ AT	0.005	0.968		
H3: PU ⟶ BI	0.4247	*	0.199	0.3572
H4: AT ⟶ BI	0.4557	*		
H5: PEOU ⟶ PU	0.398	***	0.639	0.558
H6: C ⟶ PU	0.241	**		
H7: E ⟶ PU	0.216	*		
H8: H ⟶ PU	0.060	0.297		
H9: H ⟶ PEOU	0.116	0.087	2.761	0.282
H10: E ⟶ PEOU	0.228	*		
H11: C ⟶ PEOU	0.207	*		

***: p-value < 0.001; **: p-value < 0.01; *: p-value < 0.05; p-value higher than 0.05 denotes non-significant items

Student Acceptance towards the Authoring Support Tool

A conceptual model, namely TAM, was used in this research to evaluate students' acceptance towards the supported KB concept mapping tool. In this section, the effect among variables in the proposed conceptual model is presented and analyzed through statistics. In summary, regression analysis result for the proposed acceptance model is depicted in Table 4.15. The hypotheses were tested with 5% significance level to consider whether to accept the null hypothesis. If null hypotheses are rejected, it means that there is significant influence between the corresponding variables. The summary of the linear regression analysis of the model is shown in Table 4.15.

Several multiple linear regression analysis was employed to evaluate the students' responses towards the model. The analysis depicts how each independent variable influences or predicts the dependent variable. The R^2 value represents the proportion of relationship variance between dependent and independent variables that are explained by the model. Hypotheses H1 and H2 depict the AT variable that dependent on PU and PEOU. Based on the multiple regression analysis results of PU and PEOU towards AT, it seems that PU influences AT, but not PEOU. The influence of PU towards AT is significant statistically. However, based on the obtained R^2 value, the model can only cover 46.6% of the variance.

The relationship between PU and AT towards BI was also evaluated using multiple linear regression analysis. This method was run to predict BI from PU and AT. The analysis result shows that both PU and AT can predict BI as the linear regression analysis shows a statistically significant result (*p-value* < 0.05). Both PU and AT are giving a relatively equal effect towards BI, as they have the linear regression coefficient value of 0.425 and 0.456, respectively. According to the regression result, the R^2 value of 0.3572 implies that 35.72% variance of BI is explained by PU and AT. However, the model is better than a simple linear model, which consider only AT or PU variable individually. If BI is predicted by AT and PU individually, the analysis yields an R^2 value of 0.3069 and 0.2937, respectively.

The three proposed additional external variables, i.e., Compatibility (C), Habit (H), and Enjoyment (E), were taken into account, along with the PEOU to identify whether these variables are affecting the PU variable through multiple linear regression analysis. The result shows that the R^2 value of 0.5577, which implies 55.77% of the variance of PU, can be predicted by C, H, E, and PEOU variables. Except for Habit (H), all of the external variables and PEOU are shown to influence PU. The multiple linear regression analysis shows that H has a p-value of 0.297, which is statistically insignificant. Therefore, it cannot be said that the students' habit influences their perceived usefulness of the tool. However, as the remaining variables have p-values of less than 0.05, the students' compatibility, enjoyment, and perceived ease of use towards using the tool are influencing their perceived usefulness of the tool. Furthermore, the student's perceived ease of use has the most considerable influence on students' perceived ease of use, followed by the students' compatibility and enjoyment of using the tool.

Similar to the previous analysis, the effect of the external variables C, H, and E towards PEOU is evaluated by using multiple linear regression. The F-test's significance indicates that the sample data have sufficient evidence to fit the regression model rather than a model without the independent variables with a *p-value* of 0.000 that is less than the specified significance level of 0.05. Even though the test result shows that all of the external variables can predict only 28.23% of the PEOU variance, both C and E variables influence the students' PEOU. Similar to PU, the students' habit is not influencing their perceived ease of use of using the tool.

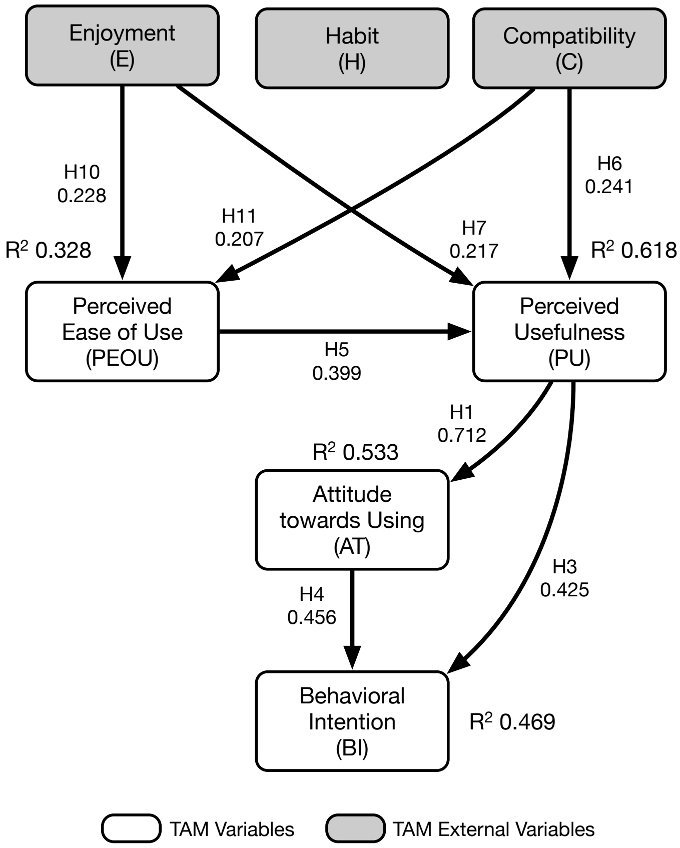

Fig. 4.12 The summary of acceptance model

Consolidating all of the multiple linear analysis results, thus disregarding all insignificant associations, the students' acceptance model of the Kit-Build concept map authoring tool is shown in Figure 4.12.

In many social science settings, some studies have an inherently more considerable amount of unexplained variation. Any field related to predicting human behavior, such as psychology, like a study about human behavior or acceptance towards new technology, typically has R^2 values lower than 50% (Moksony, 1990). This research also shows the low value of R^2 that happens due to higher variability that exists around the regression line. Our findings indicate that human behaviors in learning using concept maps are hard to predict. Hence, the resulting data are relatively noisy. Nevertheless, the result mostly fits the proposed model, as most regression analysis results towards the model fall below the statistical significance level of 0.05.

The overall result shows that most of the relationships conform to the previous TAM research to depict students' intention in using new technology. In this study, the students' perceived usefulness is positively affecting their attitude towards using the tool. On the contrary, their perceived ease of use shows statistically insignificant results towards their attitude towards using the tool. Hence, if they think that the tool is useful, they will still use it regardless of how they think about the tools' ease of use level.

Other research claimed that habit is an unconscious behavior, which is learned through repetition (Alsharo et al., 2020). Regardless of the students' prior habit in concept mapping, as long as the tool is enjoyable and compatible with their previous work, they will perceive that the kit is easy to use and useful to help them make a concept map. Hence, they will use the tool when they learn English reading comprehension material. However, the finding does not support the result found in (Hubert et al., 2017; Rafique et al., 2020).

As the tool is considered new to the students, they might need to familiarize themselves with the concept mapping tool so that they can fully utilize it properly. However, based on the results, the students' attitude towards using the tool was not influenced by the students' perceived ease of use. Their attitude towards using the tool is greatly influenced by their perceived usefulness of using the tool. The result implies that the students' will still intend to continue using the tool to help them understand the English learning materials through concept mapping regardless of their perceived ease of use in using the tool. Most students do not mind learning and using a new concept mapping tool to support them in studying English reading comprehension with concept maps.

Furthermore, the students' perceived usefulness towards the concept map authoring tool plays an essential role as the only factor influencing their intention to adopt the Kit-Build concept map authoring tool the most. Additionally, as the students had experienced that using the tool to create concept maps is easy, they will perceive that the tool is useful for them. Thus, the students' perceived ease of use indirectly influences their intention to use the Kit-Build concept map authoring tool.

4.3.3 Limitation

The UEQ-S can provide a quick overview of a software UX in higher-level meta-dimensions. It allows software UX designer to depict how users are thinking about the software quickly. However, it cannot measure detailed UX qualities. Therefore, applying the full UEQ and interpreting the results in UX evaluation can be quite useful to define areas of improvement of a software or system. Evaluating the UX of a system or software also opens a potential cross-field research in finding a relationship between UX, cognitive psychology, education, and technology.

The acceptance being evaluated in this research captures the students' impression when using the concept mapping tool. According to the questionnaire results given to the students, their experiences in using a computer-supported concept mapping tool may be limited. Before this experiment, they do not usually use a computer-concept mapping tool or have any previous experience using the Kit-Build method in their daily learning activities. Before being introduced with the Kit-Build method and also its tool, most of the students already know about concept maps and have several experiences in concept mapping. Previously, most of the students use a traditional pencil and paper or other digital methods that allow them to take some notes or drew concept maps during learning. Hence, many of them were new to the Kit-Build concept mapping tool and the Kit-Build method.

Due to the specific and limited number of participants, the results presented in this research may not cover the expected target and also difficult to generalize or interpret as uncovered and voluntary bias may occur. Therefore, extra care must be taken in interpreting the result of this research.

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Chapter 5

Real-time Collaborative Learning System with Concept Maps

5.1 Study 1: Design and Development of Real-time Collaborative Learning System

5.1.1 Methodology

In order to extend the existing Kit-Build concept map authoring tool with collaboration features and address the research questions, a general design and development methodology as shown in Fig. 5.1, is followed. This study was started with a preliminary review and analysis phase, which includes: (1) review and analysis to the current Kit-Build concept map authoring tool, (2) requirements specification of new features, (3) discovering how the tool works, (4) identifying possible technology approaches to be used, and (5) identifying how the new features be integrated into the system.

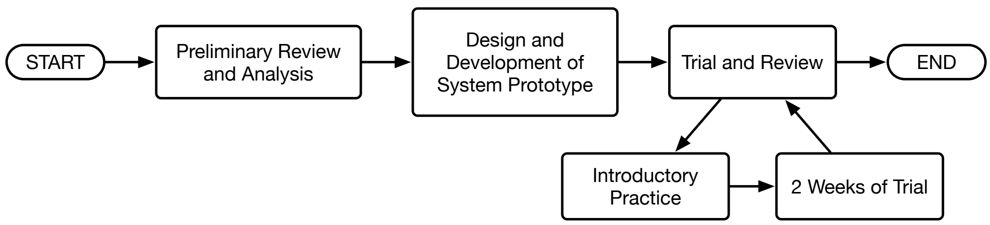

Fig. 5.1 Research Methodology

The design and development phase of the system prototype followed a prototyping approach where several prototypes were developed and tested to satisfy the specified requirements. After all requirements have been satisfied by the prototype, the latest prototype was put into a trial to discover whether the tool could effectively support the collaborative learning with Kit-Build concept map in an online classroom for several meetings. During the meetings, the students learned the topics by collaboratively recomposing Kit-Build concept map in pair groups. The students and the learning subjects were targetting the undergraduate students of Information System department of Universitas Brawijaya, Indonesia. At the last meeting of the class, the students were given a questionnaire regading their attitude towards using the collaborative Kit-Build concept map authoring tool using a validated Online Cooperative Learning Application (OCLA) scale (Korkmaz, 2012) to portray how the tool supported a collaborative learning activity with Kit-Build concept map.

5.1.2 Design and Development

Requirement Analysis

This study assumes that a Kit-Build concept map authoring tool has been developed. Thus, design and development of the collaboration tool was focused on extending the tool with the development of group collaboration support feature of the existing Kit-Build concept mapping authoring tool; hence, the basis of the collaboration platform development in this study.

In supporting collaborative work of concept mapping in an online environment, there are two major issues that need to be taken care of, i.e., (1) reflecting one working activities to others' workspace, and (2) providing communication interface as one way for collaborators to communicate with each other. Hence, meaningful interaction could be attained. Minimizing delay during collaboration becomes the key factor for a useful online collaboration system, including one that used for collaborative learning. Several general functional requirements were defined in guiding the design and development process of the system. The requirements for the collaboration features of the authoring tool were specified in Table 5.1.

All requirements as specified in Table 5.1 extended the current Kit-Build concept map authoring tool functionalities that used HTML5 and Javascript technology. The extension was expected not to alter the behavior of users to use and run the concept map authoring tool with their web browser.

Table 5.1 Requirement Specification

ID	Requirement Definition
FR1	The system should provide collaborative mechanisms that reflect concept map authoring activities of one collaborator to other collaborators.
FR2	The system should provide a general text-based communication channel that allow collaborators to send and receive broadcast message in a collaboration room.
FR3	The system should provide a text-based communication channel that allows collaborators to send and receive message for a specific concept or link node.
FR4	The system should provide notification and indicators for incoming messages of a particular concept or link node.
FR5	The system should keep track of concept and link node in discussion, hence collaborators could quickly switch and discuss on a different concept or link channel.

Architecture Design

In the current Kit-Build concept map authoring tool, there is a Javascript object—called Canvas—that handles all user concept mapping activities and all user interactions with the authoring tool. The Canvas object has an interface that allows other object to listen to concept mapping activity of a user, namely ActivityListener. Another part of the application who listen to users' concept mapping activities should implement the interface and attach itself to the Canvas object; hence, all users' concept mapping activities could be captured by external objects. The Canvas object also provides public methods that allow external entities to control the Canvas object; thus, automate the concept mapping composition activities on the drawing canvas, such as visualizing the concept map composition process from activity log data or manipulating objects drawn on canvas. This Canvas object becomes the key entry point in extending the authoring tool functionality to support collaborative work in concept mapping. The system architecture design, which extends the current Kit-Build concept map authoring tool to support real-time collaboration in this study, is shown in Fig. 5.2. Additionally, to address functional requirements regarding communication features, a new communication module (Discuss UI) was incorporated as a user interface to send and receive messages for discussion during collaboration.

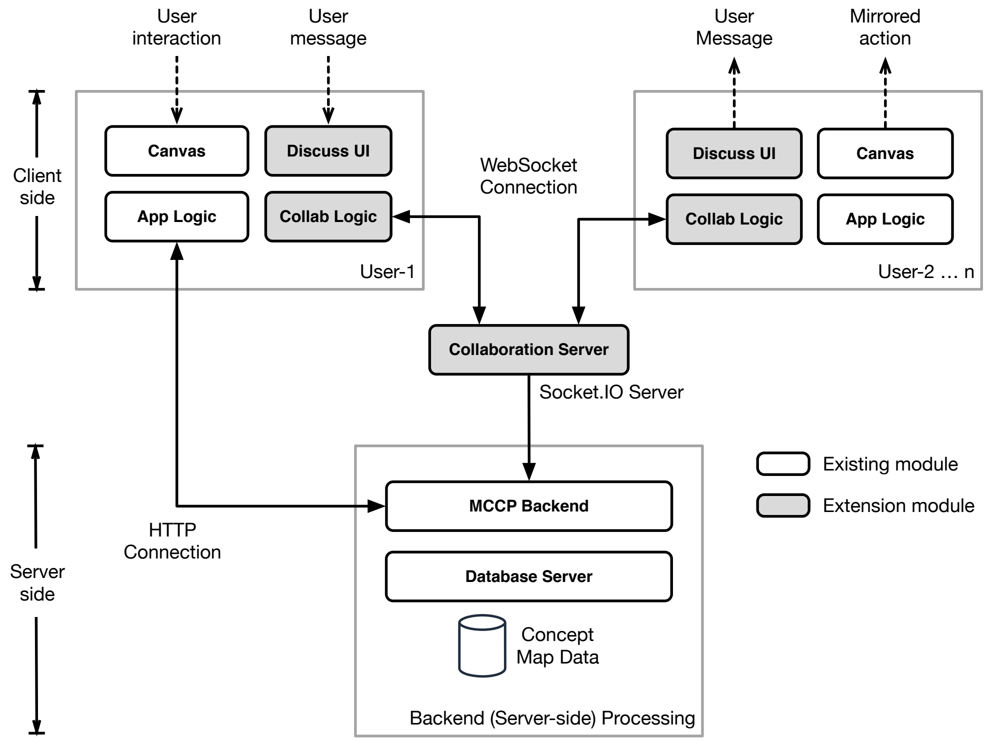

Fig. 5.2 System architecture for activity and message synchronization

The backend processing at server side is processed using a web application framework as previously designed and developed in (Pinandito et al., 2017). The framework utilizes Model-CollectionService-Controller-Presenter (MCCP) design pattern, which is an adaptation from Model-View-Controller (MVC) pattern, that allows data model and collection service code be reused by many different application controllers. In the case of this study, two application controllers were created; one existing controller serves the App Logic on the client side, while another one new controller serves the Collaboration Server. Both controllers inside the MCCP Backend module, which served two different target platforms, i.e., the App Logic and Collaboration Server, could reuse the same service components that provided data processing service to a database server; hence, reusing or restructuring existing codes becomes more efficient and easy. Most importantly, the design should implement component-based and modular design patterns; hence, better reusability for further development.

Real-time Inter-client Communication Pattern of Concept Mapping Activity and Messaging

Concept mapping synchronization among collaborators could be performed when all collaborators have been connected to the Collaboration Server, join a collaboration room, and ready to listen collaboration and concept mapping activity message. According to the requirements as specified in Table 5.1, the system should be able to synchronize concept map authoring activities of one canvas to other collaborators' canvas. A synchronization flow example of concept mapping activity across different collaborators is depicted in Fig. 5.3. The flow assumed that the Collaboration Server has been online, both end-clients have connected to the Collaboration Server, and both end-clients have joined the same collaboration room.

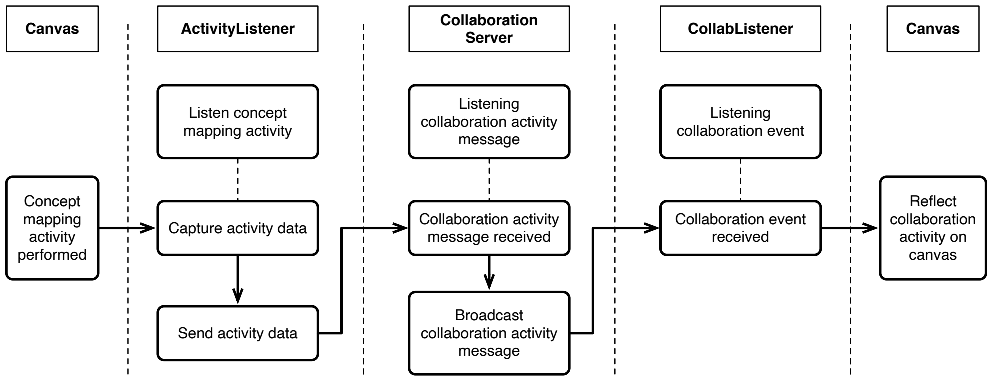

Fig. 5.3 Synchronization flow of concept mapping activity across collaborators.

The Collab Logic module as shown in Fig. 5.2 is broken down into two submodules, i.e., ActivityListener and CollabListener submodule. The ActivityListener and CollabListener object are two new object interfaces that responsible in listening users' concept mapping activity and listen to any collaboration message sent from collaboration server respectively. The collaboration server is responsible to maintain connection between clients and forward activities and messages to all collaborators in a collaboration room. Sending chat messages from one collaborator to other collaborators is performed in a similar fashion to synchronizing the concept mapping activity via collaboration server.

ActivityListener object has responsibility to listen to concept mapping activity on canvas, encapsulate the activity into collaboration messages, and send the messages to other collaborators through Collaboration Server. The Collaboration Server listens to incoming messages from clients—the ActivityListeners—and broadcast the messages to all collaborators in the specified room. Lastly, the CollabListener object listens to any messages coming from Collaboration Server and interpret the message as a concept mapping instruction to be reflected on collaborators' canvas. Every collaborator could serve both the sender and receiver of concept map activity messages.

In addressing functional requirement FR2, FR3, FR4, and FR5, the system should provide a text-based communication mechanism among collaborators. The system should provide two type of discussion in the system, i.e., general discussion and concept/link-channeled discussion. The synchronization flow of the collaboration messaging system is shown in Fig. 5.4.

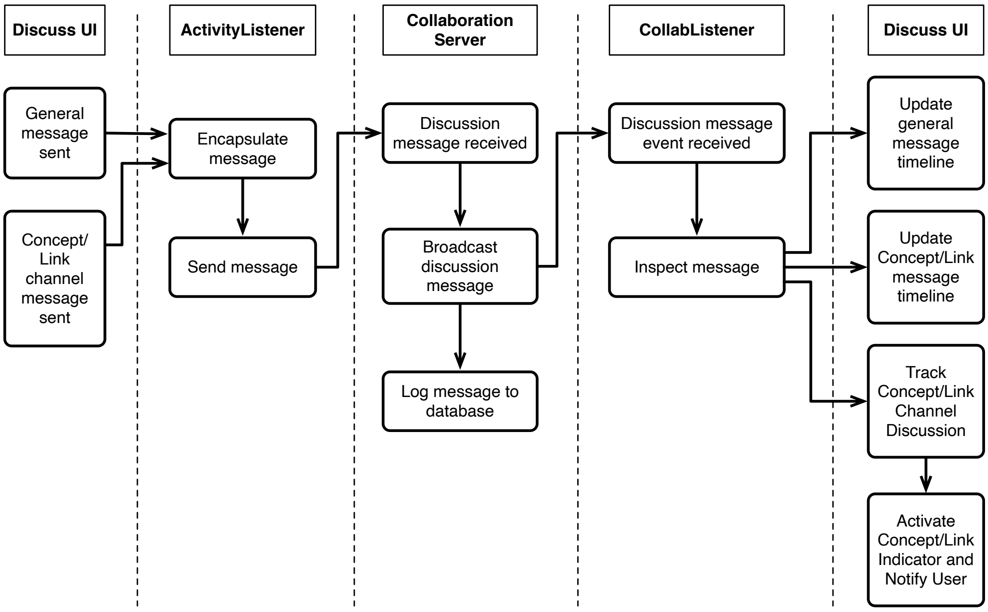

Fig. 5.4 Synchronization flow of discussion message across collaborators.

Implementation

On the client side, the new extension modules were implemented in the same fashion as the existing module. The user interface and collaboration module were implemented in HTML5 and Javascript program code. Real-time, bidirectional and event-based communication between the browser and the server, which is serverd by the Collaboration Server, is implemented by a separate instance of Node.js server and is running the Socket.IO communication library. Thus, the extended concept map authoring tool will still be able to run on the client's web browser without the need of additional software.

The Canvas and ActivityListener object communicate in an event-based interface with two arguments—type and data—representing the event type and data of an activity. The data consisted of information needed to replicate said activity on another canvas. The following code excerpts depict how an activity is being distributed to other collaborators' canvas by ActivityListener, Collaboration Server, and CollabListener objects; written in Javascript programming language:

Example of a program code of an ActivityListener listening to activity on Canvas and sending the activity information as a message to a Collaboration Server.

```
// Setup Socket.IO connection
var url = new URL(window.location.origin);
url.port = 3000;
this.socket = io(url.toString());

// Event listener of concept mapping activity on Canvas
// The data argument consists of node id
// and x-y coordinate of the node on Canvas.
onCanvasEvent(event, data) {
  switch (event) {
    case 'move-concept':
      this.moveNode(data);
      break;
  }
}

// Sending activity message
// Encapsulate activity data and room information
moveNode(node) {
  let data = { room: this.room, node: node };
  // this.socket is Socket.IO server socket
  this.socket.emit('move-node', data);
}
```

Example of a program code of an Socket.IO server listening to an activity message and broadcast the activity information to all connected clients of a particular room.

```
// Initializing Socket.IO server
var express = require('express');
var http = require('http').createServer(express());
var io = require('socket.io')(http);

io.on('connection', (socket) => {
  // Listen to activity nessage from client
  socket.on('move-node', (data, callback) => {
    // Retrieve room name
    let room = data.room;
    // Broadcast data to all socket on room, except sender.
```

```
    socket.to(room).emit('move-node', data);
    // Log activity to database through a DB helper
    DB.log('move-node', data);
  });
});
```

Example of a program code of a CollabListener object listening to an activity message and reflect the activity to Canvas.

```
// Listen to activity broadcast from Socket.IO server
this.socket.on('move-node', (data) => {
  // Reflect activity on Canvas
  this.canvas.moveNode(
    data.node.id,
    data.node.x,
    data.node.y
  );
});
```

Sending and receiving general and channel-based messages were implemented in a similar way with sending concept mapping activity messages. However, instead of listening to Canvas object, ActivityListener object listens to the Discuss UI for chat messages. If a chat message is received by the CollabListener, the message will be inspected for its attributes; thus, CollabListener object updates the UI, e.g., updating the chat message list and displaying notification, in respect to the received chat message type.

5.1.3 Result and Discussion

With the designed mechanism to facilitate collaboration in the concept mapping activity with Kit-Build concept map authoring tool, it is now possible for students and teachers to collaborate and communicate at a distance. Using HTML5 WebSocket technology with Socket.IO allows web-based applications to implement real-time, two-way active communication; moving one step forward from the traditional request-based passive client-server communication method. Thus, real-time communication and collaborative work and learning on a web platform can be realized.

System Prototype

To address the first research question, a prototype of the online collaborative concept mapping system has been developed. The collaboration system was designed to support both closed-end and open-ended concept map composition approach for learning activity that used the Kit-Build method. A Socket.IO server was deployed as the middleware for the collaboration system in addition to the existing HTTP server that serves the client application. Using the Socket.IO library as a middleware to leverage HTML5 WebSocket technology in fostering collaborative concept mapping activities with Kit-Build concept map is shown to be effective. One's concept mapping activities could be effectively distributed across collaborators in real-time to constitute the effect of real-time distant collaborative concept map composition. A screenshot of the developed collaboration system prototype is shown in Fig. 5.5.

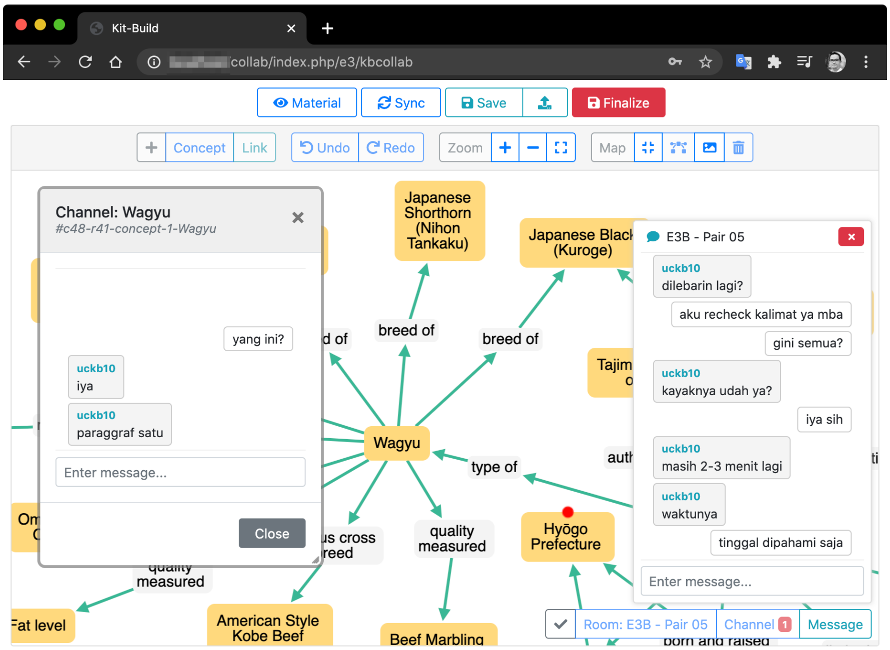

Fig. 5.5 Kit-Build concept map authoring tool prototype; displaying general discussion messages, concept channel discussion, and new message notification of a collaboration group.

With the developed system prototype, all requirements as specified in Table 5.1 have been met. Referring the prototype shown in Fig. 5.5, it can be seen that students could effectively collaborate and discuss a specific topic by using the destined discussion interface. The system could notify the user when new discussion messages arrive and track their discussion across different concepts or links; hence, talk separation between process and content could be maintained and keep the collaboration process smooth.

Table 5.2 Students' response to OCLA Scale regarding the developed Collaborative Concept Mapping Tool (CCMT).

Positive learning attitude					*Negative learning attitude*				
ID	n	Mean	Median	s.d.	ID	n	Mean	Median	s.d.
A1	95	4.51	5	0.634	A12	95	2.25	2	1.250
A2	95	4.33	4	0.706	A13	95	1.55	1	0.782
A3	95	4.46	5	0.616	A14	95	1.76	2	0.896
A4	95	4.41	4	0.627	A15	95	2.72	3	1.390
A5	95	4.31	4	0.685	A16	95	1.74	2	0.902
A6	95	4.08	4	0.895	A17	95	1.61	1	0.803
A7	95	4.42	5	0.708					
A8	95	4.28	4	0.767					
A9	95	4.06	4	0.885					
A10	95	4.15	4	0.699					
A11	95	4.39	4	0.673					
		4.31	*Average Mean Score*				1.94		

User Feedback and System Evaluation

To address the second research questions, the system was put into a trial with students to collaboratively learn several learning materials in an online class and captured their responses about the system. In evaluating the new collaborative features of Kit-Build concept map authoring tool, 95 students were invited to experience learning with Kit-Build concept map and use the developed concept mapping tool. In addition to recomposing concept maps to learn a course's subject learning material, they recomposed a concept map from a given kit with their partners collaboratively. They were also requested to discuss their map using the provided communication system. Students attitude towards using the Kit-Build concept map collaboratively online was measured using 17 items of the OCLA scale (Korkmaz, 2012). The detail of the scale is shown in Appendix and the responses were summarized in Table 5.2 and Fig. 5.6.

According to the results, students have positive attitude towards the designed collaborative concept mapping tool. Most students agree to strongly agree that learning with the online collaborative Kit-Build concept map was

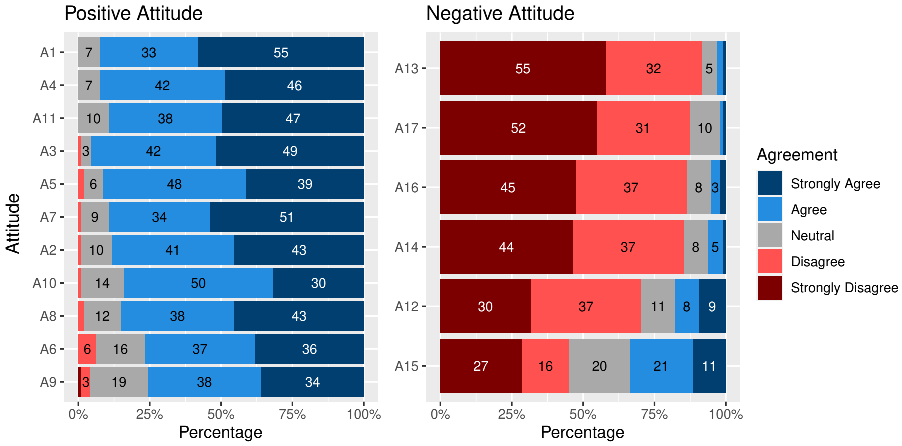

Fig. 5.6 Distribution of students' attitude response of OCLA regarding the developed concept mapping tool.

enjoyable, useful, entertaining, and help them learn better with friends as all of their responses to the OCLA positive attitude items have an average mean of higher than 4 (the higher the better) from a maximum score of 5 (strongly agree). They responded their disagreement to negative attitude items of the OCLA, meaning they actually have positive attitude towards using the online collaborative Kit-Build concept map tool (the lower the better).

There were two noticable attitude items that were perceived in both positive and negative view; having a mean score between 2 and 3 of 5 scale, i.e., item A12 and A15. They responded that somehow they need to teach their partners of something during collaboration that makes them feel tired (item A12). There also cases during collaboration where their partners are too depending in doing their work (A15). The students tend to disagree more on item A12 than item A15, which means that they don't like more if their partners are depending on them rather than requesting them to teach on how to use the system or solve the problem. These issues were also mentioned on previous study (Gao et al., 2007) as a challenge to elucidate in collaborative learning. Furthermore, these issues might indicate that the collaboration system needs to be improved regarding usability. Providing feedback or features could motivate group members to collaborate and contribute on their collaborative work. Nevertheless, a deeper investigation is required to discover the cause and elucidate the issue.

Limitation and Future Work

According to the result of this study, a web-based application for collaborative learning—such as the case of collaborative learning with Kit-Build concept map—could be implemented and well used in online classroom. However, issues in technical point of view do exists on collaboration systems that run over computer network.

Intermittent network connection and system compatibility are two examples of issue that might cause problems to the system functionalities. The system has to maintain collaboration activities synchronized among different collaborators; thus, ensuring the collaboration product consistent and becomes a target of future development of the system developed in this study.

Current study does not evaluate the learning effect of the students when they collaboratively learn by recomposing concept maps with Kit-Build. Investigating the learning effect of the system and how the students interact and discuss within the system could discover how the system would impact the learning effectiveness in comparison to the traditional learning approach that carried out in an online classroom. There are many factors that influence the collaborative concept mapping activity; thus affecting its effectiveness towards learning (Gao et al., 2007). This study assumed that the students who respond to the evaluation questionnaire have adequate experience in using web-based applications and have experienced learning with concept map. Prior using the system, users have to understand on how to compose a concept map and how to use the system to compose a concept map; otherwise, they might fail to achieve the expected learning achievement. Therefore, providing apparent guidance regarding the activity when using the system should keep users focus on the collaboration; thus, improve their meaningful learning and interaction more.

Even though current evaluation to the collaborative learning system with Kit-Build concept map yielded a positive result. More in depth experiment and trial to the system in learning environment should be conducted for more sufficient and accurate depictions regarding the developed system readiness for use in an actual learning environment. Hence, an immediate future work of the study in supporting distant collaborative learning with Kit-Build concept maps.

5.2 Study 2: Learning Effect and Conversation Analysis

5.2.1 Methodology

Reading Material and Concept Map Kit

The context of this research was the use of the Kit-Build concept map in supporting the online collaborative learning of EFL reading comprehension. The EFL reading comprehension subject used in the experiment was a general English reading text entitled "Wagyu." The reading consisted of 900 English words without any graphics that discussed Wagyu—the Japanese-breed cows. The reading content was obtained from various online sources consisting of factual information, uncommon vocabularies, and several complex linguistic aspects as problems that the students have to overcome to comprehend the content thoroughly.

A concept map (Kit-Build goal map) was specifically composed as a Kit-Build kit. The kit consisted of 20 links and 19 concepts that covered most of the reading's main topics and ideas. The kit was provided only to participants who compose their concept maps with Kit-Build. The type of kit was a set of fully deconstructed components of the goal map; there were no link nodes that have been pre-connected to a concept node, neither entirely nor partially when the kit was given. For the purpose of this study, the goal map and the kit implied the answers to only half the questions of pre-, post-, and delayed-test. As an example, several parts of the kit to be recomposed by the students are shown in Fig. 5.7.

Participants

The experiment involved 40 international students that consisted of 25 men and 15 women. They were graduate students studying at Hiroshima University and used English as a foreign language, pursuing master's (60%) and doctoral (40%) degrees in engineering, social science, education, linguistic, finance, and department policy. They originated from Asian countries, and none of them were native English speakers or used English as their second language, i.e., Indonesia (75%), China (20%), and Laos (5%). Their age was in the range of 20-25 (27.5%), 25-30 (37.5%), 30-35 (15%), 35-40 (17.5%), and 40-45 (2.5%). Their ability in English was high enough to adequately under-

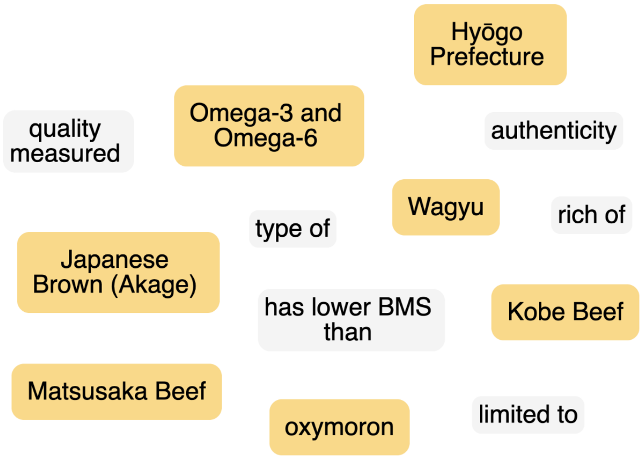

Fig. 5.7 Part of the provided kit that implied the answer to several comprehension test questions.

stand various learning subjects delivered in English as they have an average equivalent ToEFL ITP score of 557.6 (SD = 41.30).

They were divided into two groups of dyads, i.e., Collaborative Scratch Mapping (CSM) group and Collaborative Kit-Building (CKB) group. The concept mapping groups solely differ in terms of the concept mapping approach used to create a concept map. During the collaboration, the students were collaboratively working in pairs of two (dyads). Students of the CSM group created their concept maps with the usual open-ended concept mapping approach, contrary to composing concept maps from a kit. However, the CKB group students created their concept maps from a pre-defined Kit-Build concept map kit. In determining the pairs, the students could freely choose their collaboration partner in concept mapping. Thus, presuming they have no problem communicating and could freely express their thinking, emotions, or ideas without reluctance.

Experiment Design

The experiment started with the preparation and training phase, where all participants were introduced to the concept maps and the Kit-Build concept map. The training and preparation phase aimed to develop a common perception concerning the underlying theory of concept maps and carry out the necessary preparations before the actual concept mapping activity was carried out. Additionally, the techniques in composing good concept maps, how to compose a concept map with Kit-Build concept map tool, and communi-

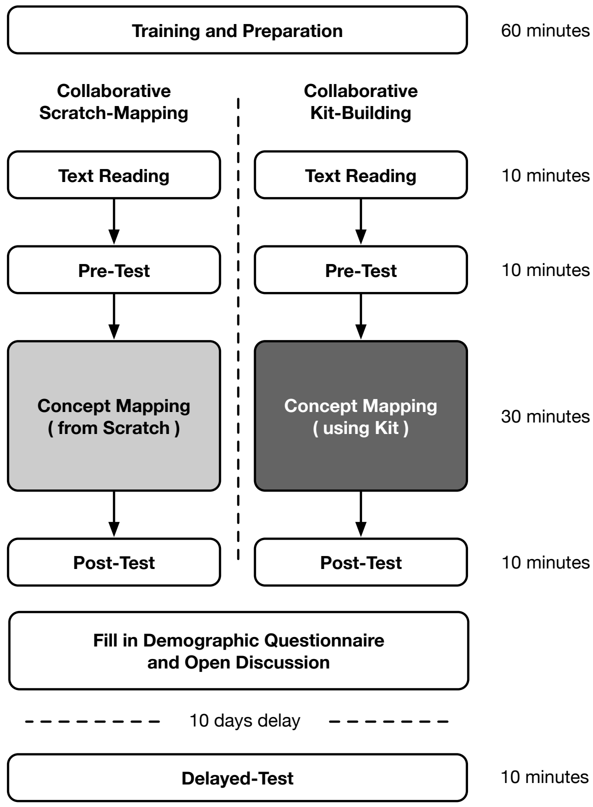

Fig. 5.8 Experiment flow.

cating using the tool's communication features were introduced. The flow of the experiment of this study is shown in Fig. 5.8.

All participants were given a user manual document regarding the concept mapping tool to try the system before participating in the experiment. During the experiment's training and preparation phase, the participants practiced concept mapping using the online collaborative Kit-Build concept mapping tool. These activities were carried out to ensure that all participants would not encounter any difficulties composing their concept map while also communicating with their collaboration partner.

For the experiment, an online system has been built specifically to follow the designed workflow. The system provided a mechanism to display the reading text on the screen. Thus, the students could read the text while they were composing their concept maps. The tool has convenient features to make the concept mapping composing of a text document faster and more convenient. Parts of the displayed text could be selected to generate concept or link nodes whose labels were obtained from the selections. However, these added features were relevant solely to participants who created their concept maps from scratch. Hence, composing concept maps from text documents could be performed with less typing and more quickly. Activities in the reading phase, pre-test, concept mapping, post-test, and delayed-test were conducted using the system. However, the experiment demographic questionnaires were given to the participants on a paper basis.

All participants in both groups were requested to work and collaborate in pairs. They composed and discussed the concept map they made in the concept mapping phase. Unless they were currently answering the tests, they could read the reading passage and access other information resources, including the Internet. During the experiment, every participant used a different computer and worked collaboratively with their partner from two separate rooms. The room in which they do the concept mapping is designed to the extent they neither can see nor have direct face-to-face communication with their collaboration partner. Therefore, simulating an online learning activity where direct communication was somewhat difficult or impossible to conduct verbally.

Measurements

During the experiment, the participants were given three kinds of tests, i.e., pre-test, post-test, and delayed-test. The pre-test and post-test were given right before and after they conducted the concept mapping activity, respectively. The delayed test was given after ten days of delay. The questions for the tests were made according to the lower and higher order of Bloom's taxonomy (Adams, 2015) in a similar manner with prior studies (Anderson et al., 2001; Dalton et al., 1986; Shorser, n.d.). The pre-test was used to measure students' understanding before the Concept Mapping phase. The pre-test score was also used later in the analysis to evaluate the participants' homogeneity of variance. The post-test was immediately given to all participants following the Concept Mapping phase and measured the learning effect of collaboration activity with concept mapping towards participants' comprehension regarding the text. The test results were analyzed to discover whether students' understanding and discussion during collaboration were different.

The tests were composed of 15 multiple-choice questions. Each question included five options with one correct answer, and the pre-, post-, and delayed-test were using the same set of questions. However, the question order and options for the answer were shuffled to motivate students to think more carefully and avoid remembering the answers. The questions were categorized into two categories, i.e., In-Kit and Not-In-Kit. The In-Kit category consisted of eight questions whose answers were implied by the kit, covering the lower and higher order of Bloom's taxonomy. However, as the name implied, the answers to the Not-In-Kit category questions were not covered by the kit. Thus, separate analyses between two concept mapping groups could be conducted based on the information covered by the kit.

Table 5.3 shows several examples of the In-Kit questions whose answer was implied by the kit. Referring to the classification of questions as demonstrated in (Adams, 2015; Anderson et al., 2001; Dalton et al., 1986; Shorser, n.d.), questions Q2 and Q8 are the types of questions that evaluate students' comprehension and ability to recall information from the text. Conversely, questions Q3 and Q9 fall into higher order questions that require students to transfer their learning and relate parts of the information. Thus, encourage the students to think deeply.

Coding the Discussion and Talks

Due to the design of the experiment, all participants were not allowed to have direct face-to-face communication. As previously mentioned, the system provided text-based communication channels for participants to communicate and discuss with their partners. Even though it was possible to provide a video or voice-based communication channel in the concept mapping tool, it was neither implemented nor used in this study.

During the concept mapping, all participants communicate and discuss their concept map using the provided communication channel. They were allowed to use their native or any other local languages that they were comfortable communicating with their partner. All of their utterances, including one that linked to link and concept nodes, were recorded. In measuring and analyzing the dynamics of problem-solving in groups or teams, the talks in the discussions were coded with the Advanced Interaction Analysis for Teams (act4teams) coding scheme (Kauffeld et al., 2018). The coding scheme categorized the talks into four main facets of group communication, i.e., problem-focused statements, procedural statements, socio-emotional statements, and action-oriented statements. Each talk or message sent by the dyad's member to the discussion window was classified into one category of the coding scheme and counted as one articulation, expression, or speech.

5.2.2 Result and Discussion

The experiment was conducted in April 2020 and held on scheduled dates and times. However, the participants could also decide the date and time

Table 5.3 Examples of In-Kit questions of the pre-test and post-test

ID	Question and Options for Answer	
Lower Order: Remember and Understand		
Q2	How many digits the assigned ID for every authentic Kobe Beef?	
	A. 8 digits	D. 11 digits
	B. 9 digits	E. 12 digits
	C. 10 digits	
Q8	Which of the following words that best explained the word "oxymoron"?	
	A. Illusion	D. Contradictory
	B. Analogy	E. Retoric
	C. Stupidness	
Higher Order: Apply and Analyze		
Q3	What is the minimum grade and marbling level of a Kobe Beef to be classified as authentic?	
	A. A4 - Marbling Level 5	D. A5 - Marbling Level 6
	B. A4 - Marbling Level 6	E. A5 - Marbling Level 10
	C. A5 - Marbling Level 4	
Q9	According to the text, which of the following statements is TRUE regarding Matsusaka Beef and Kobe Beef?	
	A. Kobe Beef is more expensive Wagyu than Matsusaka Beef.	
	B. Kobe Beef has richer fat than Matsusaka Beef.	
	C. Kobe Beef has lower BMS level than Matsusaka Beef.	
	D. Kobe Beef has higher Omega-9 acid than Matsusaka Beef.	
	E. Both Beef are coming from breeds of Japanese Brown cow.	

at their convenience. Even though not all participants participated on the same schedule, they agreed to follow the entire experiment workflow. The experiment was conducted at Learning Engineering Laboratory, Hiroshima University. All participants used computers with similar specifications to interact with the system.

Online Collaborative Concept Mapping Tool

The trial of the extended Kit-Build concept map tool in this study could depict the potential implementation of Kit-Build concept map framework in an online learning environment or another learning context that involved concept mapping as one of its activities. Despite the tool's limited features in facilitating communication, effective conversation and discussion can be made without major issues that could disrupt the collaboration process of composing a concept map. Complaints from participants who were having difficulties in communicating with their partners were absent. However, according to the feedback from post-experiment and open discussions with the participants, they strongly demanded audio and video-based communication to the extent of minimizing communication delay during collaboration. The participants also suggested supports for graphical and numerical contents.

Test Score

The test results were divided into two categories per question's group. One score was given for each correct answer. However, no penalty was given for incorrect answers or unanswered questions. The maximum score was 8 and 7 for the In-Kit and Not-In-Kit questions set, respectively. Therefore, if they answered all questions correctly, they would be given a score of 15. However, analysis of the scores was carried out per question's type.

As each question category has a different number of questions, the test scores between each group were normalized for comparison analysis. The descriptive statistics of test scores for In-Kit questions, which are grouped by test type, and the concept mapping type, are shown in Table 5.4, and the descriptive statistics for Not-In-Kit questions are shown in Table 5.5. All scores in Table 5.5 have been normalized to a maximum score of 10.

Figure 5.9 shows graphical comparison of pre-test, post-test, and delay-test score between two concept mapping approaches as well as the question type. Regarding Not-In-Kit questions, students from both CSM and CKB groups obtained similar scores. No statistical differences in the pre-test, post-test, and delayed test scores between the CSM and CKB group could indicate that all students could have a similar cognitive competence regardless of the group. However, the post-test and the delayed test result for the In-Kit questions between the CSM and the CKB group were different. Hence, the difference in learning effect.

Table 5.4 Descriptive statistics of test score for In-Kit questions.

Test Type	Group	n	Mean	s.d.
Pre Test	CSM	20	4.29	1.61
Pre Test	CKB	20	4.25	1.49
Post Test	CSM	20	6.14	1.32
Post Test	CKB	20	7.63	1.21
Delayed Test	CSM	20	4.86	1.50
Delayed Test	CKB	20	6.25	1.41

Table 5.5 Descriptive statistics of test score for Not-In-Kit questions.

Test Type	Group	n	Mean	s.d.
Pre Test	CSM	20	4.21	1.64
Pre Test	CKB	20	4.63	1.52
Post Test	CSM	20	6.21	1.81
Post Test	CKB	20	6.25	1.41
Delayed Test	CSM	20	5.00	1.50
Delayed Test	CKB	20	5.06	1.60

Because of the number of participants who participated in this study was limited, the experiment's data were failed to conform to the Shapiro-Wilk normality test. Non-parametric approaches were used to analyze the data and interpret the results. According to the non-parametric Mann-Whitney U test to compare the test results between the CSM and CKB group, the pre-test scores for the In-Kit questions were statistically insignificant (*p-value* = 0.87). Therefore, it can be said that students from the CSM and CKB group have a similar level of understanding prior to collaborative learning with concept maps. However, significant differences were shown for the post-test score (*p-value* = 0.0001958) and the delayed-test score (*p-value* = 0.003786) between the CSM and CKB group for the In-Kit questions score. The differences were significant because the p-values of Mann-Whitney U tests were less than the specified significance level of 0.05. Therefore, students who used the Kit-Building approach gained better scores than the CSM group students who collaboratively created their concept maps from scratch.

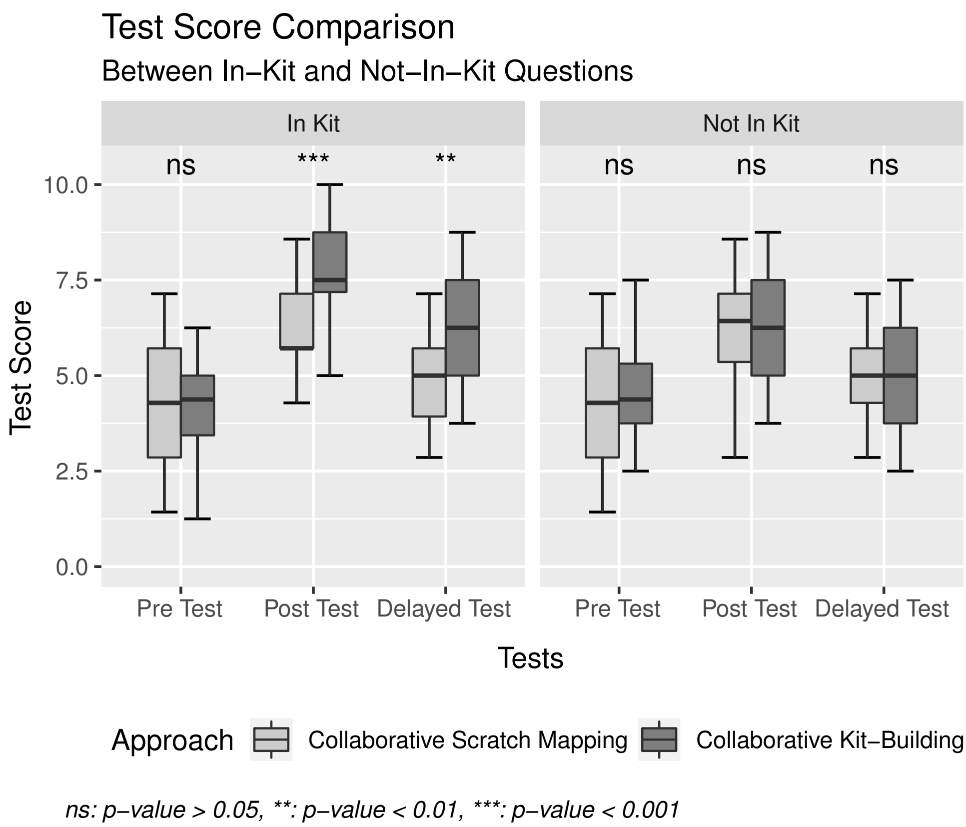

Fig. 5.9 Test Score Comparison Between Different Concept Mapping Approach.

In evaluating the memory effect of post-learning activity with concept maps, a GLM analysis of the delayed-test score was carried out. However, this study did not evaluate participants' cognitive competence before learning with concept maps; thus, it cannot be included in the analysis. The GLM analysis provided the delayed-test score as the dependent variable and set the post-test score and group as the influencing factors. According to the GLM analysis result as shown in Table 5.6, it can be said that the delayed-test score, which measured the students' retained knowledge, was significantly affected by their knowledge after the concept-mapping activity (*p-value* < 0.05) instead of the instructional method used during concept mapping (*p-value* > 0.05). The delayed-test score of the CKB group students is higher than the CSM group students because the post-test score of the CKB group students is also higher. In other words, all students retained their knowledge in a similar manner. Nevertheless, students who collaboratively learn with Kit-Build could retain more knowledge as they could focus more on the topics represented by the kit than the students who did not use Kit-Build.

Table 5.6 GLM analysis result of the delayed-test score.

	Estimate	Std. Error	t value	p-value	Sig.
(Intercept)	-10.56	10.71	-0.99	0.331	
post-test	0.61	0.16	3.84	4.62×10^{-4}	***
group	0.49	0.46	1.06	0.296	

Similar with other studies about learning with concept maps, collaboratively learning with Kit-Build concept map could also improve learners' understanding of a particular topic. In this study, the students' understanding of the reading was improved, regardless of how they do the concept mapping. However, the CKB group students have better post-test scores than the students of the CSM group. By collaborating with the provided kit, students of the CKB group could focus more on recomposing a concept map by connecting key ideas implied by the kit into correct propositions; less-thinking about concepts and links that should be identified from the text in restructuring their concept map. Thus, the Kit-Build approach could help students deepen their understanding and answer questions of a higher cognitive level.

In delving into questions that Kit-Build could help the students to understand more, the number of students who correctly answered the In-Kit questions of pre-test and post-test (C) was counted and is shown in Table 5.7. The In-Kit questions consisted of eight questions, i.e., four lower-order questions and four higher-order questions. Finding the difference in the number of students between pre-test and post-test using (5.1) portrayed the questions that the Kit-Build approach has helped the students understand more than the traditional concept mapping approach. According to the difference in the number of students between the two groups (Δ_C), the Kit-Build concept map approach helped the students to answer relatively higher order questions; thus, encouraging more profound and meaningful thinking.

$$\begin{aligned}\Delta_C &= \mid (C_{kbb} - C_{kba}) - (C_{smb} - C_{sma}) \mid \\ &= \mid \Delta_{kb} - \Delta_{sm} \mid\end{aligned} \tag{5.1}$$

On the contrary, there were no significant statistical differences in the pre-test, post-test, and delayed-test scores of Not-In-Kit questions between the CSM and CKB group. The Mann-Whitney U comparison tests to both groups' pre-test, post-test, and delayed-test scores resulted in non-significant differences with a *p-value* of 0.7228, 0.8486, and 0.8701, respectively. Therefore, it can be said that both groups have a similar comprehension level before and

Table 5.7 The number of students who answered the questions correctly.

ID	Pre-Test		Post-Test		Δ_{kb}	Δ_{sm}	Δ_C
	C_{kba}	C_{sma}	C_{kbb}	C_{smb}			
Lower order questions							
Q1	12	13	19	16	7	3	4
Q2	12	8	19	14	7	6	1
Q4	5	6	8	10	3	4	1
Q8	8	6	11	10	3	4	1
Higher order questions							
Q3	7	5	19	7	12	2	10
Q6	9	8	16	10	7	2	5
Q9	11	11	19	13	8	2	6
Q14	5	4	11	8	6	4	2

after concept mapping. It can also be said that they could retain a similar level of information after several days.

A study showed that concept maps helped students focus their attention on essential ideas and explore what to learn and how they learn (Vodovozov & Raud, 2015). With Kit-Build concept map, the students could focus more on restructuring the learning contents into concept maps (Hirashima et al., 2015). One might argue that when the students focused more on restructuring a concept map with a Kit-Build kit, they would ignore the remaining part of the contents. However, the argument appears incongruously to the analysis result of the score of Not-In-Kit questions in this study. According to the answers to Not-In-Kit questions, students from both CKB and CSM groups have a similar understanding level on all tests. In answering the Not-In-Kit questions, if the CKB group students ignored parts uncovered by the kit, they could have lower scores than the CSM group students. The score comparison tests to the Not-In-Kit questions showed non-significant differences; hence, a similar learning effect.

During the post-experiment open discussion, all participants were asked to share their thought and experiences by participating in the experiment. Several participants criticized that recomposing a concept map with Kit-Build should allow them to extend the concept map further, adding more content and ideas to the concept map and discussing more with the new content. Expressing one understanding with a concept map could not be expressed by merely using the kit. Furthermore, extending a Kit-Build concept map to an open-end concept map was known to impact learners' comprehension significantly (Prasetya et al., 2021). Withholding part of the information into a concept map kit stimulated students' curiosity towards uncovered parts of the learning contents, hence the "spread of effect" that rippled the students' thinking to think about information outside the parts covered by the given kit. As their focus spread to nearby information, their comprehension regarding the topic shall follow. Therefore, this explains why students who used Kit-Build have similar learning effects with students who composed their concept maps from scratch.

Utterances in the Discussion

Finding how participants communicate while using the online concept mapping tool to compose a concept map collaboratively is interesting. From the experiment, the collaboration system has captured 828 utterances from 20 dyads during the Concept Mapping phase. Of the total utterance data, 597 (72%) talks came from the CKB group and the remaining 231 (28%) talks came from the CSM group. The utterances were captured from the general and node-linked communication channels. For analysis, their utterances were coded into four categories of act4teams coding scheme and is shown in Fig. 5.10. Each talk or message, which was sent by a dyad member, was counted as one utterance. The graph in Fig. 5.10 also shows the number of utterances (volume) sent by members of each dyad for each concept mapping group. The comparison of the act4teams-categorized utterance of the CSM and CKB group is shown in Fig. 5.11.

According to the graph in Fig. 5.10, most dyads of the CKB group tended to talk or communicate more than dyads of the CSM group. The comparison chart in Fig. 5.11 shows that the CKB group dyads discussed the content more (43.6%) than procedural matters (23.5%) during collaboration. However, the situation in the CSM group was quite the opposite of the CKB group. Dyads of the CSM group tended to talk more about the map creation procedure than have a more focused discussion towards the contents. Nevertheless, it is interesting to see that dyad K02 of the CKB group did not talk much during the collaboration activity, and dyad K09 did not talk about the contents. Further investigation might be required to discover issues that might overcome them

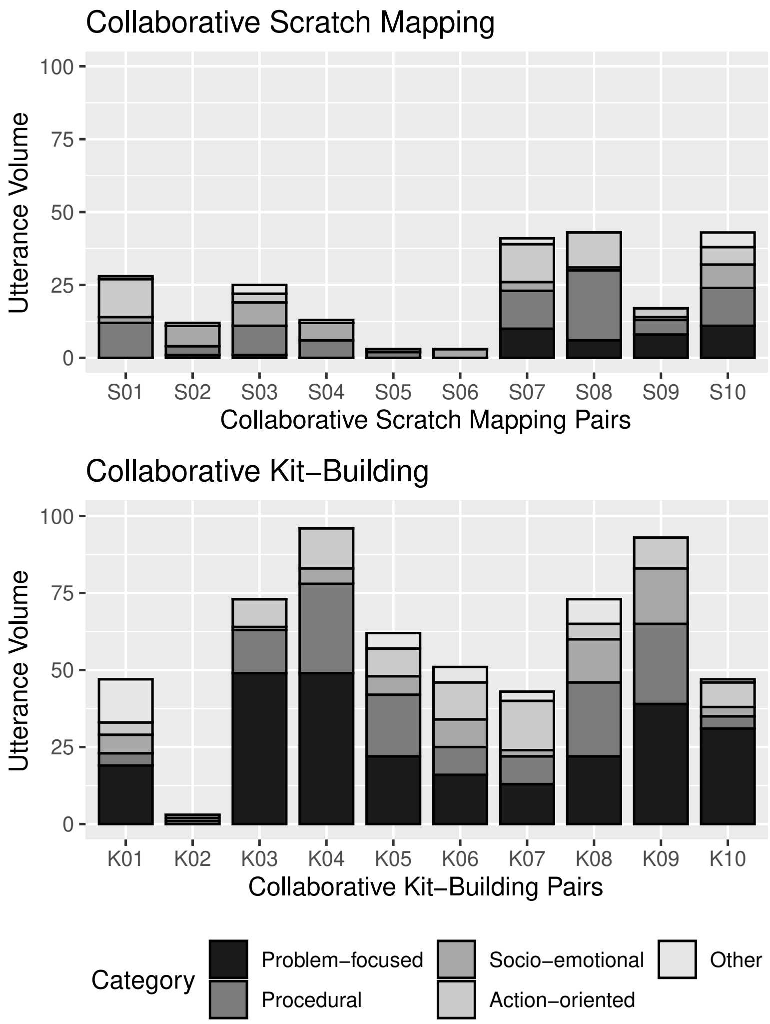

Fig. 5.10 Act4teams-coded utterance distribution of dyads of Collaborative Scratch Mapping and Collaborative Kit-Building groups

to discuss during collaboration. The descriptive statistics for the act4teams-categorized utterance data are shown in Table 5.8.

Students' utterance data were analyzed with Spearman's correlation test to discover the correlation between talks and the concept mapping groups. Spearman's correlation test between concept mapping group and problem-focused utterance category showed a significantly strong correlation (*p-value* = 0.0002245, ρ = 0.73). The concept mapping approach and the total utterance volume also have a significant strong correlation (*p-value* = 0.0006488, ρ = 0.69). However, Spearman correlation test results for the remaining categories showed weak and non-significant correlations (*p-value* > 0.05 and 0.20 < ρ < 0.39). Therefore, students of the CKB group, which used the Kit-Build

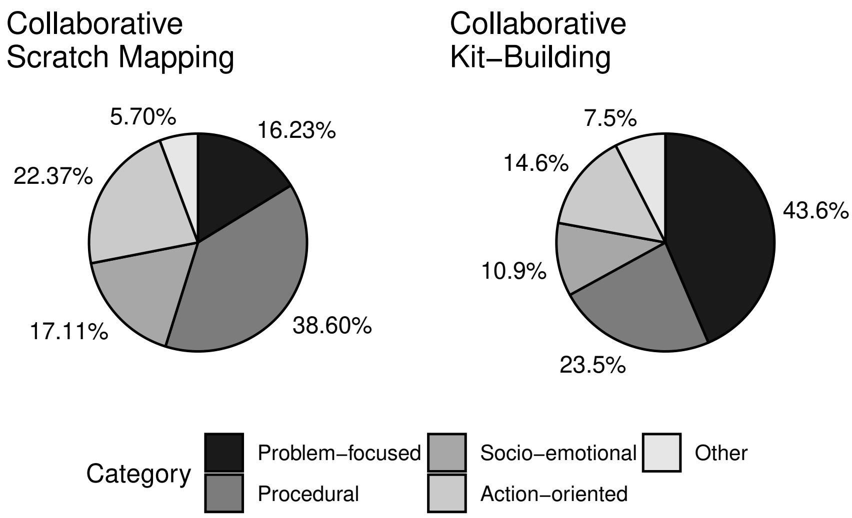

Fig. 5.11 Percentage of utterances between concept mapping approaches

approach, tended to discuss the contents more than students of the CSM group. The result was in harmony with the previous study regarding reciprocal use of Kit-Build concept map in collaborative learning. Students who discuss using Kit-Build concept maps have more exploratory talks than students who discuss using self-created concept maps (Wunnasri et al., 2018b).

In analyzing the difference in students' utterances of the two groups, the non-parametric Mann-Whitney U test for independent samples was utilized for each act4teams category. The analysis also included one "other" category to classify talks that did not fit into other act4teams categories during the collaboration. Additionally, their utterance volume was analyzed. The comparison analysis tests showed that the total volume and problem-focused utterance between the CSM and CKB group were significantly different. The comparison test for the total utterance volume and the problem-focused utterance of the CSM and CKB groups resulted in a significant *p-value* of 0.002404 and 0.001361, respectively. However, the remaining categories, i.e., procedural, socio-emotional, action-oriented, and other, were insignificantly different as the comparison tests to the categories resulted in p-values of higher than the specified significance level of 0.05. Therefore, it can be said that other than discussing the contents, both groups talked similarly. The comparison of students' utterances between the CSM and CKB group for each act4teams category is shown in Fig. 5.12.

Table 5.8 Descriptive statistics for the act4teams-categorized utterance.

Approach	Category	n	Mean	SD
CSM	Problem-focused	10	3.7	4.547
CSM	Procedural	10	8.8	7.131
CSM	Socio-emotional	10	3.9	3.071
CSM	Action-oriented	10	5.1	5.547
CSM	Other	10	1.3	1.636
CSM	Total Volume	10	23.1	15.466
CKB	Problem-focused	10	26	15.909
CKB	Procedural	10	14	10.132
CKB	Socio-emotional	10	6.5	5.681
CKB	Action-oriented	10	8.7	4.473
CKB	Other	10	4.5	4.696
CKB	Total Volume	10	59.7	28.593

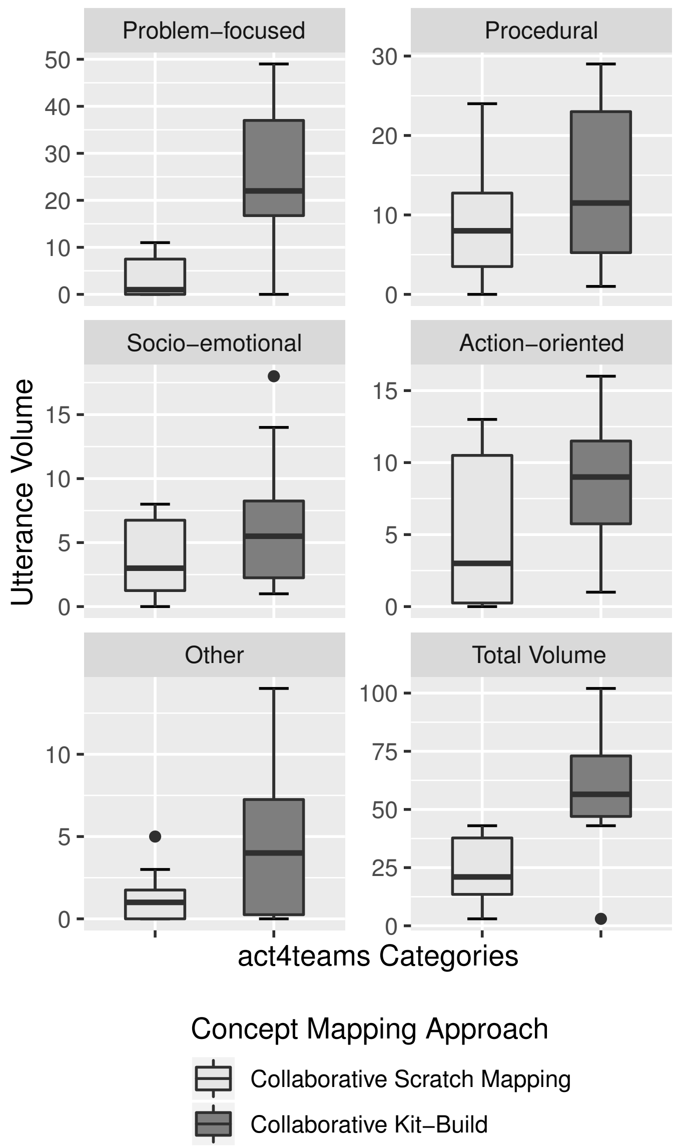

Fig. 5.12 Comparison of utterance category between concept mapping approaches

Chapter 6

Conclusion

6.1 Concept Map Authoring Support System

The concept map authoring tool, which employs CMM approach, has been designed and developed as an extension the existing Kit-Build concept map tool. One practical learning strategy in learning EFL reading comprehension was designed and the viability of the authoring support tool were presented. The authoring tool provided semi-automatic assistance in authoring concept maps of EFL reading comprehension text in the form of suggestions at keyword and proposition level.

Two experiments and one evaluation involving expert teachers were conducted to evaluate the developed concept map authoring support tool; thus, answered the defined research questions. The experiments involved teachers and undergraduate students to experience the tool in composing concept maps from English learning material. Research questions RQA-1 and RQA-2 were answered from evaluation with three experts.The first experiment, which involved English teachers, answered the research questions RQA-3, RQA-4, and RQA-5. The second experiment, which involved undergraduate students, answered the research questions RQA-6, RQA-7, and RQA-8.

RQA-1: *With the designed extraction approach towards EFL reading comprehension learning strategy with Kit-Build, how is the accuracy of the suggested keywords and proposition triples of the authoring support tool?*

Concerning the learning strategy of EFL reading comprehension of this research, accuracy level of 55.9%, 40.3%, and 44.8% could be attained from the respective keywords, open domain-based triples, and verb-based triples recommendation of the initial concept maps. Better accuracy could be achieved if potential suggestions were incorporated to refine the concept maps, yielding an improved accuracy of 95.1%, 69.3%, and 76.7% for the respective keywords, open domain-based triples, and verb-based triples recommendation.

Even though the resulting concept maps were subject to the teacher's subjectivity, the designed semi-automatic concept map generation approach could achieve average-to-good accuracy level. Nevertheless, the authoring tool support feature could perform exceptionally well, especially in supporting teachers to refine and improve their concept maps in more detail.

RQA-2: *Will the developed concept map authoring support tool perceived to be useful for assisting teachers in composing concept maps from EFL reading comprehension texts and support their teaching activities with Kit-Build concept map?*

Experts perceived the developed concept map authoring tool useful; thus, ascertaining the tool useful to assist teachers compose concept maps from EFL reading material even though several limitations exists and improvement regarding the tool's usability is needed.

From the first experiment, which involved English teachers, the following research questions were addressed:

RQA-3: *Will the concept map authoring support tool, which generates concept maps semi-automatically, could improve the concept mapping efficiency in terms of the yielded number of propositions?*

According to the analysis result, larger concept maps could be attained when teachers compose concept maps using the supported authoring tool. Larger concept maps could be regarded as improvement in concept mapping efficiency.

RQA-4: *Will using the authoring support tool yields concept maps of better quality than a manually composed concept map?*

When teachers were using the supported authoring tool to compose concept maps from English reading material, the attained concept maps quality remains at the same level even though the resulting concept maps have a slightly better quality.

RQA-5: *How will the teachers perceive the usefulness of the concept map authoring support tool to create concept maps of English reading materials for teaching?*

According to English teachers response in perceiving the usefulness of the tool, positive responses were obtained. The concept map authoring support tool was confirmed useful in providing assistance to compose concept maps of English reading material for teaching.

The second experiment was conducted with undergraduate students to experience the concept map authoring support tool and evaluate their experience regarding the supported tool with UEQ-S and TAM. The experiment answered the following research questions:

RQA-6: *Will the developed concept map authoring support tool provides better experience towards concept mapping than the existing authoring tool?*

Generally, both concept map authoring tools evaluated in this research showed a good UX evaluation result. Both tools could provide a positive UX in composing concept maps from learning material.

Pragmatically, composing a concept map can be considered a simple task. Users might think that composing a concept map by using a simple tool is more comfortable. On the other hand, if users were using another tool with aiding features, they could have more interest towards the tool; gaining comfort emotionally. Their interest and comfort might trigger eagerness to experience new kind of activities or interactions that are different from usual habit.

One simple concept map authoring tool might be less efficient and less supportive, but it yields a clearer and easier tool to help users accomplishing their tasks. On the other side, a feature-rich tool, which is used to construct a concept map, is hedonically able to provide a better comfort—emotionally—and a better interest to do their tasks efficiently.

Nevertheless, the UX evaluation suggested that the developed concept map authoring support tool has better hedonic UX but has less pragmatic UX than the existing authoring tool.

RQA-7: *How is the user acceptance model with TAM for the developed concept map authoring support tool?*

The proposed model of TAM used in this research mostly conform to the original TAM, except that in this study, the students' perceived ease of use don't influence their attitude towards using the tool in this research. Nevertheless, it can be suggested that the students accepted the concept map authoring support tool to help them compose concept maps of English reading material.

RQA-8: *Among several factors that could possibly influence the acceptance model, what are the factors that contributed to the acceptance of using the developed concept map authoring support tool?*

Among the three additional external variables, i.e., Compatibility, Habit, and Enjoyment, which were included in the proposed model, Habit is the only aspect that has no significant influence towards student intention in using the tool. Therefore, in order to improve the students' acceptance in using the Kit-Build concept map authoring tool, the tool should improve its suggestions' quality and usability, thus raise its usefulness level.

6.2 Real-time Collaborative Concept Mapping System for Online Learning with Concept Maps

In evaluating the developed online collaboration system and depicting how the tool could perform in practical use, an experiment with students, which simulated an online collaborative learning with Kit-Build concept maps, was conducted. Several tests were designed to measure the effectiveness of online collaborative learning with the tools. The following research questions were addressed by the analysis to the experiment results:

RQB-1: *How is the design of a system that enables the current Kit-Build concept map system supports online real-time composition and discussion of concept maps?*

An online collaborative concept mapping system of Kit-Build concept map has been successfully designed and developed; facilitating students to learn collaboratively using Kit-Build concept map with others online. With the proposed real-time communication design, which employ Socket.IO library as the middleware that bridges the communication between two or more clients, seamless collaborative concept mapping and discussion with the developed Kit-Build concept map authoring tool could be well attained.

RQB-2: *How is the students' attitude towards the system usability in supporting collaborative learning with Kit-Build concept map?*

Having a trial with students in evaluating the system usability have yielded a positive response towards the system and useful for further development and use. According to the Online Cooperative Learning Application learning attitude measurement, the system prototype yielded a positive learning attitude score of 4.31 from a maximum score of 5. Thus, the developed online collaborative Kit-Build concept map system was shown to be useful, enjoyable, and fun where they could express their ideas and creativity.

RQB-3: *How the use of Kit-Build concept map in an online collaborative learning environment of EFL reading comprehension, which uses concept maps composition as its learning strategy, affects student comprehension as opposed to the regular open-end concept mapping?*

According to the experiment result and analysis, using the online collaborative Kit-Build concept mapping tool effectively supports collaborative learning of reading comprehension of English as a Foreign Language that involves concept mapping activities. Both scratch-mapping and kit-building approaches effectively improve students' comprehension of English reading in an online collaborative learning environment with concept maps.

In harmony with previous studies, recomposing concept maps in collaborative learning with Kit-Build helps students focus more on essential ideas depicted by the kit, hence significantly better comprehension than composing concept maps from scratch. The findings in this study showed that partially included the information about the contents into a Kit-Build kit could arouse students' curiosity, creating the "spread of effect" to think about ideas other than one that implied by the kit. The students who composed concept maps with Kit-Build would have similar knowledge with the other students who composed concept maps from scratch when asked about information uncovered by the kit. Therefore, it is better to use Kit-Build than the traditional concept map to learn EFL reading comprehension collaboratively.

RQB-4: *How is the discussion during online collaborative work with concept maps with and without the Kit-Build method?*

> According to the analysis of the students' conversation, using a kit to construct and discuss with concept maps will allow them to talk more about the contents rather than talk about procedural matters.

6.3 Overall Conclusion and Future Work

A computer-supported concept mapping tool has been developed, providing authoring assistance through semi-automatic concept map generation process with CMM. Additionally, a collaboration system for the concept mapping tool was developed. Allowing student and teacher collaboratively learn online with Kit-Build concept map. The collaboration system allow real-time communication and collaboration of concept map composition and recomposition with Kit-Build concept map framework. Thus, demonstrate the effectiveness of the using the tool in learning with Kit-Build concept map online.

The authoring support tool was developed with CMM approach, thus adapted the NLP and several text mining techniques to extract concepts and propositions from text-based learning material. The tool provided assistance by suggesting the extracted concepts and propositions to be incorporated as part of the author's concept map. In addition to have a good assisting performance in the authoring process, the tool was perceived useful by both teacher and student for learning. By using the support feature to compose concept maps from learning material is shown to improve the efficiency of producing larger and more detail concept maps at a slightly better quality. They expressed their positive response and acceptance regarding the authoring support tool through UEQ-S and TAM evaluation.

The result of TAM analysis from this research identifies aspects that influence the students' intention in using Kit-Build concept mapping tool for learning. This research experiment result shows that several future improvements to the authoring tool can be made, focusing to the areas that influence the most or lack of. A further usability analysis can also be carried out to evaluate and analyze the user experience in using the concept map authoring tool.

This study also confirmed that learning with Kit-Build concept map in online settings has similar learning effect to learning with Kit-Build offline. Evaluation to the online collaboration feature also demonstrated the tool effective for collaborative concept mapping composition use where multiple users could work with concept maps remotely on the same concept mapping space in real-time. Further improvements, integration, and inclusion of Kit-

Build concept map framework into broader contexts, such as Massive Open Online Course (MOOC) and other learning subjects, are several potential research topics of learning research with Kit-Build concept map.

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Appendices

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Appendix A

Online Cooperative Learning Attitude

A.1 Positive Attitude Scale

ID	Items
A1	I enjoy solving problems regarding the group project using Collaborative Concept Mapping Tool (CCMT) with my group members.
A2	Being interactive with the other group members using CCMT increases my motivation for learning.
A3	I enjoy experiencing collaborative learning using CCMT with my group members.
A4	Online group activity increases our creativity.
A5	I believe that the group can work on a concept map effectively with the CCMT.
A6	CCMT improves my social skills.
A7	I enjoy helping others in CCMT.
A8	CCMT is very entertaining for me.
A9	CCMT helps me feel better psychologically.
A10	More ideas come up as a result of CCMT.
A11	I think that I have had/will have more successful results since I work with a group in CCMT.

A.2 Negative Attitude Scale

ID	Items
A12	Trying to teach something to my group members in CCMT makes me tired
A13	CCMT does not make any sense to me.
A14	I cannot develop my own ideas in CCMT.
A15	I don't like that people are depending on me in CCMT.
A16	I don't think that my interaction with my group members in CCMT will make any contribution to me.
A17	CCMT is not suitable for me.

Abbreviations

act4teams Advanced Interaction Analysis for Teams 90, 97–99

ANOVA Analysis of Variance 53

API Application Programming Interface 24, 37, 39

AT Attitude Towards Using 62, 65, 69, 70

BI Behavioral Intention 62, 65, 70

CKB Collaborative Kit-Building 87, 92–99

CMM Concept Map Mining 13, 14, 16, 18, 29, 30, 33, 34, 102, 107

COVID19 2019 Corona Virus Disease 3

CSM Collaborative Scratch Mapping 87, 92–97, 99

EFL English as a Foreign Language 7–9, 14, 26, 29, 30, 32, 34, 35, 40, 42, 46, 47, 86, 102, 103, 106

GLM Generalized Linear Model 53, 54, 94

HTML5 Hypertext Markup Language 5 13, 23, 24, 27, 33, 48, 75, 79, 81, 82

HTTP Hypertext Transfer Protocol 25, 37, 82

IDT Innovation Diffusion Theory 21

ITP Institutional Testing Program 61, 66, 87

JSON JavaScript Object Notation 37

MCCP Model-CollectionService-Controller-Presenter 77

MOOC Massive Open Online Course 108

MVC Model-View-Controller 77

NLP Natural Language Processing 13–17, 30, 33, 34, 37, 39, 107

OCLA Online Cooperative Learning Application 75, 83, 84

Open IE Open Information Extraction 16, 18, 38, 40, 42

PEOU Perceived Ease of Use 21, 62, 64, 65, 69, 70

PHP PHP Hypertext Preprocessor 39

POS Part of Speech 16, 18, 38, 40

PPV Positive Predictive Value 36, 37

PU Perceived Usefulness 21, 62, 64, 65, 69, 70

RAKE Rapid Automatic Keyword Extraction 14, 17, 38–40, 42

SRE Syntactic Relationship Extraction 38–40, 42

TAM Technology Acceptance Model 20–22, 31, 44, 58, 61, 62, 64, 69, 71, 104, 105, 107

TF-IDF Term Frequency-Inverse Document Frequency 15, 17, 19, 38, 39

TIB Theory of Interpersonal Behavior 22

ToEFL Test of English as a Foreign Language 36, 61, 66, 87

TPB Theory of Planned Behavior 21

TPR True Positive Rate 36, 37

TRA Theory of Reasoned Action 21

UEQ User Experience Questionnaire 19, 20, 61–64, 72

UEQ-S User Experience Questionnaire-Short 20, 61, 62, 66, 68, 72, 104, 107

UI User Interface 19, 81

UX User Experience 19, 31, 61, 66–68, 72, 104