The Development of Web Application to Enhance Knowledge Construction and Analytical Thinking in 21st Century Learning for Higher Education

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Abstract

The purposes of the present study were 1) designing and developing a web application to enhance knowledge construction and analytical thinking in the 21st century learning for the students in higher education 2) evaluating web application to enhance knowledge construction and analytical thinking in the 21st century learning for students in higher education. The study employed the developmental research design method comprising 2 stages: 1) design and development and 2) evaluation. Participants of the research were 12 experts and 39 third-year industrial engineering students, Faculty of Engineering, Ubon Ratchathani University. The results revealed that: 1) the design and development of web application comprised of 5 components, namely, 1) Problem Base 2) Learning Resource 3) Scaffolding 4) Center for Collaborative Learning, and 5) Coach. The results of the experts' evaluation suggested that all learning elements of the web application were suitable and had efficiency in enhancing the knowledge construction and analysis thinking of the students. Moreover, the findings in terms of the use of the web application in terms of learners' achievement and the analytical skills showed that the learners' performance in the posttest was significantly higher than that of the pretest. With regard to the results of the questionnaire, the learners found that all aspects of the web application were appropriate and could help them improve their knowledge construction and analytical thinking skill.

Keywords: Web Application, Knowledge Construction, Analytical Thinking, 21st Century Learning

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Introduction

Technological advances have great impacts on learning process of people in the 21st century. Learning management, therefore, has to be adapted to correspond to today's world. Learning in the 21st Century needs to go beyond "traditional subject themes" towards "21st Century skills," abilities that cannot be taught by teachers. As a result, development of learning skills and knowledge construction are necessary tools in grasping ample of information available in today's technology. As Chaijaroen (2014) puts it, knowledge construction is an important instrument in linking one's existing experience to new knowledge, which leads to an effective problem-solving process. This is consistent with Thailand's Education Reform Policy in the Second Decade, B.E. 2552-2561 (2009-2018) (Office of Education Council Thailand, 2009) which focuses on the improvement of education quality and offers of learning opportunities to Thai people, and encouragement of more involvement from every sector in education management, as prescribed in Thailand's National Education Act, B.E. 2542 (1999) amended (3rd Issue), B.E. 2553 (2010) (Thailand Office of the Basic Education Commission, 2015)

One of the most influential principles or theories in designing learning media and materials that corresponds to today's learning activities is the Constructivist Theory adapted from by Piaget's (1965) constructivism and Vygotsky's (1925) which emphasize social constructivism. Design of learning innovation in the present does not only focuses on learners' abilities to remember, but also their abilities in constructing knowledge, scrutinizing, and thinking. Moreover, meaningful learning is also promoted (Chaijaroen, 2014). Besides, it is also important to raise awareness of the preparation for such paradigm shift, which is one of the key strategies specified in the Strategies to Develop Quality and Society of Thai People to be the Society of Intelligence and Learning. This strategic scheme focuses on the enhancement of knowledge and basic skills such as thinking skills, analysis skills, problem-solving skills, creative skills, team-work skills, work ethics and disciplines, in order to support and promote learning in high-technology settings. These skills help improve learners' abilities to adapt themselves in modern technology era and getting prepared for the upcoming society of learning and life-long learning development.

Technological development offers easy access to learning anytime and anywhere incorporated with useful portable devices such as smartphones and tablets. Moreover, web applications or any applications that are accessible on the Internet or intranet have also been developed. Web applications are becoming more and more popular because they offer easy upload platforms, web keeping, and ample add-on software free of charge. These features of web applications are a strong motivation for the research to conduct the present study on designing online lessons using web application.

Apart from the advantages mentioned above, web application also makes another learning channel for ubiquitous learning. In the other words, learners have access to learning anywhere and anytime, depending on individual needs. One of the most interesting advantages of web application is that users can change contents in the websites deliberately to make them up to date.

In spite of the advancement in technology, the educational outcome of Thailand has not met the standard, for example, lacking desired characteristics; lacking enthusiasm in learning, seeking new knowledge, thinking and decision skills; and most importantly lacking analytical skills. Analytical skills are fundamental for higher-level thinking skills. Moreover, they also elevate intelligence of modern learners to live their social lives. Because when they encounter difficult situations in their daily lives, they can make decisions what to do and not to do to overcome problems by themselves (Phinla, 2016).

Recent studies have shown that instructional designs and learning innovations have been created to support analytical skills, using learning enviroments, lessons on multimedia network and knowledge construction programs (Chaijaroen, 2014; Yaisomboon & In-udom, 2011). However, there is still no evidence in the utilization of web applications to promote thinking skills for learning in the 21st Century.

Therefore, this study emphasized a study to develop learning innovations to be a guideline for construction of new knowledge through web application to enhance knowledge construction and analytical thinking in 21st century learning for higher education. Moreover, learning achievements, analytical thinking abilities, and comments of learners were considered to assist 21st century learning management and to improve learners' intellectual potentials. Besides, the study was expected to serve as a guideline in elevating efficiency in learning management at all levels of education with a primary emphasis on utilizing innovation and information technology, to be a guideline for education reform and educational personnel development. The research also hoped that the present work would be useful for learning management, innovation development, and study of higher-level skills for 21st century, which are beneficial to life-long learning process. Thus the Objectives of the study is as following:

a) To design and develop a web application to promote knowledge construction and analytical skills in 21st century learning for students in higher education.
b) To study the effects of the designed web application on knowledge construction and analytical skills of the students in higher education.

This article is organized as following in session 2 the methodology will be presented. In the methodology session, the research design, the research participants, the instrument, and the data collection and analysis will be presented. Session 3 the result of the study will be discuss and follow by session 4 which is the conclusion and discussion. Last session the future research and implication is recommended.

Methodology

1. Research Design

This study was a developmental research adapted from Richey and Klein (2007). The procedure was divided into 2 stages: Stage 1 - Design and development stage, and Stage 2 - Evaluation stage using quantitative and qualitative data collection methods.

2. Research Participants

Participants in this research were classified into 2 stages.

The participants in Stage 1 were a group of 12 experts from the purposive sampling who were the evaluators of the web application developed by the researcher. Areas to be evaluated were contents, web application design on the basis of constructivism theory, use of media, and evaluation of learners' outcomes.

The participants in Stage 2 were 39 undergraduate students majoring in industrial engineering, Faculty of Engineering, Ubon Ratchathani University, who were enrolled in Production Planning and Control Course in semester 2/2017.

3. Instruments

The instruments in this research were classified into 2 stages.

3.1 The instrument in Stage1 were 1) the document examination and analysis recording form. The scope of document analysis regarding with constructivist theories, knowledge construction, analytical thinking in the 21st century and web application. 2) the record form for synthesis of the designing framework of web application in enhancing students'

knowledge construction and analytical thinking and 3) the expert review record form for evaluation of the designing framework consists of 3 major issues which are: learning content, instruction design, and web application.

3.2 The instrument in stage 2 as following: the instrument used in the experiment was the web application to enhance knowledge construction and analytical thinking in the 21st century learning for higher education. The instruments employed for the data collection were 1) an evaluation form for the web application, 2) students' achievement tests consisted 30 items that each of which has four multiple choices, the Index of Item-Objective Congruence value (IOC) is 0.67-1.00, the Difficulty index (p) is 0.21 -0.61, the discriminant power (r) is 0.29-0.90 and the reliability (KR-20) is 0.92 3) the analytical thinking skills test is subjective tests consisted 5 items, the Index of Item-Objective Congruence value (IOC) is 0.80-1.00, the Difficulty index (p) is 0.53 -0.59, the discriminant power (r) is 0.47 -0.80 and alpha coefficient is 0.82 and 4) a questionnaire on the students' opinions on the web application based on the learning environment assessing framework (Chaijaroen, 2014) which composed of 3 issues which were content, media, and instructional design. The survey was open-ended, providing a rationale or suggestion for improvement in the case of a consistent or inconsistent opinion. From the evaluation of the experts, it was found that all questions are consistent with the evaluation framework.

4. Data Collection and Analysis

4.1 Stage 1

The design and development of the web application were carried out on the basis of Instructional Design theory (ID theory) with the following details.

4.1.1 Synthesis of Theory Framework

In this stage, the information was collected through analytical description and inference from information regarding related principles, theories, research and contextual studies of the constructivist theories, cognitive theories, and analytical thinking in the 21st century. The synthesis of theory framework including the document analysis, and the analysis of document verification.

4.1.2 Synthesis of the Designing Framework

The data were collected using analytical description and inference of information related to synthesis of designing framework.

4.1.3 Development of Web Application

In the last step of Stage 1, the web application was developed in accordance with the components synthesized from the designing framework.

4.2 Stage 2

The researcher brings a web application that has been evaluated and improved by experts for tested with the target group. There are 3 steps to learning with the web application as follows. The first step is to take the lesson. The students take a pre-test to measure the learning achievement and students' thinking skills. The next step is to process of learning. The web application is web supported courses in some topic. The learners spent 8 hours for learning with the web application. The researchers explain and guide for the learners on how to learn with the web applications. The students were divided into 3 persons per a group. The learners will study problem based and find the resource for solve the problems in learning task. They can solutions to problems or answers by the elements in the web application include: learning resource, scaffolding, center for collaborative learning, and the coach. During the learning process, students will collaborate to find and discuss the problems. The research will serve as the coach. The conclude step, the researchers summarizes the lesson. After learning with the web application. The researchers take students to make a post-test of learning achievement,

analytical thinking skills and in-depth interview on students' opinions after using the web application. After the experiment has been executed, the evaluation of the web application will be performed.

Evaluation, quality control, and study of the effects of the web application in enhancing students' knowledge construction and analytical thinking were performed using innovation evaluation framework on the basis of constructivist approach (Chaijaroen, 2014), which were comprised of evaluation in terms of product, context, cognitive abilities, learning achievements, and students' opinions. Details of the framework are discussed below.

4.2.1 Evaluation of Product

The web application was evaluated in terms of contents, use of media, and design, using analytical description and inference.

4.2.2 Evaluation of Context

An interview was carried out to study web application context. The data were analyzed using analytical description and inference.

4.2.3 Evaluation of Cognitive Ability

Analytical thinking skills test is subjective tests consisted 5 items. A pre-test and post-test on analytical skills were carried out to the learners. The results of the tests were compared using the dependent t-test.

4.2.4 Assessment of Learning Achievement

Students' achievement tests consisted 30 items that each of which has four multiple choices. A pre-test and post-test were given to the learners before and after learning through the web application. The data was analyzed by mean, standard deviation and t-test dependent samples.

4.2.5 Evaluation of Learners' Opinions

The final step of data collection was conducted using a questionnaire and an in-depth interview on students' opinions after using the web application developed by the researcher.

Results

1. The results of the synthesis of the theoretical framework of the web application suggested that the web application was comprised of four crucial bases which compose of: context based, learning psychology based, pedagogical approach based, and technology and theory of media Based. The diagram of the components is shown in Figure 1.

2. The Synthesis of the Theoretical Framework of the Web Application.

The results from the synthesis of the theoretical framework of the researchers were taken as the basis of the synthesis of the designing framework of the web application by transforming theory into practice. After that, components of web application were designed, as shown in Figure 2.

With regard to the results of the synthesis of designing framework of the web application, 5 components were identified: 1) problem base; 2) learning resource; 3) scaffolding; 4) center for collaborative learning; and 5) coach. The five components are illustrated in Figure 3. And development the web application to enhance knowledge construction and analytical skills in 21st century learning of students in higher education base on designing framework as presented in Figure 4.

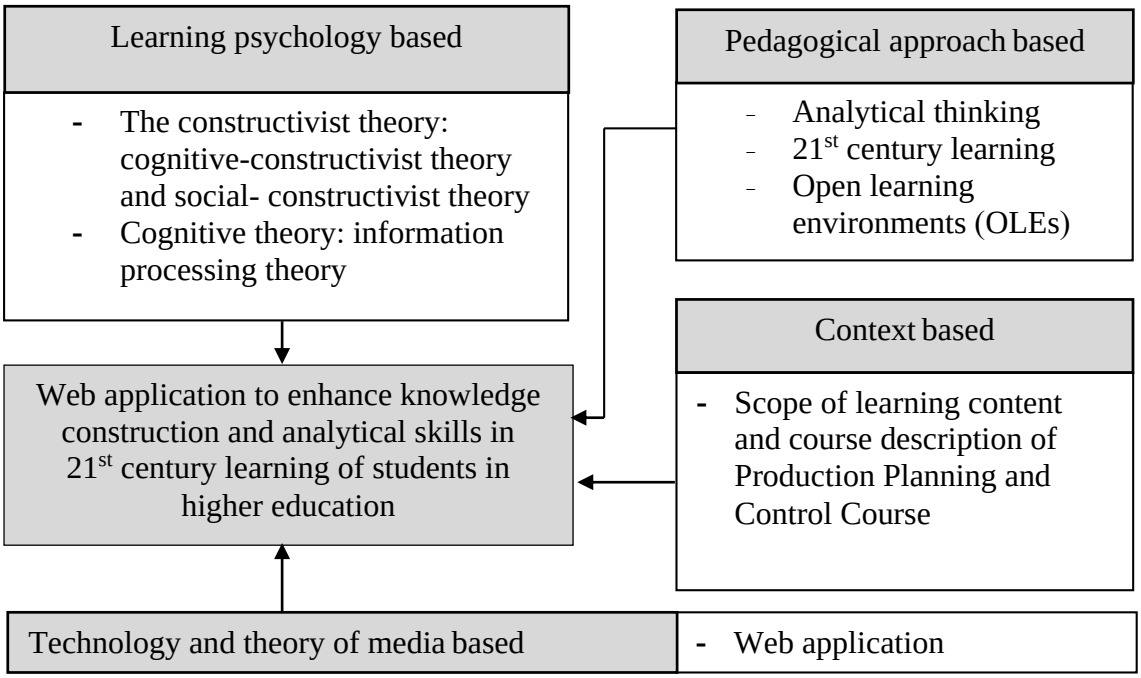

Figure 1. Theoretical framework of web application to enhance knowledge construction and analytical skills in 21st century learning of students in higher education

2.1 Problem base

Problem base is the first component that serves as the door to learning. It stimulates cognitive structure on the basis of cognitive constructivism adapted from Piaget's (1965). It emphasizes knowledge construction, in which learning activities were designed to be problem-solving situations that are based on real-world settings and context. These activities connect learner's existing experiences to new missions assigned by the activities that focuses on learner's analytical thinking skills.

2.2 Learning Resource

The learning resource of the web application was designed in accordance with information processing theory introduced by Klausmeier (1985). The contents were designed to present a mind map showing the relation among all contents with regard to the course description specified in the Thailand's Qualifications Framework for Higher Education (TQF). This component also focuses on the use of graphics and animation with an emphasis on key information such as use of colors, selection of size, underlining, and design of contents in the form of defined concepts, which shows the connection of the obtained information. Moreover, the web application was designed to encourage the learners to search for information from various learning sources to solve the problems specified in each learning mission. The learners use it to discovery learning through various information technologies. The instructor prepares the information in advance and it is embedded in the web application. However the learners can search for the information through the search engine.

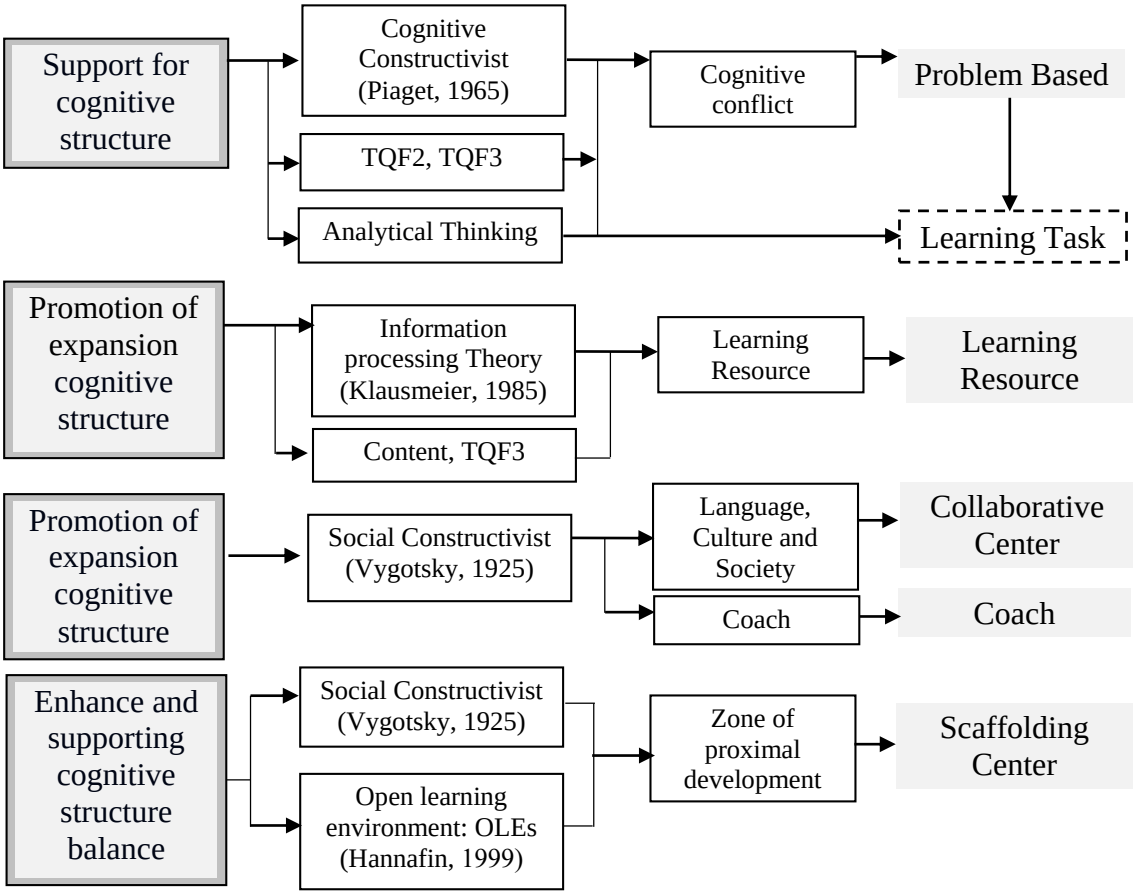

Figure 2. Theoretical framework of the design of web application to enhance knowledge construction and analytical skills in 21st century learning of students in higher education

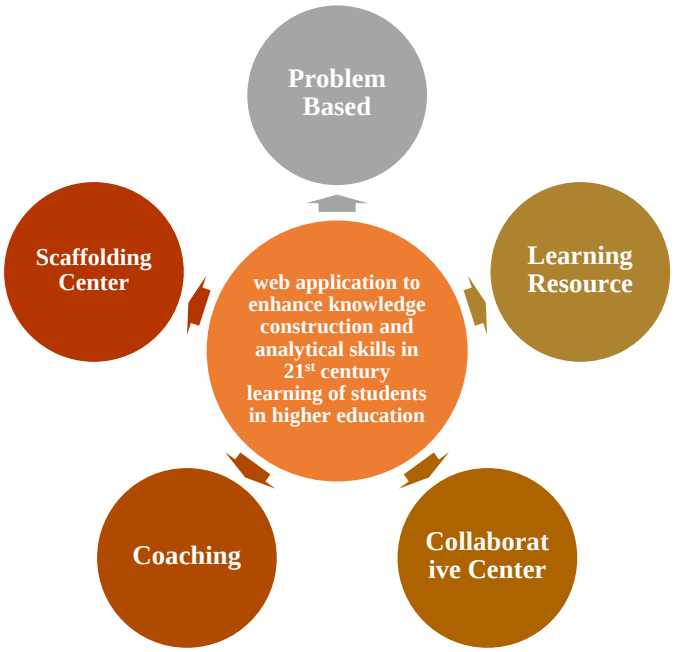

Figure 3. The components of web application to enhance knowledge construction and analytical skills in 21st century learning of students in higher education

2.3 Scaffolding

Scaffolding is one of the key components in intellectual balancing. It is based on Vygotsky's (1925) theory who asserts that cognitive potential may be restricted by what is called the Zone of Proximal Development (ZPD). If the learner's cognitive potential is below ZPD, a scaffolding comes into play. The web application was, therefore, designed to promote scaffolding, which is a strategy in helping learners with the utmost use of their efforts together with open learning environment to solve a problem (Hannafin, 1999). Also, scaffolding places its primary emphasis on divergent thinking. As a result, the researchers designed the web application to provide a scaffolding regarding concept, thinking, process, and strategies as followings. 1) Conceptual Scaffolding were helping students to make concepts and suggestions or hints can help learners to access resources or other learning resources. It is designed to show the link to the relationship of each topic by bringing the content to a critical point, it is structured in a format that allows learners to recognize the key points of the content 2) Meta-cognitive Scaffolding is a supportive foundation that deals with the processes involved in individual learning management and help to guide how to think while they are learning, the way of thinking to solve the problem under what they are studying and consider the possible strategies to solve the problem. It is designed as a guideline that helps to guide you through the way that they think. Students are supervised, monitored, assessed and evaluated on the problem solving of each person. 3) Procedural Scaffolding is a supportive base that guides how resources and tools relate to the system characteristics and the functionality, and 4) Strategic Scaffolding is a supportive base that focuses on alternative approaches that may prove to be useful and support analytical thinking, strategic planning, problem solving strategy during the learning, identify and select the required information, include the assessment of resources provided and link the relationship between knowledge and prior knowledge and the learner's experience. It is designed as a way to analyze students to solve problems in the learning task.

2.4 Center for Collaborative Learning

Center for collaborative learning helps promote cognitive development according to Piaget's (1965) socio-constructivist theory. Learners have the opportunity to collaborate with each other to create a society where members share knowledge and help each other solve problems, exchange ideas, and points of view, and to settle conflicts of understanding. The center for collaborative learning was designed to be a center for learning through social network such as Facebook, line application, and web board. This social network serves as a communication channel between the teacher and learners to share their opinions and suggestions. Teachers observe the learners as they try to complete the task and prepare for the hint and help when they need.

2.5 Coach

Based on Piaget's (1965) social-constructivist theory, the teacher's roles were to analyze learners, communicate and give feedback, provide a learning guideline, encourage learners' cognitive process, and provide guidelines for active operation to complete learning missions. The teacher was set to be an online coach via social network and email. Besides, the learners could make queries to experts at any time they desire.

3. Results of Evaluation of the Web Application

Framework for the evaluation of innovation on the basis of constructivist theory was used in the evaluation of the web application, which was evaluated in the following aspects: product, context, intellectual abilities, learning achievement, and learner's

3.1 Evaluation of Product

Evaluation of the web application showed that its contents in the production planning and control course on the topic of selected research activities for undergraduate students were correct and complete as specified in the course description, and suitable for learners' age group. In terms of media, the web application was rated as being easy to install and having a consistent format regarding the use of fonts and icons. With reference to the design, every component of the web application was evaluated as having efficiency in assisting learners to construct their knowledge and improve their analytical thinking.

3.2 Evaluation of Context

In terms of context of the use of web application, the experts suggested that learners be arranged into groups of 3 people to maximize the opportunities in exchanging their opinions with each other.

3.3 Evaluation of Learner's Cognitive Ability

The Cognitive Ability evaluation used analytical thinking skills test. The study revealed that abilities in analytical thinking of the learners significantly improved after using the web application ($p < .05$).

3.4 Evaluation of Learning Achievement

The results of the pre and post-test showed that learning achievements of the learners in the post-test was significantly higher that the set criteria ($p < .05$).

3.5 Learners' Opinions

The survey indicated that the learners perceived the web application as being suitable for all aspects and agreed that it could help them construct knowledge and improve their analytical thinking skills.

4 Effects of the Web Application on Learners' Knowledge Construction and Analytical Thinking

The results of the study regarding learning achievements, analytical thinking skills, and opinions of the learners are discussed below.

4.1 The study revealed that the learners' average score in the post-test ($\overline{X} = 25.90$, S.D. $= 1.52$) was higher than that of the pre-test ($\overline{X} = 16.36$, S.D. $= 1.01$) at a significance level ($p < .05$).

4.2 The results of the tests on analytical thinking of the learners in the pre- and post-test revealed that the learners achieved a higher average score in the post-test ($\overline{X} = 25.74$, S.D. = 1.43) than in the pre-test ($\overline{X} = 13.31$, S.D. = 1.00) at a significance level ($p < .05$).

4.3 The study on learners' opinions on the use of web application revealed that the learners considered the web application to be suitable with their level of proficiency and provided sufficient examples to help them understand the contents. Furthermore, they agreed that the contents, images, and video clips assisted their learning. Regarding the design, the learners thought that the design, learning missions, and problems in the web application covered the contents of learning, and encouraged the learners to do more research to complete their assigned tasks. Moreover, the web application offered various learning missions which challenged the learners' analytical skills such as synthesis and identifying relationship of information. In terms of media, the learners found that the web application was user friendly and easy to install on their computers and smartphones. However, there was a report on restriction of operating system of the application. The application was compatible with only android system making it a major barrier for IOS users, who were eventually forced to use the application on their PCs only.

Figure 4. Show web application to enhance knowledge construction and analytical skills in 21st century learning of students in higher education

Conclusion and Discussion

The study showed that the web application to enhance knowledge construction and analytical skills in 21st century learning of students in higher education comprised 5 key components, 1) problem base, 2) learning resource, 3) scaffolding, 4) center for collaborative learning, and 5) coach.

The results of the evaluation on various aspects of the application suggested that every component could effectively enhance knowledge construction and analytical thinking skills of the learners. This might be a result of the employment of cognitive constructivist and socio-cognitive constructivist as a foundation of the design of the web application that was aimed to promote knowledge construction incorporated with analytical skills, in which learners were engaged in real practice using their existing experiences.

Furthermore, the web application was designed to challenge the learners to seek new ways to solve the given problems which is a foundation for the transformation of cognitive structure and requires the learning settings to be authentic with relation to learners' contexts. This could optimize learning efficiency, which is consistent with previous studies that employed constructivist theory as a principle of the design and development (Kwangmuang & Chaijaroen, 2016; Tedtun et al, 2017; Jiambunsri et al, 2012). Also, the learners had more opportunities to exchange their ideas of problem solution with other learners, to choose what they wanted to learn and to promote their knowledge construction.

The findings in terms of the effects of the web application on learners' achievements in knowledge construction and analytical thinking skills revealed that the learners had significant improvement in both types of skills. This could be incurred from the application's flexibility that allowed the teachers to modify or update the lessons at any time, while the learners had access to the lessons at any time they wanted too. In addition to the application's flexibility, the learning activities were designed to promote analytical thinking that challenged the learners to synthesize and make connection of obtained information. This is consistent with the previous studies that adapted learner's analytical thinking skills as a foundation of learning management (Multri, 2013; Suksuwan et al., 2017; Lumpkin, 1991; Rosman, 1996; Bergthold, 1999).

Recommendations

1. Recommendations for Further Research

1.1 Learners' satisfaction or comments about learning through web application to enhance knowledge construction and analytical thinking in 21st century learning should be studied.

1.2 Qualitative studies regarding learners' knowledge construction should be carried out to evaluate learners' abilities in constructing knowledge on the basis of principle and theory used in the design of the web application.

2. Recommendation for Implication

The web application developed by the researchers may be used for learning management with consideration of the diversity of learners' contexts, institution, learning contents, and the suitability of media characteristics.

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