

*Full Length Research Paper*

# Development of web-based learning environment model to enhance cognitive skills for undergraduate students in the field of electrical engineering

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Received 19 September, 2015; Accepted 12 October, 2015

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This research aimed to develop a web-based learning environment model for enhancing cognitive skills of undergraduate students in the field of electrical engineering. The research is divided into 4 phases: 1) investigating the current status and requirements of web-based learning environment models. 2) developing a web-based learning environment model. 3) reporting the results of the web-based learning environment model from. 4) validation of a web-based learning environment model and its role in the development of cognitive skills of the students. The results revealed the following: 1) the current status and requirements of a web-based learning environment model revealed that the model can be expressed in aspects of its structure, web-based instruction and web-based instruction for developing cognitive based skills. Its current operating status is at a moderate level, and the user's requirement is at the highest level. 2) The developed web-based learning environment model consists of 4 main elements: principles, objectives, processes and activities, and the measurement and the evaluation of three sub-elements: web-based learning environment, web-based learning and development of cognitive skills. The web-based learning environment consists of 4 elements: introduction to the context, data sources, instruments, and base of help. Web-based learning consists of 3 elements: lessons, communication, and activities. In term of the development of cognitive skills, there are 4 elements: encouragement of cognitive structure, encouragement of cognitive balance, encouragement of the expansion of cognitive structure, and encouragement and support of knowledge construction. 3) The results of model implementation efficiency: The students who studied by using the developed web-based learning environment model received pre-and post-points of – achievement (52.37 and 92.40%). The learning achievement and the cognitive skills increased at the .01 statistical significant level. Learning achievement was related to the cognitive skills at the .01 statistical significant level. The more points students earned on their achievement, the more points they received on their cognitive skills evaluation. The mean value of an overview of all aspects and each individual aspect of undergraduate students' satisfaction towards the model was at a high level. 4) An overview of all aspects and each individual aspect of the quality evaluation model evaluated by the experts was at the highest level. It could be assumed that the web-based learning environment model had its quality at the highest level and persons concerned could used it as a pedagogical tool for undergraduate students.

**Key words:** Web-based learning environment, cognitive skills.

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## INTRODUCTION

In a world with so much technology advancement, cognitive skills are vital because they show how developed humans are. Cognitive skills are also important for living a life in the modern world as the more people with cognitive skills, the more harmonized the society is (Khaemmani et al., 2000). This is because cognitive skills are tools to enhance us all to keep pace with and enable us to solve problems appropriately. Understanding this aspect, scholars have been suggesting that cognitive skills be taught together with academic lessons. Cognitive skills are essential for education because they are something that can be practiced. Regularly solving problems will sharpen your brain, motivate you to view the problems from various perspectives, and the existing knowledge can be applied to tackle new problems. Presently, it is believed that education teaches people how to think. Cognitive skills produce students, the product of education, with quality by teaching them cognitive skills together with academic lessons in class (Mapranit, 1996; Luang, 1992).

Higher education institutes today under the higher education standard have shifted the focus to the desirable qualifications of their graduates. Some of them have established a learning standard that mirrors cognitive skills as one of the desirable qualifications of the graduates. To explain, a graduate needs to have satisfying cognitive skills and be able to integrate, research, analyze, and summarize the problems, and solve them systematically. The students are also expected to utilize the available data to make an effective decision, be imaginative, and flexible to properly apply their knowledge to develop innovations or extend the knowledge beyond their current capacity in a creative manner. More important, it is desirable that they be able to research for new knowledge on their own for the goal of lifelong learning and to keep pace with the ever changing body of knowledge and new technology (The Council of Engineering Deans of Thailand, 2009).

Today, higher education institutes offer a wide range of education systems. Some teach students in the traditional way in classroom while others have introduced more advanced technologies. Education in the engineering field focuses on producing graduates with theoretical and practical knowledge, enabling them to think, analyze, and synthesize systematically, and apply the knowledge appropriately, for further studies and for being brought to the labor market in the industrial sector. The purpose of education to equip people with the skills to live a happy life is highlighting the higher level skills or the task for technology users in a creative way. Such skills require

cognitive skills as the basics. Cognitive skills are important for learning: learners are able to logically apply their knowledge in real situations which are different from those they learned from school. Teachers have the responsibility to develop such skills for learners so that they have the tools for living a good life in the society. A person, who lacks cognitive skills, facing problems or challenges, will not be able to choose an appropriate solution. In contrast, those with cognitive skills will not be easily fooled and can solve problems better.

The solutions in the references indicated that “environment” plays an important role in learning and development of cognitive skills. Hannafin et al. (1999) presented the principles for designing a learning environment called Open Learning Environment: OLEs, with the focus on enhancing and developing divergent thinking, depends on each individual to give definition, set the intention to learn, specify the learning purpose, and create the learning activity. All these have to go in line with the design principles with student-centered learning where the ideas of each individual will be used to explain, define the meanings, and understand a situation. Students will learn from the actual contexts and their own interest using their own knowledge and experience to solve problems (Chaicharoen, 2003)

As mentioned above, it is seen that the cognitive skills development process is vital for improving, solving, and initiating the progress in all types of work and professions, as well as a living of everyone in the society. Academic institutes produce graduates to satisfy the needs of society and community. Electrical engineering is one of the most popular fields for continuing education after a vocational degree. It has been observed that the majority of applicants each year choose to study in electrical engineering. This may be because the students expect that after graduation, the degree in this field will earn them a good salary. To learn well in electrical engineering, the students should be knowledgeable and possess the desirable graduate qualifications as defined by the standard. The philosophy of electrical engineering says “aim to produce graduates who have both theoretical and practical knowledge, ability to analyze and synthesize, plan systematically, and ability to apply the knowledge appropriately.” Therefore, in order to produce the quality graduates as defined in the desirable qualifications of graduates, expected learning standard, and qualification framework of higher education in term of knowledge, it is necessary to provide a wider range of instruction, learning environment, and teaching methods that facilitates learning. Students are also expected to

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have the ability to do research, understand, and be able to process the data, experiment on new concepts and proofs from an extensive database, and apply the conclusions to solve many different problems and arguments without guidance from outside. They should be able to understand the complicated problems and suggest new and creative solutions considering relevant theoretical knowledge, practical experience, and the consequences of the decision made. The graduates should also be able to apply their skills and in-depth understandings in the academic field and professions related to their specialty.

They are expected to use the regular working process appropriately and identify the situations that require innovative solutions by also applying theoretical and practical knowledge to tackle the problems. Therefore, it is important that everyone involved plays a part in this development.

The researcher, as education personnel, realizes the importance of this and is interested in developing a model for web-based learning environment to develop cognitive skills for students in electrical engineering by using the network technology as the media to transfer the suggestions, workshop, and lesson content according to the cognitive skills development.

This will be used as a guideline for the learning process that focuses on students' learning lessons together with developing their cognitive skills, fundamentals of technology which will allow them to learn by themselves and transfer knowledge and experience in solving problems effectively. It is considered that students of this age are able to use the experiment tools and the research results will be used as the guideline for promoting and developing other abilities which will be useful for teaching in other fields of studies in higher education in the future.

### Research objectives

This research aimed to,

1. investigate the current contexts and demand for a web-based learning environment to enhance cognitive skills for electrical engineering students
2. develop the web-based learning environment to enhance cognitive skills for electrical engineering students
3. investigate the result of using the web-based learning environment to enhance cognitive skills for electrical engineering students
4. confirm the web-based learning environment to enhance cognitive skills for electrical engineering students

### METHODOLOGY

This research was meant for developing the web-based learning

environment to enhance cognitive skills for electrical engineering students. The research was divided into 4 phases of the research and development method as follows.

#### Phase 1: investigate the current contexts and demand for a web-based learning environment to enhance cognitive skills for electrical engineering students

Review literatures including related documents, books, research, frameworks, and theories such as 1) Open Learning Environments: OLEs, 2) Constructivist Learning Environments: CLEs, and 3) Situated Learning Environments: SLEs

Investigate the current implementation and the demand for web-based learning environment model to enhance cognitive skills from related parties. The possible research questions were administered on two sample groups from the Faculty of Engineering, Public University in the north-east of Thailand: lecturers (n=65) and students (n=180). The sampling was selected by fifty percent technique, including 33 lecturers and 90 students (123 persons in total).

#### Research tools

##### Document synthesis

The questionnaire consists of 2 phases: 1) the current implementation context with reliability of 0.825, discrimination index between .251 - .759, 2); the demand for the model for a web-based learning environment with reliability of 0.845, discrimination index between .442 - .745.

##### Data collection and analysis

All related documents, books, and research to form the model for a web-based learning environment to enhance cognitive skills for electrical engineering students were synthesized. To do this, the researcher used the synthetic record in the form of content analysis.

The current context and the demand for the web-based learning environment were surveyed. The researcher used a questionnaire created and qualified to collect the data from the sample group, analyze the data using basic statistics (such as average, percentage, and standard deviation).

#### Phase 2: develop the web-based learning environment to enhance cognitive skills for electrical engineering students

The web-based learning environment to enhance cognitive skills for electrical engineering students was developed. It started with the interviews of 9 experts to determine the elements of the model, including 3 educational technology and communication experts, 3 electrical engineering curriculum experts, and 3 teaching experts. The pilot model of the web-based learning environment to enhance cognitive skills for electrical engineering students was developed. The pilot model of the web-based learning environment to enhance cognitive skills for electrical engineering was evaluated by 5 qualified experts, including the qualifications with the minimum academic rank of associate professor and expert in educational technology and communication.

The web-based learning environment according to the principle, objectives, elements, procedure, and activity was developed. After that, the web-based learning environment was evaluated by the 9 experts before the experimental use with 30 electrical engineering students. The 30 sample students were chosen with simple random sampling from top, average, and bottom groups, 10 in each group, to find the effectiveness of the lesson from the criteria of 80/80.

### Research tools

1. Interviews consisted of 6 topics: 1) infrastructure, 2) enabling contexts, 3) resources, 4) tools, 5) scaffolding, and 6) other suggestions
2. Pilot model evaluation form consisted of 1) related theories, 2) principles, 3) elements, 4) procedures, 5) web-based class activities, and 6) assessment.
3. Web-based learning environment/web-based lesson consisted of media content on the web and web-based learning environment
4. Cognitive skills evaluation form according to higher education's qualification standard in engineering consisted of 1) ability to think with cognitive skills, 2) ability to compile, research, analyze, and summarize the problems, 3) ability to think, analyze, and solve engineering issues, 4) imaginativeness and flexibility to apply knowledge, and 5) ability to research for data and additional knowledge
5. Learning achievement evaluation form consisted of difficulty index (P) between 0.20 – 0.80 and discrimination index of at least 0.20.

### Data collection and analysis

Experts were interviewed. The data derived from the interviews were used to design the pilot model of the web-based learning environment to enhance cognitive skills for electrical engineering students

The model of web-based learning environment to enhance cognitive skills for engineering students was evaluated by experts. Acceptable average of each item was above 3.51.

Suitability of web-based learning environment/web-based lesson was evaluated by expert in 3 different fields (electrical engineering, web-based media, and web-based learning environment) and the data were analyzed with basic statistics (average and standard deviation).

Field trial was conducted with 30 electrical engineering students. The 30 sample students were chosen with simple random sampling from top, average, and bottom groups, 10 in each group. After completing the lesson, the students were asked to respond to the survey and give comments and suggestion for improvement to actual use.

The web-based learning environment was analyzed for its quality according to  $E_1/E_2$  and 80/80 criteria.

### Phase 3: investigate the result of using the web-based learning environment to enhance cognitive skills for electrical engineering students

The developed web-based learning environment to enhance cognitive skills for electrical engineering students was used in the trial mode. The environment was developed according to the principles, objectives, elements, procedure, and activity of the web-based learning environment model. Researcher administered the

**Table 1.** The actual field trial period.

Week	Lesson
1	Pretest
2-4	Unit1
5-7	Unit2
8-11	Unit3
12-16	Unit4
17	Posttest

model on the sample size by purposive sample of 30 students majoring in electrical engineering, Faculty of Engineering, Mahasarakham University, who registered in the course 0307303 Supply and Distribution of Electric Power in the first semester, academic year 2013. The researcher employed the research design called "one group pretest–posttest".

### Research tools

1. Web-based learning environment/web-based lesson
2. Cognitive skill evaluation form
3. Academic achievement evaluation form
4. Students' satisfaction questionnaire

### Data collection and analysis

Pretest was conducted by using the academic achievement form after the students had understood the instructions from the researcher. All students in the sample groups responded to the academic achievement evaluation form and cognitive skills evaluation form.

The web-based learning environment/web-based lesson was used in the field trial mode. The web-based lesson was developed according to the principles, objectives, element, procedures, and activities of the web-based learning environment model. It was used with undergraduate students majoring in Electrical Engineering at the Faculty of Engineering, Mahasarakham University for 15 weeks, from June to September 2013 (Table 1).

Posttest was conducted by using the same academic achievement form and cognitive skills evaluation form as the pretest. The results of posttest were compared with the pretest, both in term of academic achievement and cognitive skills.

The relationship between the post-lesson academic achievement and post-lesson cognitive skills of the students was analyzed.

Student's satisfaction after learning all units was surveyed and analyzed to find their satisfaction with the web-based learning environment.

### Phase 4: confirm the web-based learning environment to enhance cognitive skills for electrical engineering students

The 5 experts were asked to confirm the web-based learning environment model with reference to the data from the field trial.

### Research tools

1. The model of the web-based learning environment to enhance

cognitive skills for electrical engineering students

2. The evaluation form to confirm the model of the web-based learning environment to enhance cognitive skills for electrical engineering students.

#### Data collection and analysis

The manuals of the model of web-based learning environment to enhance cognitive skills for electrical engineering students were distributed to 5 experts.

The data in the evaluation form received as the feedback were collected and checked thoroughly before analyzing with basic statistics (average and standard deviation).

## RESULTS

The investigation of the current contexts and demand for a web-based learning environment to enhance cognitive skills for electrical engineering students revealed that the structure, web-based learning, and web-based learning to enhance cognitive skills were implemented at the intermediate level ( $\bar{x}$  = 2.56-3.50) and the demand was high ( $\bar{x}$  = 3.51-4.50).

The model of the web-based learning environment to enhance cognitive skills for electrical engineering students derived from this development consisted of 4 major elements: 1) principles, 2) objectives, 3) procedures/activities, and 4) evaluation. There were also 3 minor elements. The first minor element was a web-based learning environment which consisted of 4 sub-elements: introduction to context, source of data, tools, and help base. The second minor element was web-based learning which consisted of 3 sub-elements: lesson, communication, and activities. The third minor element was the development of cognitive skills, which consisted of 4 sub-elements: motivation of cognitive structure, promotion of cognitive balance, promotion of cognitive structure expansion, and promotion and support in knowledge creation. The model can be summarized as in Figure 1.

Investigation of the results of using the web-based learning environment to enhance cognitive skills for electrical engineering students revealed that,

1. students learning with the web-based learning environment model had an academic pretest score of 52.37 percent and posttest of 92.40 percent, indicating that their academic achievements increased with the significance level of .01
2. students learning with the web-based learning environment model had the pretest cognitive skills of 28.26 percent and posttest of 56.60 percent, indicating that their cognitive skills were developed with the significance level of .01.
3. academic achievements had a relationship with cognitive skills with the significance level of 0.01.

4 students were satisfied with the web-based learning environment model, by overall and by single item at the high level ( $\bar{x}$  = 4.05 - 4.23).

The experts evaluated the quality of the web-based learning environment model by the overall and by single item to be the highest ( $\bar{x}$  = 4.63 S.D. = 0.80) and it can be concluded that the model of the web-based learning environment to enhance cognitive skills for electrical engineering students was the most suitable and could be used for teaching students effectively.

## DISCUSSION

The findings of the research on development of the model of web-based learning environment to enhance cognitive skills for electrical engineering students worth discussing are as follows.

The model of the web-based learning environment to enhance cognitive skills for electrical engineering students consisted of 4 major elements: 1) principles, 2) objectives, 3) procedures and activities, 4) evaluation. This agreed with the concept of model development by Thitsana Khaemmani (2000), Khacha kritLiamthaisong (2011), Anderson (1999), Arends (2001), and Joyce and Weil (2004). There were also 3 minor elements. The first minor element was a web-based learning environment which consisted of 4 sub-elements: introduction to context, source of data, tools, and help base. This agreed with the explanation of Thongdiloet (2004), Buaphan (2004), Chaicharoen (2007), and Hannafin et al. (1999). The second minor element was web-based learning which consisted of 3 sub-elements: lesson, communication, and activities. This agreed with the discussion of Rueangsuwan (2011), Malithong (2000), Na Songkhla (1999), Rattanaphian (1999) and Campese and Campese (1998). The third minor element was the development of cognitive skills, which consisted of 4 sub-elements: motivation of cognitive structure, promotion of cognitive balance, promotion of cognitive structure expansion, and promotion and support in knowledge creation. This agreed with Chaicharoen (2007).

The web-based environment was of very high quality. The developed environment was effective with the score of 81.40/82.35, higher than the defined standard of 80/80. The effectiveness index was 0.8725, indicating that students learning in the web-based learning environment had more academic achievements by 87.25 percent. This may be because the researcher designed the web-based learning environment exactly as the design principle, considering the best benefit of learners. The researcher developed the web-based learning environment systematically. The outcome learning environment was

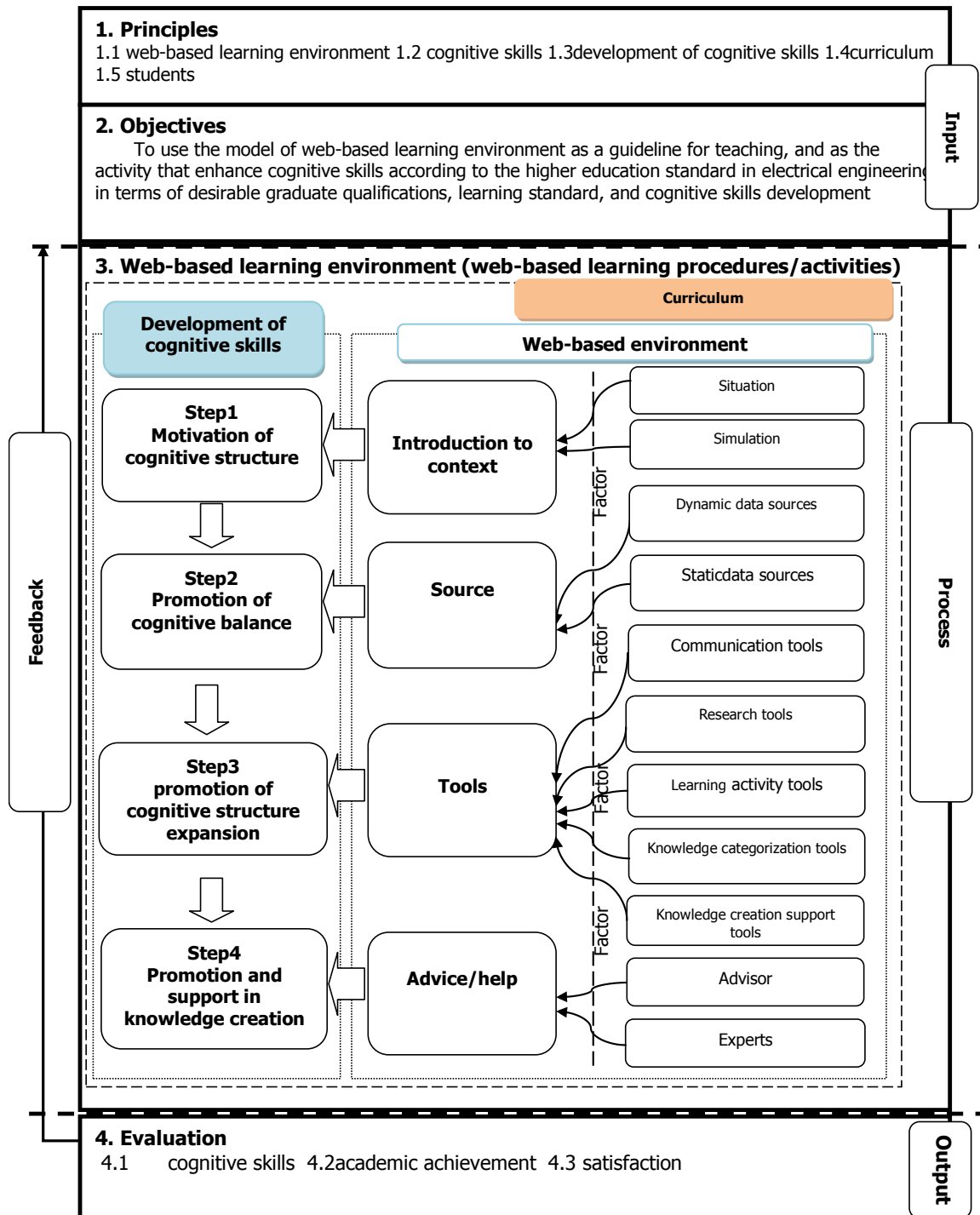


Figure 1. The model of web-based learning environment to enhance cognitive skills for electrical engineering students.

used through the learning management system (LMS), which has been accepted and applied widely for web-

based learning and evaluated by experts in content, web media, and web-based learning environment design. The

overall quality was very good. According to the study on the field trial with students, the advantages were as follows:

Students had more cognitive skills evaluation scores after learning than before learning with the significance level of .01. The research result suggested that the developed model of web-based learning environment contributed to higher cognitive skills development and student's academic achievement had a positive relationship with cognitive skills with the significance level of .01. That is to say, when students learned in the web-based learning environment, their academic achievements increased, making their cognitive skills develop better as a result. This findings agreed with Charuni (2009), who conducted research on the development of a model of web-based learning according to the constructivist theory that promotes creative thinking among undergraduate students. Charuni's study revealed that creative thinking had a positive relationship with students' academic achievement, as in the second and third phases of the study the correlation coefficients were 0.71 and 0.74 respectively. The results also accorded with Suchat (2010) who investigated the development of the model of web-based learning environment according to the constructivist theory that promotes problem solving and knowledge transferring. Suchat's research revealed that problem solving had a positive relationship with students' academic achievements as in the second and third phases of the study the correlation coefficients were 0.81 and 0.70 respectively.

The students had higher academic achievements after learning than before learning with the significance level of .01. The findings indicated that the developed model of a web-based learning environment contributed to higher academic achievements, which agreed with Itsara Kanchak (2004) who conducted a study on web-based learning environment developed according to the theory of constructivism: open learning environment: OLEs. Itsara found that academic achievements of students learning in the web-based developed with constructivist theory was higher than before learning.

Student's academic achievements and cognitive skills after learning in the web-based environment showed a relationship with the significance level of .01. That is to say, when academic achievements increased, cognitive skills developed accordingly. The outcome also agreed with Charuni (2009) who conducted research on the development of a model of web-based learning according to the constructivist theory that promotes creative thinking among undergraduate students. Charuni's study revealed that creative thinking had a positive relationship with students' academic achievement, as in the second and third phases of the study the correlation coefficients were 0.71 and 0.74 respectively. The results also accorded with Suchat (2010) who investigated the development of

the model of a web-based learning environment according to the constructivist theory that promotes problem solving and learning connection. Suchat's research revealed that problem solving had a positive relationship with students' academic achievements as in the second and third phases of the study the correlation coefficients were 0.81 and 0.70 respectively.

The students were satisfied with the web-based learning environment to enhance cognitive skills for electrical engineering both by overall and by single item at high level ( $\bar{x} = 4.13$  S.D. = 0.76). This may be because the web-based learning environment allows students to learn and review the lessons online at any time, do activities, and ask questions. This agreed with Charuni (2009) who conducted research on the development of a model of web-based learning according to the constructivist theory that promotes creative thinking of undergraduate students. Charuni found that students thought the lesson content, network media, and the design were suitable and could promote students' ability to learn and creativity. This research was also in accordance with Suchat (2010) who investigated the development of the model of web-based learning environment according to the constructivist theory that promotes problem solving and learning connection. Suchat's research revealed that students thought the lesson content, network media, and the design were suitable and could promote students' ability to learn, solve problems, and transfer knowledge better.

## Suggestion

### General suggestion

Management, lecturers, as well as related personnel should emphasize on student development in cognitive skills together with academic lessons. Cognitive skills are considered the important part of education because they are trainable and beneficial in solving problems by looking at them from many different perspectives. Moreover, the old knowledge can be applied to solve new problems in the future.

### Suggestions for further research

Web-based learning environment should be developed to support new technologies such as tablets and mobile phone. Since the 21<sup>st</sup> century is the age of IT and communication, students should be able to use technologies tools for learning at their maximum potential and efficiency.

The model of a web-based learning environment to enhance cognitive skills for electrical engineering students

should be applied with other universities such as those in the northern and central regions, including private universities. In addition, other models should also be improved to satisfy the need of language development in preparation for AEC during which web-based learning will be an important tool that will minimize the gap in face-to-face communication.

### Conflict of Interests

The authors have not declared any conflicts of interest.

### ACKNOWLEDGEMENT

The authors thank Mahasarakham University for financial support.

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