วารสารศึกษาศาสตร์ มหาวิทยาลัยขอนแก่น ปีที่ 43 ฉบับที่ 4 (เดือน ตุลาคม – ธันวาคม 2563) หน้า 1-16
Journal of Education Khon Kaen University, Volume 43 No. 4 (October – December 2020) Page 1-16
บทความวิจัย (Research Article)

วารสารศึกษาศาสตร์ มหาวิทยาลัยขอนแก่น
https://www.tci-thaijo.org/index.php/edkkuj
ดำเนินการวารสารโดย คณะศึกษาศาสตร์ มหาวิทยาลัยขอนแก่น

The Validation of Online Learning Environments for Enhancing Mental Model of Programming

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Received: November 30, 2020 Revised: December 4, 2020 Accepted: December 4, 2020

Abstract

This research proposes to validate Online Learning Environments Model. The research design is model research Phase II about Model validation composed of internal validation and external validation. The results are collected both in quantitative and qualitative data. The data are analyzed and summarized by synthesizing the protocol, interpretating summaries and descriptive statistics. The outcomes of the study proved that 1) the model has internal validity in the learning contents, the media, and the design of the model. The model holds all seven components whose quality is consistent with the synthesis of a theoretical framework and conceptual framework for designing and developing the online learning environments model. 2) the external validity of this model is confirmed by the impact of the learning paradigm on students. The Mental Model of Programming shows that the students were able to create knowledge representation and understanding the programming. Students who learned with Online Learning Environments Model had the post-test average scores of 24.9 (S.D. = 0.99) or 83.0 % which is higher than the criteria of 70 per cent. The students' opinion towards Online Learning Environments Model showed that the learning contents, the media, and the design are suitable and supported to enhance the Mental Model of Programming.

Keywords: Mental Model, Programming, Learning Environments, Pedagogy, Constructivist

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Introduction

Nowadays, the world is changing and changing fast. One of the most considerable changes that have affected everyday life is technology. The other change which is resulted from technology is in the fields of education. Technology has created fantastic innovation and resources in education, improving the pattern of teaching and learning. There are many factors affecting learning and teaching management, such as school activities, transportation, safety, environment, and academic competitions, especially on the internet, which is growing by leaps and bounds. This benefit of technology is useful to apply in education. Therefore, online learning is developed to improve the quality of education. The development of digital technology influenced learning behavior of people. Many academic institutions have modified teaching methods which focus on authentic context to promote learning. This teaching method has the integration of different disciplines. Learners are searching for flexible learning styles and innovations to respond to the needs of learners quickly and appropriately. In the 21st century, the knowledge of the world developed and became a dynamic evolution of knowledge. Digital technology is a tool of the era that allows people to access knowledge, other experiences, and practices on the network instantly. The necessary learning outcomes of learners in this century consist of thinking skills, cognitive skills, digital literacy, technology skills, and modern life-career skills (Ministry of Education, 1999).

Education in the digital era is not only preparing and educating, but also improving the learner's moral values. This concept can describe as, besides giving knowledge, the learners should have morality and be able to live with others as well. The skills comprise analytical thinking and learning dispositions that have been placed as being required for success in 21st century society and workplaces. Therefore, education reform is needed in Thai learners, especially in curriculum and instruction. Currently, the Ministry of Education is updating the curriculum to be used in the academic year 2018, from previously studying eight subject groups to learn in some subjected as same as the past. The curriculum's content will depend on the knowledge in the modern world, focusing and deep on the essential topics. This situation may affect to create new subjects such as Computing which will be learning about programs which are controlling the operation of machinery. These subjects will enhance the learners' ability to innovate, keep up with technology, and increase the knowledge of engineering and new science. Finally, the learners can apply this knowledge to establish innovation in the age of Creative and Innovation technology, focusing on creating Thai students can think by themselves.

From the literature reviews, the principle of online learning environments designing is focusing on learners. The learners create the knowledge by themselves from the environment which set up from the instructor. The principle of constructivist learning environments presents the learning content that is comprehensive and sufficient to solve problems. This content presentation has the order in a sequence and summarizing it into the essences. This principle helps design the structure of learning environments on the network which is easily accessed to resources. Accordingly, the attribution of constructivist learning environments enhances learners to create knowledge representatives as a mental model (Mayer, 1989).

วารสารศึกษาศาสตร์ มหาวิทยาลัยขอนแก่น, 43(4), 1-16
doi: 10.14456/edkkuj.2020.x

The mental model defines the simple representation of knowledge created by learners during studying in the content. The model can be presented in an image or sign that supports the learners' understanding. The learners create the mental model from the interaction between their experience and new knowledge from various resources (Chaijaroen, 2014). The characteristics of constructivist learning environments help create knowledge and enhance the mental model of learners. The mental model and programming from various problem bases in Subject 237216 Constructivism is used to integrate with technology and innovation or media to enhance the efficacy of learning and give students the skills to create knowledge.

The problems of learning and teaching Computer science in many schools are inadequacy of the computer teacher who own expertise level of knowledge in the field or complete pure major in computer science requirements. Secondly, the topics in the subject are not standardized because the content is set depending on the competition program trend. Thirdly, students did not learn programming throughout the curriculum in some schools. Fourthly, due to the Ministry of Education's announcement, Computing science, which focuses on programming, is included in Basis Education Core Curriculum 2008 (Revision 2017) in every school. Thus, the researcher is interested in using online learning environments to develop the instructional model. The online learning environments focus on developing students' ideas and collaboration, which is designed by using three theories e.g. Philosophy of Education (epistemology and social constructivism), Educational Psychology (behavioral, cognitive, social-psychological, and non-cognitive) and Educational Technology. The expectation that the use of online learning environments for programming will affect the cognitive process of learners related to learning in the digital age and 21st century skill.

For these reasons, the researcher is aware of the importance and need to develop the Online Learning Environments for Enhancing the Mental Model of Programming using the Theoretical framework. The information about many theories and previous studies of programming and mental model is applied to design and develop the online learning environments. This media focuses on the learners to study the content with programming, mainly in the cognitive process. The outcomes from this study lead to the development of the learners' quality of programming and continuous self-development at every stage in life (Jonassen, 1999).

■ Literature Review

Constructivism

Constructivism believes that learning is a process of building rather than acquiring knowledge, so learning changes the teaching and learning process in which the learner has to work with knowledge, not just receiving knowledge The teaching process has to change the concept from the teacher to the teaching and learning process. Become a learner and create knowledge from the learner himself. Therefore, at present, there is a paradigm shift from emphasizing "teaching" to "learning" that is most important to learners. Manage education in the era of education reform at present Which educators have given ideas about constructivist theory (Samat and Chaijaroen, 2016).

Constructivist learning environments

Viewing constructivism as a different perspective from objectivism on the learning process and a complementary learning tool with objectivism, Jonassen (1999) proposed a model for designing constructivist learning environments. Since the epistemological belief of the constructivism that knowledge can not be transmitted, the design puts the emphasis on providing learning experiences that facilitate knowledge construction and in meaning making.

1. Jonassesn (1999) described that the essential components in the constructivist learning environments include: Problem, question or project as the focus of the environment: the focus on problem, question or project constitutes a learning goal driving the learning process. The desired quality of this driving power is to be interesting, relevant, and authentic. Three major components need to be included in the design of the problem:

1.1 The problem context: a description of the physical, organization, and sociocultural context in which the problem occur should be represented to the learners.

1.2 The problem representation or simulation: the principle of representing the problem is to make the representation interesting, appealing and engaging. The representation of the problem needs to be authentic to "present the same types of cognitive challenges as those in the real world," as well as to be interesting and relevant to the learners so that they can engage in solving the problems.

1.3 The problem manipulation space: meaningful learning needs to be a mindful activity, in which the learners are provided opportunities to manipulate objects and interact with the environment. The problem manipulation spaces exactly provide such opportunities. They can be the causal models for students to test the effects of the manipulation by receiving feedback in the changes of the physical objects or the simulation, or they can be the students' argumentation to support their solutions to problems.

2. Related Cases: Representing a set of related experience, the related cases support learning by scaffolding student memory; providing different perspectives, themes and interpretations, the related cases conveys the complexity of the problem and enhance student cognitive flexibility.

3. Information Resources: CLEs have to provide just-in-time information to help learners comprehend and solve the problem.

4. Cognitive Tools: Cognitive tools are computer tools that help "visualize (represent), organize, automate, or supplant thinking skills." There are four major types of tools differing in their functions:

4.1 Problem/Task Representation Tools: they help learners to visualize and construct the mental model about how the objects behave and interact.

4.2 Static and dynamic Knowledge Modeling Tools: the tools help the learners' to make their understanding of the problem explicit. The questions of "what do I know" and "what does it mean" are the center of the inquiry.

4.3 Performance Support Tools: the tools share the cognitive loads to perform routine tasks, such as calculation and memorization.

4.4 Information Gathering Tools: Information searching tools can be provided to eliminate the distraction and help the students to focus on problem solving.

วารสารศึกษาศาสตร์ มหาวิทยาลัยขอนแก่น, 43(4), 1-16
doi: 10.14456/edkkuj.2020.x

4.5 Conversation and Collaborative Tools: social negotiation and interaction are part of the learning process. Learning can facilitated through support of discourse community, knowledge-building community and communities of learners.

4.6 Social/Contextual Support: the implementation of the design of any learning environment has to accommodate contextual factors to get support for its success**.**

In the constructivist learning environments, learners are encouraged to engage exploration, articulation and reflection; instructors are encouraged to provide instructional support in:

- Modeling, which focuses on the expert's performance (how to do it): including modeling the performance and the thinking processes, i.e. behavioral and cognitive modeling.
- Coaching, which focuses on the learner's performance (how am I doing): to motivational prompts, monitor and regulate the learner's performance, provoke reflection, and perturb learners' models.
- Scaffolding, which is a systemic approach to supporting the learners in different aspects of the learning environment (the tasks, the teacher, the learner, the materials, the tools): based on learner's level of understanding and need, adjust task difficulty, restructure the task and provide alternative assessments.

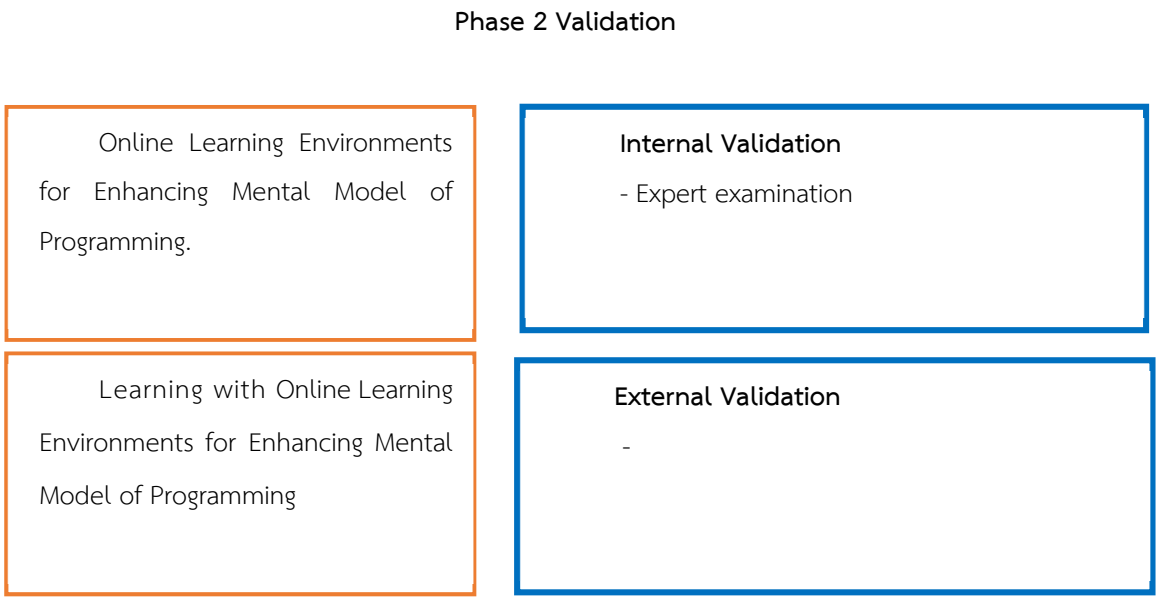
Model of Online Learning Environments for Enhancing Mental Model of Programming

Referring to the model of learning environment design based on the theoretical principles (ID Theory) (Chaijaroen, 2014) of the learning environment model which obtained from the synthesis of principles the main theories comprise of the foundations of cognitive psychology and constructivist theory. Cognitivism Fundamentals of Pedagogy Problem Solving Fundamentals Basics of mental modeling for programming and Fundamentals of Media Theory and Technology and Context Fundamentals including features and symbolic systems of the media synthesize a model of the learning environment which consists of various elements are as follows 1) Problem base 2) Resources 3) Cognitive Tools 4) Collaboration 5) Mental model of Programming Labs 6) Scaffolding 7) Coaching.

The Research Design of Model Research Phase II

Model validation composed of internal validation and external validation. The model component of internal validation was examined by experts while the external validation was utilized by studying the impact of Online learning environments model from Phase I to the targeted group in similar context to confirm the quality of the model. The both of the results were collected quantitatively and qualitatively (Richey, Klein, 2007)

Conceptual Framework



■ Research Methodology

The research design of this study was based on model research Phase II: model validation. The developed Online Learning Environments Model in Phase I was evaluated in a particular context which was similar to targeted group to confirm the quality of the model.

Participants

1. The target group for the internal validation consisted of 2 content experts, 2 model design experts and 2 media experts. The number of each expert was calculated based on the principle of model research Phase II (Richey, Klein, 2007)

2. The target group for the external validation was 30 students who were studying in the Demonstration School of Khon Kaen University (Modindaeng), Thailand. The students were specifically selected from grade 9 in the first semester of the academic year 2019. The selection of students for external validation was purposive sampling which had no significant differences between students' proficiency.

วารสารศึกษาศาสตร์ มหาวิทยาลัยขอนแก่น, 43(4), 1-16
doi: 10.14456/edkkuj.2020.x

Research design

The research design of internal validation was survey research while the pre-experimental design with one-shot case study was used to examine the external validation. The diagram of pre-experimental design is as follow:

X O

When X is the learning management by Online Learning Environments Model

O is external validation from protocol analysis. Follow as: Mental Model of Programming, learners' achievement, and learners' opinions.

Research Instruments

1. The instruments which were used in the study was Online Learning Environments Model. The process of design and development included 1) studying the principles and theoretical of mental model, programming, and knowledge construction. 2) studying learning management system of learner, teacher, and curriculum. 3) synthesizing of theoretical framework which comprised of included psychology of learning, context, technology, programming, pedagogy, and mental model by using the principles and theoretical and context. 4) synthesizing the designing framework by using theoretical framework 5) synthesizing the component of the Online Learning Environments Model which were problem base, resource, scaffolding, mental model programming labs, cognitive tool, collaboration, and coaching from designing framework 6) designing and developing the model extracted from the previous data and 7) evaluating the efficacy of the model from contexts, media and model designing.

2. Data collection instruments included the followings:

2.1 Internal validation: data were collected from the experts interview to evaluate the quality of content, media and model designing. The interview combined interview questions and research questions in accordance with contexts, media and model designing from experts of measurement and assessment.

2.2 External validation were 1) the interview of the Mental Model Of Programming, which was a semi-structured interview based on Mayer's basic model (Mayer, 1989). This interview was purposively used to investigate learners' mental model after studying in Online Learning Environments Model 2) achievement tests were four subjective tests about basic computer programming. Guidelines for grading each test were established by specifying a scoring rubric which described overall quality of programming. The guideline reflected the examination of the consistency of the core education curriculum's questions and indicators of the core education curriculum. 3) open-ended questions survey of learners' opinions consisted of three main points: content, media, model designing as well as specifying reasons for various issues. All tests and interviews in external validation combined interview questions and research questions in accordance with contexts, media and model designing from experts of measurement and assessment.

Data collection

1. The data was collected to verify internal validation by inspecting the quality of the model. The Online Learning Environment Model was evaluated by using the survey from the experts in 3 fields which were content, media, and model designing. The results of the study showed that the quality of seven components were qualified according to the quality of the synthesis of the theoretical framework and the framework of the basis for the design and development of the learning environment model on the network as shown in Table 1:

Table 1

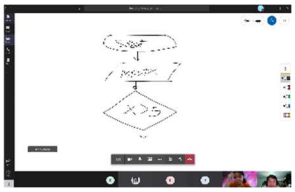
The data was collected to verify internal validation.

List assessment	Expert incorrected	Expert uncorrected	Comment
Problem base	Yes	No	In situation, Real world
Resources	Yes	No	Illustrator
Cognitive Tools	Yes	No	-
Collaboration	Yes	No	-
Mental model of Programming Labs	Yes	No	-
Scaffolding	Yes	No	-
Coaching	Yes	No	-
Content	Yes	No	-
Media	Yes	No	-

2. The data was collected to verify external validation using the Online Learning Environments Model on the network as a tool in this study. The model which was modified from Phase I were utilized in lesson which learners studied by using the Online Learning Environments Model on the network as a tool to study the mental model of programming. The learning achievement and students' opinions from the model were also examined in this part. The process of the study could be described as shown in Table 2:

วารสารศึกษาศาสตร์ มหาวิทยาลัยขอนแก่น, 43(4), 1-16
doi: 10.14456/edkkuj.2020.x

The process of data collection on Phase II

Online Learning Environments	Learning Process	Activities
Online Self Learning	- Learning process though Online Learning Environments by themselves. - Live teachers teach online via Microsoft Team. - Students perform tasks in groups of 3 people in accordance with the learning situation on the Online Learning Environments. - Teachers, coaches via Microsoft Team and answers questions via inbox Facebook.	- Learning by themselves - Discussing in group  -
Online in Class	- Students practice coding the programs in the computer Labs. - Presenting a critical example of the mission submitted in the Online Learning Environments. - Reflection + Summary.	- Reflection - Present - Coding 
Online Post Class	- Teachers follow the online summary. - Students review knowledge. - Students reflect knowledge by sharing their mission in the Online Learning Environments.	-Reflect & Share. 

According to Table 2, In the learning management model, it is divided into 3 steps. Based on the principles of Flipped Classroom (Kanjug, 2017). Steps 1 was Online Self Learning which emphasizes on the learners' self-learning from the mission in Online Learning Environments. Learners will be motivated to solve problems. And create knowledge by themselves. Step 2 was Online in Class Used Online Face to Face instructions with Microsoft Team. In teaching and learning, mosquito nets emphasize on self-learning results from Online Self Learning. And the last step was Online Post Class After finishing both activities. The students will study their understanding of attributes as well as train their thinking and sharing in Online Learning Environments. Therefore, students review and create a deeper understanding.

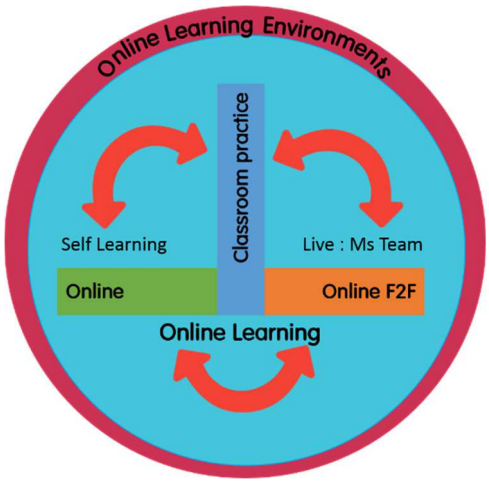


Figure 1 Learning with online learning environments model

The process of learning with Online Learning Environments Model was shown in Figure 1. The student priory studied by themselves through the Online Learning Environments Model before going to the class. Then the students and teacher perform the activity in the class together in the group activity where students were separated into various groups. Each group has three students who practice coding, join discussion and summarize the activity which they learned together. After the activity, the teacher and student summarized and shared the knowledge which the students have learned independently with the Online Learning Environments Model using the Microsoft team.

Data Analysis

1. Internal validation are qualitatively analyzed by using the analytic descriptive and summarization which was collected from experts in three fields: content, media, and model design.

2. External validation of model utilization was examined as following:

2.1 Mental Model of Programming was analyzed by using qualitative data analysis methods. The protocol analysis derived from the interview data which was applied from the framework of Mayer's model (Mayer, 1989).

2.2 The learning achievement was analyzed by using a descriptive statistic e.g. percent, average ($\bar{X}$) and standard deviation (S.D.)

2.3 The student's opinion about Online Learning Environments Model was analyzed by using the summarization and descriptive analysis.

วารสารศึกษาศาสตร์ มหาวิทยาลัยขอนแก่น, 43(4), 1-16
doi: 10.14456/edkkuj.2020.x

Table 3

Show the research validate on Phase II.

Objective	Instruments	Target group	Data analysis
1) To study the results of an expert's assessment of the quality of the internal reliability of various components of the environmental model.	- Online Learning Environments. - Assessment from the Learning Environments Model.	Experts of measurement and assessment. - Ex. experts of design, and experts of media	Analytic descriptive and summarization which was collected from experts
2) To study the Learner's Mental Model of Programming.	- Online Learning Environments - the interview of the Mental Model Of Programming, which was a semi-structured interview based on Mayer's basic model (Mayer, 1989).	The 30 students who were studying in the Demonstration School of Khon Kaen University (Modindaeng), Thailand. The students were specifically selected from grade 9 in the first semester of the academic year 2019.	- Protocol Analysis - Analytic descriptive and summarization which was collected from leaner's Protocol
3) To study the Learner's Achievement.	- Online Learning Environments -The achievement tests were four subjective tests about basic computer programming.	The 30 students who were studying in the Demonstration School of Khon Kaen University (Modindaeng), Thailand. The students were specifically selected from grade 9 in the first semester of the academic year 2019.	- The guideline reflected the examination of the consistency of the core education curriculum's questions and indicators of the core education curriculum.
4) To study the Learner's opinion.	- Online Learning Environments - Assessment from the Learning Environments Model for learner.	The 30 students who were studying in the Demonstration School of Khon Kaen University (Modindaeng), Thailand. The students were specifically selected from grade 9 in the first semester of the academic year 2019.	Analytic descriptive and summarization which was collected from learner.

According to Table 3, it shows that the instrument and the process of data analysis in Model Research Phase II.

Findings and Discussion

1 . The result of internal validation showed that the seven components of Online Learning Environments Model have the consistency according to the synthesis of a theoretical framework and conceptual framework for designing and developing the Online Learning Environments Model on the network. Due to the result of the evaluation, the online learning environments model had internal validity. From these internal results showed that internal validity of theoretical framework, designing framework and learning environment was consistent with the previous research (Singha and Chaijaroen, 2019).

2. The result of external validation shows as follows:

2.1 The results of the Mental Model of Programming study showed that the students were able to create knowledge representation and understanding the programming. The student was able to create their mental model which showed the component of programming. Moreover, the students were capable of explaining the effect of the model on the programming when the model's component was changed.

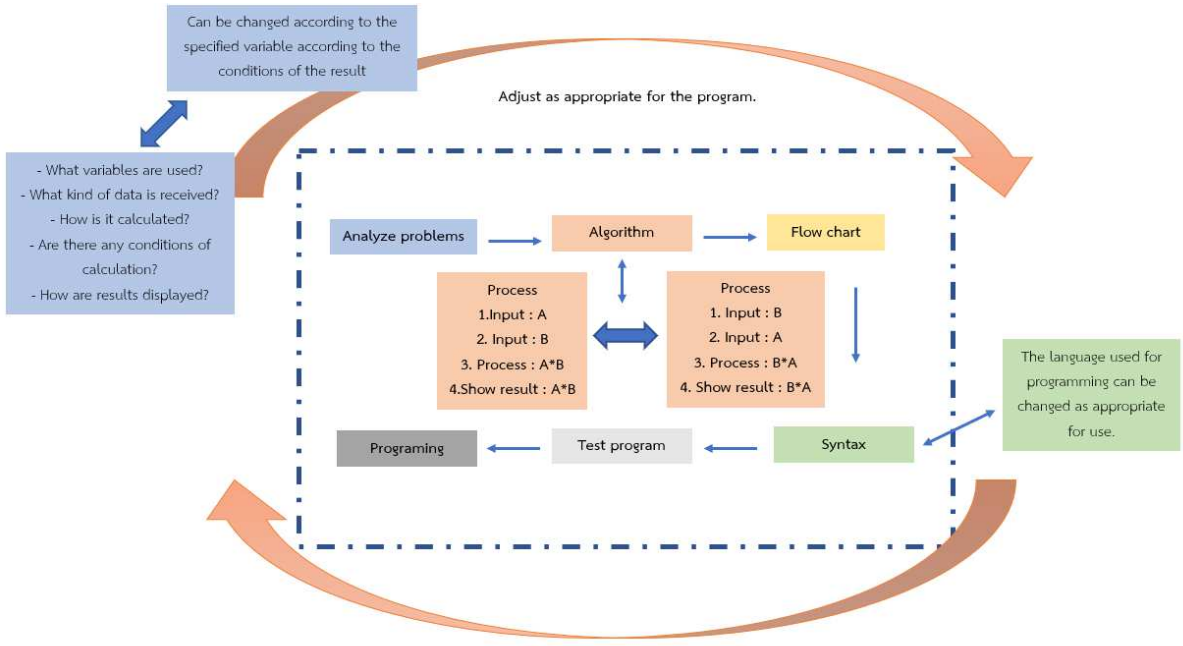


Figure 2 Mental Model of Programming

2.2 The learning achievement of students who learned by using Online Learning Environments Model had the post -test average scores is 24.9 (S.D. = 0.99) or 83.0 %, which was higher than the criteria of 70% percent (Table 2).

วารสารศึกษาศาสตร์ มหาวิทยาลัยขอนแก่น, 43(4), 1-16
doi: 10.14456/edkkuj.2020.x

Table 3

The learning achievement of students who learned with Online Learning Environments Model.

Parameter	Average score ($\bar{X}$)	Standard deviation (S.D.)	Percentage (%)
The score of learning achievement of students	24.9	0.99	83.0

2.3 The opinions of learners who used the Online Learning Environments could be divided into 3 aspects: content, media, and design model. 1) the contents were clear, diverse, up-to-date, practical, and comprehensive. It was also able to facilitate the student's research. The technology was used to present the content which enhances the students' initiation and autonomy. The content format design had a logical order and was easily recognizable. The texts and sentences in the content were apparently illustrious which increase learning motivation, comprehension, and interest. 2) The navigator was designed in the media to access and search the information promptly. Icons in the Online Learning Environment which were able to link to the other information represented their functions. The communication was facilitated by social network flatform such as Facebook, which was easily accessible and popular. The use of online flatform substantially replaced the use of paper. Moreover, this media seamlessly connected the learner to the lesson despite of place and time. 3) The Online Learning Environment Model was contemplated to be noticeably appropriate and attractive. The size of images and texts were related to the contents to increase the learning engagement. For example, (1) Problem base could boost the learners' involvement in a situation resulting in initiative solution. The involvement occurred during learning process could be applied to real-world problems. Moreover, it was predictable that the students would be able to develop a broader knowledge and more learning framework. (2) The resource and the illustration which were systematically organized and were divided into distinctive categories promoted ease of access and search. (3) Mental Model Programming Labs was the training step to practice descriptive speaking ability of the principles and process of programming. The knowledge and vision of learners related to the two dimensions-mental models of programming were improved. Furthermore, they had different contents which contributed to a variety of ideas to solve problems. (4) Cognitive tools supported the learners in selecting the tool during learning and/or doing the mission to acquire additional knowledge. (5) Collaboration was considered as supporting the exchange of knowledge and co-working which students could discuss via chat room (6) Scaffolding can stimulate the learners to solve the problem. (7) Coaching was used to support, help, and advise the learners besides it could assist the communication between teachers and learners in seeking and finding various answers. These findings confirmed that the environment learning which was designed by using constructivist theory significantly encourage, support, enhance, and help build the student's knowledge of programming. Similar results were observed in the research of Moeikao (2018).

Conclusion

1. The results of the internal validation from the evaluation of the experts in media and model design found that the Online Learning Environment Model had the quality in every component of the model and were consistent with the theoretical framework and conceptual framework for designing and developing the online learning environments model.

2. The results of the external validation are as follows:

2.1 The Mental Model of Programming showed that the learners had the mental model of programming. The learners could create knowledge representation and applied the understanding of programming into the model. The model created by learners showed the components of programming. Moreover, the learners were able to explain the effect of the changeable model on the programming related to Mayer's model (Mayer, 1989).

2.2 For the learning achievement of learners from the post-test, it was found that the average scores are 24.9 (S.D. = 0.99) or 83.0 %, which was higher than the criteria of 70 percent. This result was explained from the effect of the Online Learning Environment Model which was designed dependently based on the principle and theory which were consistent to learning management, the mission, and the Mental Model of Programming. These tools improved the knowledge of learners in programming. Learners can represent the understanding of programming to the model including the component of programming. The impact of Mental Model of Programming can be clearly seen on the average score of learning achievement which was higher than the criteria.

2.3 Opinions of the students who learned with the Online Learning Environment Model consisted of 3 topics: content, media, and model design. It is reflected that the model was appropriate and responsive to the learning to enhance learners' Mental Model of Programming.

Contribution

1. Classroom management of Online Learning Environments for Enhancing Mental Model of Programming must be concerned about the appropriate context of learner, institution, content, and media.

2. The Mental Model of Programming could be used as a basis to promote learners to have the ability of programming.

วารสารศึกษาศาสตร์ มหาวิทยาลัยขอนแก่น, 43(4), 1-16
doi: 10.14456/edkkuj.2020.x

Suggestion

1. The study should investigate other factors which affected the Mental Model of Programming such as gender, age, and emotion of students to improve the Online Learning Environment Model for Enhancing Mental Model of Programming which corresponded to the learning environment.

2. The study should examine the characteristic of model to develop the efficacy of the mental model of programming.

Limitation

The research is conducted to examine the internal and external validation, thus the result could use in other studies which owe similar populations in term of the context.

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