The Development of Rich Chemistry Multimedia Learning Environment Model to Foster Scientific Thinking: Validation Phase

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Abstract: The purpose of this research was to examine the internal and the external validation of the rich chemistry multimedia learning environments model to foster scientific thinking. The target group for the internal validation consisted of 9 expert reviewers, 1 teacher teaching chemistry in grade 10 and 30 students in grade 10 from Piboonrukpittaya school. The developmental research phase II: model validation was employed in this study. The results were revealed as follows; firstly, for the internal validation, it was found that the model design was consistent with underlined theories based on Instruction Design theories (ID Theories). Secondly, for the external validation, it exposed that the students learning with model have high levels of scientific thinking and achievements. The average scores of scientific thinking test and achievements test were 73.92 % over the 70 percent threshold and 75.67% over the 70 percent threshold respectively. The students' opinions toward the rich chemistry multimedia learning environments model to foster scientific thinking were appropriate in all aspects and could enhance students' scientific thinking.

Keywords: Instructional design, multimedia learning environment, scientific thinking, constructivist learning environment, chemistry education

1. Introduction

The rapid developments of information technology and telecommunications in Thailand and around the world have struggle the changes. The flows of culture across the world and the social network have been happening by utilizing both economic and learning. Thai society is the outcome of a knowledge-based society. The amount of information has increased tremendously. Knowledge is constantly changing. The human needs to learn continuously throughout life. The students themselves must have the skills to seek knowledge and knowledge construction at all times which is consistent with the National Education to be given the learning process for learners to practice thinking and encounter situations. In particular, science education focused on human development followed by the development of scientific thinking. Student can think to inquire, make critical thinking, and make a decision by using a variety of information and evidences to review (Office of Education Council, 2005). Therefore, to encourage the students to construct the knowledge that inquires knowledge, students then use scientific thinking processes. The Cognitive process in solving problems is to think logically for the problems in situations in which the scientific inquiry is as to include scientific analysis and a summary of the justifications. This leads to an understanding and concepts of the science learners (Kuhn, Amsel and O'Loughlin, 1988; Indrani, 1995; Boo and Toh, 1998; Dunbar, 1999; Li & Klahr, 2006; Kuhn, 2004 & Zimmerman, 2007). However, the development of scientific thinking to students in schools is learning, most students focus on content rather than on recognition of the students thinking. In addition, students lack of problems solving ability in everyday life and not able to develop the inquiry idea for knowledge and critical thinking (Kaewdee, 2005).

Learning how to handle students to construct knowledge and promote thinking in people which mentioned above is concerning the philosophy of constructivist learning. The students must act with enthusiasm and construct their knowledge by themselves. Based on the theories of philosopher; Dewey (1891), Piaget (1985), Vygotsky (1962), and Glasersfeld (1995); students understand and learn by themselves. And they create knowledge through interaction within the provided environments. Learning how to learn is about the way how we come to know. It is consistent with the epistemology about how humans learn, and believe that knowledge can be changed. Students must construct the knowledge and understanding actively and focus on the development of meaningful learning and understanding (Kowtrakul, 2005). Jean Piaget stated that students construct knowledge by having cognitive equilibrium in their cognitive structure. If they are activated by a problem and confront cognitive conflict evoking or disequilibrium, students then try to restructure the cognitive structure to equilibrium via modification of intellectual structure. And Vygotsky believed that students learn from social and cultural context by emphasizing in cognitive development that occured when students interact with environment in society. Regards Zone of Proximal Development, it is the potential of cognitive development that may lead to restrictions on the development. If students are lower than the Zone of Proximal Development. They need assistance which is called Scaffolding, also the support from the teacher (Chaijareon, 2005).

To support the above mentioned towards the cognitive process, the characteristics of the media are needed. The media attribution and symbol system influence the cognitive process; especially multimedia that can represent text, visual, animation and audio as hypertext, hyperlink and hypermedia to support knowledge construction, meaningful learning, and thinking ability as well as to promote an inquiry for knowledge efficiently. In addition, learning with multimedia on network also provide opportunities for students to learn by interaction, share cognition, correct misconception, enhance scientific thinking and communication with the cognitive tools that include a variety of symbol systems (Kozma, 1991; Jonassen,2004; Khun,2004; Chaijaroen,2006; Gumlunlert, 2011). This can be supported by the study of media attribution and symbol system that can help enhancing cognitive process such as cognitive skills, sharing cognition, knowledge constructing and thinking ability as cognitive tools (Kozma, 1991; Fraser, 1998; Chaijaroen, 2006.)

The reasons mentioned above, this study recognize the importance of science learning environment design. The researcher applied the scientific thinking, constructivist theory and the multimedia attribution and symbols system used, synthesizing them as the framework for designing the rich chemistry multimedia learning environments model to foster scientific thinking. The finding may help to promote the scientific thinking and knowledge construction to the students.

2. Method

The target groups used in the internal validation and external validation are as follows: the target group for the internal validation consisted of 9 experts, 3 content experts, 3 the model design experts, 3 media experts in order to evaluate the rich chemistry multimedia learning environments model to foster scientific thinking. Moreover, the target group for external validation consisted of 30 students who studying chemistry during the first semester of 2011 academic year.

The instruments for collecting data of internal validation of the rich chemistry multimedia learning environments model to foster scientific thinking consisted of 3 evaluation forms as follows: the evaluation form for content, the evaluation form for instructional design, and the evaluation form for media design. Moreover, the instruments for collecting data of external validation of the rich chemistry multimedia learning environments model to foster scientific thinking were: (1) the interview form used for examining of scientific thinking using open-ended questions based on 4 aspects of scientific thinking: Inquiry, Analysis, Inference, and Argument. (Kuhn, 2004); (2) the scientific thinking test; (3) the achievement tests for the students on the topic of chemical reaction; and (4) the opinionnaire of students towards the rich chemistry multimedia learning environments model to foster scientific thinking (Khan, 1997; Hanafin, 1999; Chaijaroen et al., 2007).

To collect and analysis data, the internal validation was the examination of the design and development of model in order to confirm the quality of the models by experts in various fields as following: (1) the content experts; (2) the media experts; and (3) the model design experts. The data were collected and analyzed by using interpretation, analytic descriptive and summarization. Moreover, the external validation of the model was to study the impact of utilization of the model in 4 aspects as following: (1) The students' scientific thinking were collected by in-depth interview based on Kuhn (2004): inquiry, analysis, inference, and argument; (2) The students' learning achievements were collected by the achievement tests for the students on the topic of chemical reaction; (3) The relationship between the students' scientific thinking and the students' achievements were collected by the scientific thinking test and the achievement tests for the students on the topic of chemical reaction and was analyzed by using Pearson product moment correlation coefficient (r) (Howell, 2007); and (4) The students' opinions toward the rich chemistry multimedia learning environments model to foster scientific thinking were collected by opinionnaire and analyzed by using the interpretation, analytic descriptive and summarization.

3. The Research Results

3.1 The results of this study can be summarized as follows:

The result of the internal validation examination of the model showed that the designing of the rich chemistry multimedia learning environments model to foster scientific thinking which was appropriate and congruent with the underlined theories and principles. Learning theories used in this research are Cognitive constructivism based on Piaget (1975), Social constructivist based on Vygotsky (1962), scientific thinking based on Kuhn (2004). Based on above mentioned theories the designing framework of the rich chemistry multimedia learning environments model to foster scientific thinking was synthesized. The designing framework consisted of 4 crucial bases: 1) activating cognitive structure 2) supporting cognitive equilibrium 3) fostering and developing scientific thinking 4) supporting knowledge construction and scientific thinking (Saman and Chaijaroen, 2012). The results showed that, for activating cognitive structure, it illustrated the relationship between the underlined theories and the component as follows: cognitive constructivism, CLEs model (Jonassen, 2004; Lambros, 2004). The design of the component of which was called Problem base focused on authentic chemical problems in daily life, real world problems, and contextualizing problems. This may help activating cognitive structure of the students. The relationship between the underlined theories and the components of the model was shown in Figure 1.

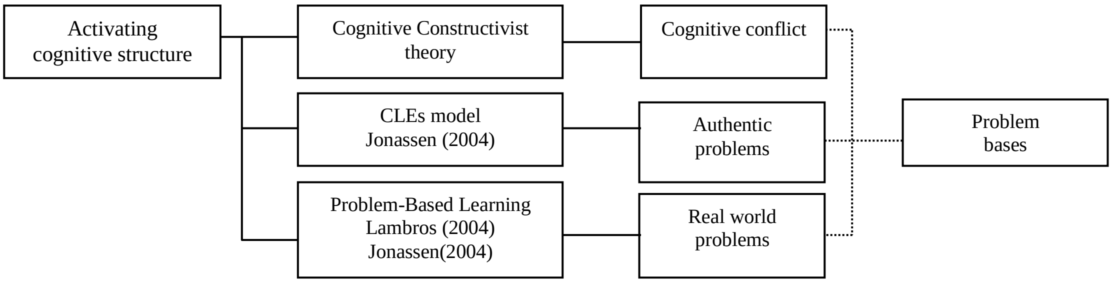

Figure 1. The relationship between the underlined theories and the activating cognitive structure

For supporting for cognitive equilibrium, it was illustrated the relationship between the underlined theories and the component as follows: cognitive theories, multimedia learning principles of Mayer (2005), SOI model (Mayer, 1996). Designing of the component of which was called (1) Learning resources. It focused on how the students process the information effectively. This can help the students understand easily; (2) the other component is Collaboration. The underlined theories used was the collaborative learning of Honebein (1996) Brewer (2006) and Palloff and Pratt (2005). It focused on the collaborative problem solving, sharing cognition and multiple perspectives and preventing misconception of the students. The relationship between the underlined theories and component was shown in Figure 2.

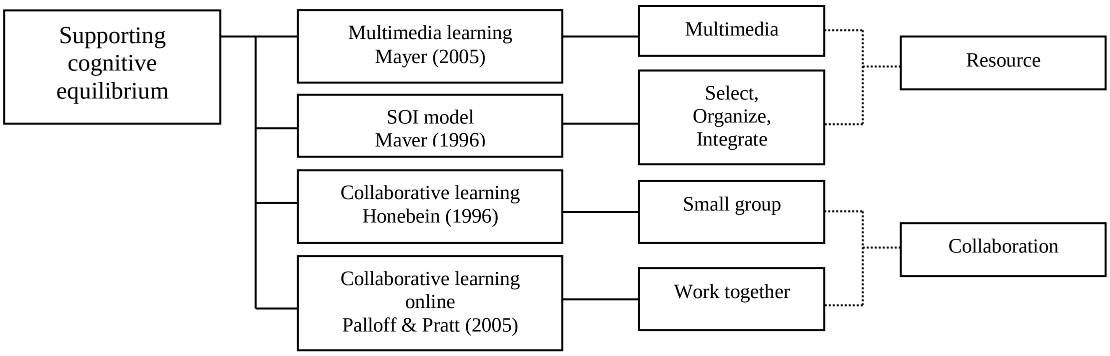

Figure 2. The relationship between the underlined theories and the components of the model

For fostering and developing scientific thinking, it illustrated the relationship between the underlined theories and the components as follows: the scientific thinking of Kuhn (2004) which consisted of (1) inquiry; (2) analysis; (3) inference; (4) argument. The design of the component was called (1) scientific thinking lab. It focused on fostering and developing scientific thinking. This could help the students to foster the ability to think scientifically. The relationship between the underlined theories and components of the model were shown in Figure 3.

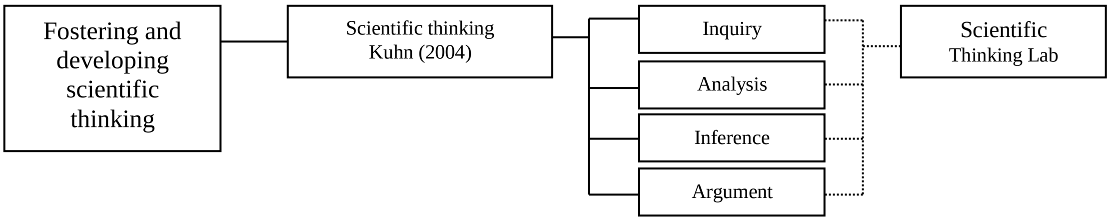

Figure 3. The relationship between the underlined theories and developing scientific thinking

For supporting knowledge construction and scientific thinking, it illustrated the relationship between the underlined theories and the components, as follows: social constructivist theory (Vygotsky,1962), CLEs model (Jonassen, 2004). They focused on the Zone of proximal development to support students in resolving conflicts and reaching a balance, or equilibrium. From these theories were designed scaffolding, coaching and related cases. Social constructivist (Vygotsky, 1962), Scientific language (Madsen, 1970) and scientific thinking (Kuhn, 2004). They focused on scientific language, which is different from the language of daily life; students should be surrounded by scientific language. From these theories a scientific language room was designed. Social constructivism (Vygotsky, 1962), Scientific community (Wandersman, 2003) and Scientific thinking (Kuhn, 2004). They focused on providing opportunities for students to learn science in the science classroom by talking, writing, and sharing. From these theories were designed a scientific community, a science museum (Fujitani, Mitsuishi & Makihara, 2002) that focuses on providing ideas of scientists and scientific discoveries to evoke thinking. From this theory was designed a science museum, the design of the components of which are (1) related cases; (2) scaffoldings, including metacognitive scaffolding, strategic scaffolding, conceptual scaffolding and procedural scaffolding; (3) coaching; (4) a scientific language room; (5) a scientific community; and (6) a science museum. The relationship between the underlined theories and components is shown in Figure 4.

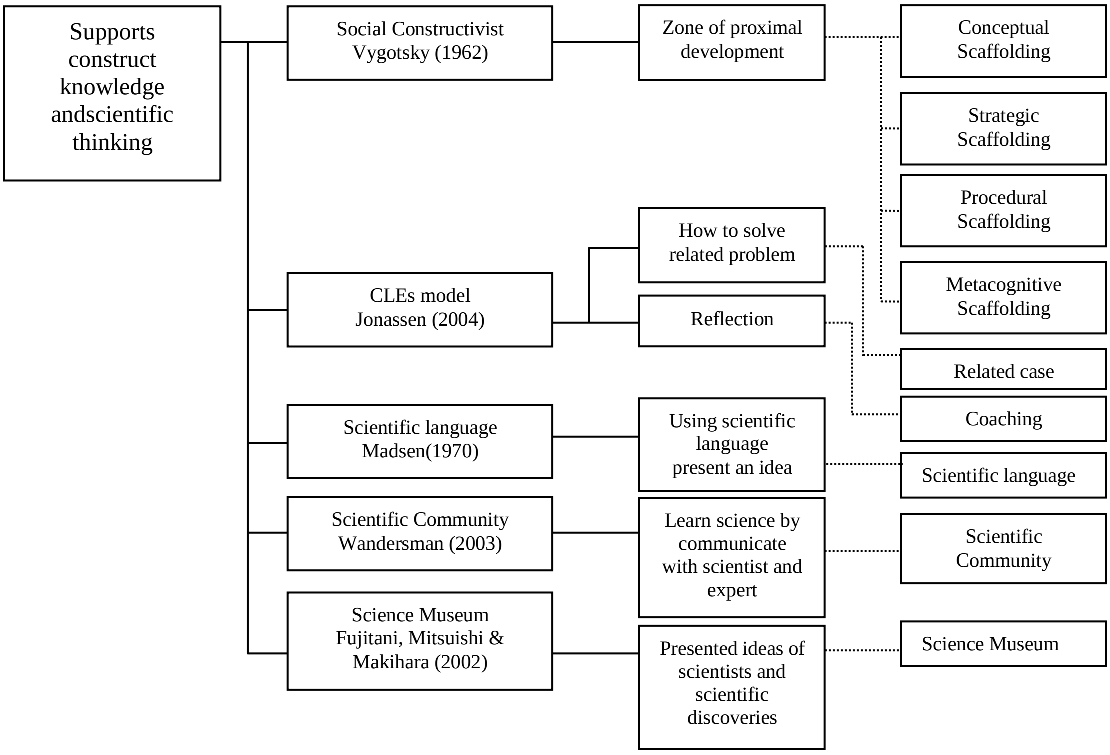

Figure 4. The relationship between the underlined theories supporting of knowledge construction and scientific thinking

In addition, the results of the external validation of the rich chemistry multimedia learning environments model to foster scientific thinking showed that, for the students' scientific thinking, the scientific thinking on inquiry, analysis, inference, and argument, helped to foster students for learning chemical reaction at high level.

The average scores of scientific thinking test was 73.92 %. It was higher than the specified criterion as 70%. Moreover, it was found that the students' scientific thinking has four aspects: inquiry, analysis, inference, and argument. For the achievement of the students, it was found that the average scores are 75.67 %. It was higher than the specified criterion as 70%. The opinions of the students toward the rich chemistry multimedia learning environments model to foster scientific thinking, show that: it was appropriate in all aspects as following details: 1) Content was up to date, clear, accurate and beneficial for them to inquiry; 2) The web-based design: the consistency of the navigation structure design helped the learners to access information easily and not make confusing; the students can access the network environment as a similar structure; and 3) The model design: the design problem was to encourage students to learn. The elements that encourage students to find answers or knowledge used to solve the problem.

4. Conclusion and Discussion

The results of the internal and the external validation were revealed as follows. For the internal validation, the model had been examined by 9 experts and it was found that the model design was consistent with underlined theories based on Instructional Design theories (ID theories). For the external validation, it was found that students learning with model had high level score in students' scientific thinking. The average scores was 73.92 %. It was higher than the specified criterion as 70%. and the standard deviation was 2.03. For the students' opinions to the rich chemistry multimedia learning environments model to foster scientific thinking, found that appropriated in all aspects and the model could foster learners' scientific thinking. These findings were consistent with the study of Chaijaroen, et al. (2008); Chaijaroen, Kanjug and Samat (2012); Saman, et al. (2011); Puangtong, and Chaijaroen (2014). In addition, it is also consistent with Monica W. Tracy (2009) studied on the design and development for the multiple intelligences. The above mentioned findings of the internal validation and the external validation of the model may cause from the Instructional design using ID theory. Theories used here were Scientific thinking based on Kuhn (2004), learning theories: Cognitive constructivist based on Piaget (1975) and Social constructivist based on Vygotsky (1962), cognitive theories, media theory and media symbol system. Those theories could enhance the student's scientific thinking. Based on the theories used as foundation in the design of the model, this led to enhancing the student's scientific thinking. In addition, the specialized designer might result in the internal validation of the model. Since she specialized in chemistry for more than 10 years and she had the educational background. Moreover she is studying in Doctor of Philosophy Program in Educational Technology focusing on Instruction design especially ID Theory. Consequently, this may help in designing the components of the model congruent with those underlined principles and theories. This might result in the internal validation of the model. It could be supported by the above mentioned experts' examination and evaluation of the rich chemistry multimedia learning environments model to foster scientific thinking. This might affect the impact of the utilization of the model to enhance the student's scientific thinking both in test scores and scientific thinking scores.

The various finding of this study could suggest that the model could be illustrated both the internal and external validation. This might result in the constructivist learning environments model enhancing scientific thinking that illustrated by the learners' scientific test scores and achievement test scores.

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