Monitoring Gender Participation with Augmented Reality represented Chemistry Phenomena and Promoting Critical Thinking

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Abstract: Currently, augmented reality (AR) is considered as cognitive tool having ability for pedagogical applications to add a part of lack experiment when the phenomenon cannot be imitated in reality. This study aims to investigate effect of AR in chemistry learning regarding gender and design how to use AR for promoting students' critical thinking. In this pilot study, 90 eleventh-grade students in northeastern region of Thailand were recruited to participate with a series of AR represented chemistry phenomena. They were measured perception toward AR technology as pretest and posttest by 21-item perception questionnaire. The results founded that the perception of females and males toward mobile augmented reality (AR) was detected that there was no significant difference between genders in fostering their perceptions to learn chemistry with mobile AR. Both males and females have positive perceptions in chemistry learning experience of acid-based interaction with mobile AR. This evidence implied that learning chemistry with AR could make science more approachable and meaningful for student. As such, the researchers present a proposed instructional strategy of chemistry learning with AR through model-based inquiry process for promoting students' conceptual understanding in chemistry and critical thinking. We believed that the AR-oriented model-based inquiry learning environment could improve the way student learning of chemistry and engage them to criticize and think about natural phenomena meaningfully.

Keywords: Augmented reality, gender, critical thinking, model-based inquiry, chemistry

1. Introduction

In the 21th century, technology was fast changed in the world, and it has become commonplace in advancing the practice of science education because of their ability of go to be change in ways of learning (Srisawasdi, 2012). In case of Thailand, the use of technology-enhanced learning is becoming more popular and increasing in research and development for school science (e.g. Meesuk & Srisawasdi, 2014; Srisawasdi & Panjaburee, 2015; Kamtoom & Srisawasdi, 2014; Piraksa & Srisawasdi, 2014). However, there was no study on the use of augmented reality (AR) in education in Thailand before.

Nowadays, the applications of AR technology have been increasingly gaining attention by researcher, educators, developers, and teachers. AR technology allows users to see a physical space with virtual elements (or information) superimposed on it in real time, and it was developed for several applications in education. Several AR studies in education have indicated the enhancement of students' motivation for learning with the AR technology (e.g., Di Serio et al., 2013; Martín-Gutiérrez and Contero, 2011), and the benefits of AR in learning effectiveness were also reported by researchers. The results of previous researches mainly showed learners' positive attitudes toward AR, whereas AR is participate in the potential for pedagogical applications (Johnson et al, 2011). According to the abovementioned, the aim of this study was to investigate effect of applying AR technology in chemistry learning of acid-base interaction.

2. Literature Review

Augmented reality (AR) refers to technologies that dynamically blend real-world environments and context-based digital information (Sommerauer & Muller, 2014). Recent advances in mobile technologies (esp., smartphones and tablets with built-in cameras, GPS and internet access) made AR applications available for educational system. Several researchers have examined the affordances and constraints of AR for teaching and learning. Today's mobile AR applications leverage science-based education and allow both teachers and students to interact with the combined environment of real- and virtual world for getting better understanding of natural phenomena. The previous result showed its effectiveness in promoting significant learning and it was indeed helpful in promoting learner motivation and willingness to learn from AR system for library instruction was developed (Chen & Tsai, 2012). Fonseca et al. (2014) stated that AR on mobile devices presented an opportunity to visualize different stages of a constructive process, in order to develop understanding of the process and to investigate the relationship among the usability of the tool, students' participation, academic performance after using AR. The results indicated that the use of AR in mobile device could increase motivation of learning and academic achievement, and they both are highly correlated each other. This paper presents the result on gender difference of a pilot study to answer the question: Do the gender differences of secondary school students impact chemistry learning in context of using AR technology?

3. The Pilot Study and Methods

In this study, the researches aim to explore the effect of gender difference on perception toward mobile AR application for chemistry learning of acid-base. The researcher expected that the findings will provide us informative data that can use to design the learning process of model-based inquiry (MBI) with AR for enhancing students' scientific conceptual understanding and critical thinking skills. The participants of this pilot study were 90 eleventh-grade students, including 30 males and 60 females, in a public school in northeastern region of Thailand. They were aged ranging from 16 to 17 years old. All of them have basic skills in using information and communication technology for learning, and they have fundamental skills in using mobiles devices.

In this study, the researchers have constructed a series of mobile AR in acid-base topic as learning material for chemistry education, as illustrates in Figure 1.

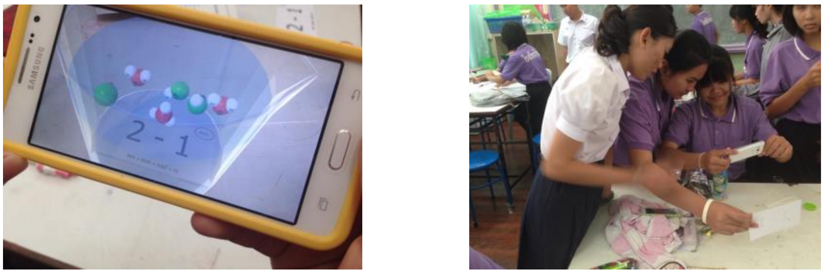

Figure 1. The acid-base augmented reality (AR) of a strong acid as shown on displays. (Left) Students explored learning activity with augmented reality (AR). (Right)

The mobile AR of acid-base has been designed to promote students' understanding of chemical phenomena regarding macro-, micro-, and symbolic representation in chemistry. The AR used in this pilot study contains a particular AR application, two markers that printed with the numbers 2–1, and an exploratory learning activity using mobile device has been created by the researchers. The mobile AR of acid-based contains a numbers of specific substances in a composition of atoms, such as the composition of hydrogen and oxygen atoms representing water molecules. To examine influence of gender gap, a 21-item perception questionnaire was used to measure students' perception toward mobile AR. The items of questionnaire were classified into six subscales: perceived learning (PL), perceived ease of use (PEU), Flow (F), perceived playfulness (PP), enjoyment (E) and satisfaction (S) (Tao, Cheng, & Sun, 2009), developed in Thai version by Meesuk & Srisawasdi (2014). The students were administered the questionnaire, as posttest, for 15 minutes at the end of the exploratory activity.

Based on the obtained data, multivariate analysis of variance)MANOVA(was used to analyze the impact of gender difference on their perception toward mobile AR application for chemistry learning of acid-base.

4. Results and Discussion

The result of statistical analysis of MANOVA shows that there was no significant difference among gender on students' perception toward the mobile AR application in chemistry learning. In details, there was no statistically significant difference for PL, F)1,88(= .748, p = .389; PEU, F)1,88(= 1.830, p = .180; F, F)1,88(= 1.811, p = .182; PPF, F)1,88(= 2.190, p = .142; PE, F)6,83(= 3.176, p = .078; and PS, F)6,83(= .081 , p = .776. The results of this study indicated that there was no significant difference between genders in fostering their perceptions to learn chemistry with mobile AR application. In additions, the finding indicated that both male and female secondary school students have positive perceptions in chemistry learning experience of acid-based interaction with the mobile AR. This is consistent with Plant et al. (2009) and Srisawasdi (2015) that exposures students to technology-enhanced inquiry learning modules did not contribute to any significant gender disparity and both genders improved motivations to learn science after participating in the learning module.

In this study, this evidence of students' perception toward mobile AR application for chemistry learning of acid-base interaction implied that learning chemistry with AR could make science more approachable and meaningful for student. With the aim to promote students' critical thinking skills to learn science, researchers have proposed a design of instructional strategy that may reduce the gender gap and increase students' critical thinking skills in chemistry learning.

5. A Proposed Instructional Strategy of Model-based Inquiry with Mobile AR for Promoting Critical Thinking Skill in Chemistry Learning

Model-based inquiry (MBI) is based on the generating, testing and revising of scientific models. This kind of inquiry-based learning process is different to typical school science investigations. This kind of minds-on inquiry activity is critical to enhance students' learning of scientific knowledge and insight into how scientists work (Abrahams and Millar, 2009). In the MBI classroom, mobile AR will be used to help students visualizing scientific model of invisible chemistry phenomena of acid-base interaction, and inquiry learning process contributes to developing critical thinking skills (Maria T.Oliver-Hoyo, 2003). In the model-based inquiry with mobile AR, scientific model was illustrated as representation that simplifies a system by focusing on key highlights to predict and explain scientific phenomena. The target of modeling includes four elements as student construct models, use models to predict phenomena, compare and evaluate the ability of different models to predict new phenomena, and modify models to explanatory and predictive power (Schwarz, 2009). To promote critical thinking skills, the mobile AR application could enhance acquisition of accurate scientific models and support student comparing and evaluating the different or alternative models and then facilitate them to reconstructing their own models of target natural phenomena. By the way, the researcher hypothesized that the AR-oriented model-based inquiry learning environment could improve the way student learning of chemistry and engages them to criticize and think about acid-base phenomena meaningfully. In the AR-oriented model-based inquiry learning, teacher will give a series of conceptual questions that describe a target chemistry phenomena associated acid-base interaction at the beginning of the class. In the pre-stage of MBI with mobile AR, initial model of the target chemistry phenomenon will be created by students. Next, students will be allowed to interact with mobile AR of acid-based phenomena and then they will be encouraged to share their own model of the chemistry phenomena against other models. After that, they will monitor the initial model and then revise the model being accurate scientific model. In the post-stage MBI, students will present the data and experiment results to others, and synthesis main idea to summarize and answer for the phenomena while teacher will add the complete information of the chemistry phenomena.

5.1 An Example of AR-oriented Model-based Inquiry Learning for Promoting Critical Thinking in Chemistry

In the AR-oriented model-based inquiry learning, teacher will give a series of conceptual questions that describe a target chemistry phenomena associated acid-base interaction at the beginning of the class. In the pre-stage of MBI with mobile AR, initial model of the target chemistry phenomenon will be created by students. Next, students will be allowed to interact with mobile AR of acid-based phenomena and then they will be encouraged to share their own model of the chemistry phenomena against other model

Table 1: An example of Modeling Base Inquiry with Augmented reality (AR).

MBI process	Description of learning process	Illustration
1. Anchoring phenomena	At the beginning of the lesson, teacher will give a series of conceptual questions and introduces the target chemistry phenomenon. Then, students will analyze the phenomenon that may necessitate using a model to figure it out. This is the analysis process of critical thinking.	
2. Construct a model	According to the phenomenon, students will be assigned to create their initial explanatory model of the phenomenon by drawing an image or forming a hypothesis. This is the disposition process of critical thinking.	
3. Empirically test the model	Students will investigate the chemistry phenomenon by interacting with mobile AR integrated with refutation text for visualizing what would happen in molecular level of the phenomenon. This is the interpretation and analysis process of critical thinking.	
4. Test the model against other ideas	Students will be assigned to test their existing model of understanding by presenting and discussing with peers, and sharing ideas for improving the initial model. This is the evaluation process of critical thinking.	
5. Revise the model	Students will be assigned to edit and revise their initial model to fit new empirical evidence and compare both models, initial and revised model, by themselves. Finally, they have to construct a consensus model of the target chemistry phenomenon. This is the evaluation and inference process of critical thinking.	
6. Use the model to predict or explain	At the end of the lesson, teacher will give them another challenge chemistry phenomenon for the whole class. Students will be assigned to use their revised model of understanding to predict and explain what would happen to the phenomenon both observable and molecular level. This is the explanation process of critical thinking.	

After that, they will monitor the initial model and then revise the model being accurate scientific model. In the post-stage MBI, students will present the data and experimental results to others, and then summarize and answer and draw a conclusion for the chemistry phenomena, while teacher will add necessary information of the chemistry phenomena. Table 1 presents the proposed learning process of AR-oriented model-based inquiry learning in chemistry.

5.2 An Example of Refutation Text for Promoting Critical Thinking in Chemistry

Refutation text is a text structure that stimulates readers' misconceptions. The structure of refutation text contains three components: (1) a commonly clasp misconception; (2) a clear refutation of that misconception with an emphasis on scientific explanation; and (3) a cue that alerts the reader to the occasion of another conception (Tippett, 2010). For promoting students' critical thinking in chemistry, the mobile AR will be used to visualize scientific model and explanation of the chemistry phenomena for supporting and opposing the misconception of students. Previous research revealed that the use of refutation text can facilitate conceptual growth and produce the change of misconception among students (Mason & Gava, 2007). An illustration of refutation text integrated with mobile AR is presented in Figure 2.

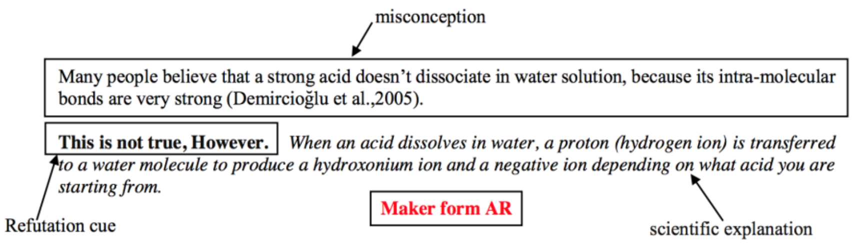

Figure 2. An example of refutation text integrated with mobile AR

5.3 Measuring Students' Critical Thinking

A main goal in chemistry education is fostering students' critical thinking skills. Ennis (2003) stated that the high demand for critical thinking assessment can be bind to the propagation of critical thinking as a goal at all levels of education. To evaluate students' critical thinking in the future study, a rubric-scored instrument developed by Saxton et al. (2012) will be used to measure their critical thinking. The instrument by Saxton et al. (2012) is Critical Thinking Analytic Rubric (CTAR) that included six categories: interpretation, analysis, evaluation, inference, explanation, and disposition. Students will be assigned to complete worksheet for each lesson and then the CTAR will be used to analyze their critical thinking during chemistry learning. The researchers hypothesize that students' critical thinking may be promoted by the pedagogy of model-based inquiry learning with refutation text integrated AR.

6. The Future Study

As the instructional design of AR-oriented model-based inquiry learning in chemistry, the results of this pilot study will be applied to design a series of learning activity for implementing with secondary school students in northeastern region of Thailand. In further study, the combination MBI pedagogy and mobile augmented-reality (AR) technology will be used to leverage students' conceptual understanding, induce cognitive mechanism of conceptual change, and also promote critical thinking skills. For the promotion of critical thinking, a series of fundamental cognitive process including interpretation, analysis, evaluation, inference, explanation, and disposition (Saxton et al., 2012) will be used to investigate students' critical thinking in chemistry learning of acid-base. The study participants comprise of two groups, a control group and an experimental group. In the future study, the experimental group will received AR-oriented model-based inquiry learning while the control group will received regular inquiry learning. The research hypothesis is that the AR-oriented model-based inquiry learning environment could improve students' conceptual understanding, induce cognitive mechanism of conceptual change, and promote critical thinking better than regular inquiry learning.

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