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Investigating Correlation between Students' Attitude toward Chemistry and Perception toward Augmented Reality, and Gender Effect

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Abstract: Augmented Reality (AR) is currently recognized as instructional innovation by the way of combining both the real- and virtual world presented via mobile device. In this combination, it benefits student learning by providing contextualized situation and visualizing the complex or invisible scientific phenomena. In this study, a series of AR on chemistry of rate of reaction has been developed and the researchers propose to use the AR as pedagogical tool for facilitating high school students' learning on the chemistry topic. The objective of this study was to examine correlation between gender and students' perception, and their attitude toward chemistry and perception also. 90 tenth-grade students were recruited to interact with the AR in groups. The 25-item attitude questionnaire regarding interest in chemistry lesson, understanding and learning chemistry, the importance of chemistry in real life, and chemistry and occupational choice, was administered to the students as pretest and a series of perceptual items regarding perceived learning, perceived ease of use, flow, perceived usefulness, enjoyment, and perceive satisfaction was administered as posttest, before and after interacting with the AR respectively. The results showed that there was no significant correlation between attitudes toward chemistry and perception toward the AR. In additions, there was also no significant correlation between genders and their perceptions toward the AR. This implied that it is possible to use AR to facilitate chemistry learning of rate of reaction disregarding students' attitudes toward chemistry and gender.

Keywords: Augmented reality, attitude toward chemistry, perception

1. Introduction

Due to the rapid advancement of information and communication technology (ICT) in science education in 21st century, many technologies have become commonplace in improving and advancing the practice of science education because of their potential of bringing about change in ways of teaching and learning (Srisawasdi, 2012). For this reason of research and development in science-based education, the effective use of technology in the classroom teaching process has become an important topic for re-thinking in community of science education. Because of its potential to change the way of teaching and learning, therefore, as part of the change, the integration of pedagogical and technological activities is responsible for improving the process of science learning that often benefit from the application of technology (Srisawasdi, Kerdcharoen and Suits, 2008).

Previous studies indicated many technological tools that could be used to support science learning, such as Microcomputer-based Laboratory (MBL) (Voogt, Tilya and Akker, 2009), computer simulation or simulation (Jaakkola and Nurmi, 2008), web-based inquiry science environment (WISE) (Linn et al., 2003), and Augmented Reality (AR) (Huang, 2011; Cai, 2014). Considering in Thai context, there are only a few of research on development of instructional technology in science teaching and learning. Researchers have been developed and then implemented various kinds of technology for enhancing the learning of science in context of Thai basic education curriculum. Previously research (e.g., Meesuk and Srisawasdi, 2014; Lokayuth and Srisawadi, 2014; Nantakaew and Srisawasdi, 2014 and Kanyapasit and Srisawasdi, 2014) developed and implemented educational digital game to facilitate chemistry and biology learning in high school level. To supporting the construction of conceptual understanding in science, researchers (e.g., Pinatuwong and Srisawasdi, 2014; Srisawasdi and Sornkhatha, 2014; Srisawasdi and Kroothkeaw, 2014 and Srisawasdi and Panjaburee, 2015) have developed effective way of inquiry-based learning by using simulation as pedagogical tool in physics and biology class. Moreover, (e.g., Niroj and Srisawasdi, 2014; Nasaro and Srisawasdi, 2014 and Kamtoom and Srisawasdi, 2014) designed and implemented blended learning environment, a combination of hands-on MBL and online-mediated WISE, to assist student visualizing both observable and unobservable level of natural phenomena. To promote students' science learning through inquiry-based process, (e.g. Piraksa and Srisawasdi, 2014; Meesamrong and Srisawasdi, 2014 and Buyai and Srisawasdi, 2014) utilized a combination of hands-on physical laboratory and computer-simulated laboratory to enhance inquiry-based science learning and promote science motivation for high school students. However, the use of AR for science learning is barely in community of science education in Thailand.

In term of chemistry education, the spatial ability plays an important role in chemistry learning, as students are required to visualize specific microstructures, but the visualization of micro-scale structures is a difficult task for students (Harle and Towns, 2011). Some researchers mentioned that computer animation should be applied for making the students truly understanding and imaging of the chemical phenomena at sub-microscopic level. However, the limitation of computer animation is that it is a virtual which simulates the real world and it may not convince student to believe the presented scientific phenomena. Currently, augmented reality (AR) is recognized as instructional innovation and it is now popularity and more interest among researchers, educators, and teachers. The environment of AR is a combination both real- and virtual world together. Cai (2014) used AR simulation application in chemistry learning and they found that the AR tool has a significant supplemental learning effect for low-achieving students than high-achieving ones. Moreover, students generally have positive attitudes toward the AR and students' learning attitudes are positively correlated with their evaluation of the AR. In additions, AR technology has a positive impact on motivation of learning for student (Di Serio et at., 2013). Learning with AR technology associated with students' positive attitude, motivation, and their genuine interest (Berg, 2005). Moreover, many researchers reported about the relationship between the gender difference and perception of AR. Researcher found that males perform better than females in spatial visualization and orientation tasks through learning with AR technology (Ahmad, 2015). Similarly as Di Serio et at. (2013) reported that augmented reality technology has a positive impact on the students' motivation after learning with augmented reality. In addition Martin et al. (2011) reported that augmented reality is in its initial stage according to its publication impact, and they have proposed that it will probably have significant influences on education in the future. According to the abovementioned, therefore, this study aims to investigate correlation between attitudes toward chemistry and students' perception toward AR, and the gender influences onto perception of AR.

2. Purpose

Accordingly, the aims of this study were to examine the correlation between attitudes toward chemistry and students' perception toward AR in context of chemistry phenomena, and to pilot investigate the efficacy of AR with student's perception related to their gender. Specifically, the following research questions were answered:

1. How were the influences of attitudes toward chemistry on perceptions toward AR after interacting with AR of chemistry of rate of reaction?
2. Are there the gender influences to perception toward AR after interacting with AR of chemistry of rate of reaction?

3. Method

3.1 Study Participants

The participants of this study were 90 eleventh-grade students consisted of 60 females and 30 males (aging between16-17 years old) in the northeastern region of Thailand. They were served in basic chemistry course about rate of reaction and they had no experience with augmented reality applications before.

3.2 *Learning activity*

In this study, the researchers designed and created a series of AR for using in chemistry learning of rate of reaction. Students were allowed to interact with the AR during a 50-minute inquiry-based lesson. In the lesson, students used mobile phone for observing the chemistry phenomena through a series of AR markers by scanning on the paper, as display in Figure 1.

Figure 1. Students used mobile phone for observing chemistry phenomena through AR marker by scanning on the paper.

3.3 *Instruments*

This study used two instruments for examining the correlation of students' attitudes toward the chemistry lesson and students' perceptions toward AR. Firstly, The 25-item Attitude Toward Chemistry Lesson Scale (ATCLS) questionnaire (Cheung, 2009), developed in Thai version by Nantakaew and Srisawasdi (2014), was used to measure students' attitudes toward chemistry.

Table1: Subscale descriptions and sample items for the ATCLS questionnaire.

Subscale	Description	Sample items
Interest in chemistry lesson (ICL)	Extent to which student prefer and dislike chemistry learning	- I would like the teaching period of the chemistry lesson more often. - I would like to have fewer chemistry topics in the lessons.
Understanding and learning chemistry (ULC)	Extent to which student developed themselves and relevant in chemistry easily	- I believe that some knowledge in chemistry helps us understand the other science lessons more easily. - Chemistry is a sophisticated and impalpable lesson.
The importance of chemistry in real life (ICR)	Extent to which student thought chemistry about real-life	- I think developments in chemistry improve the quality of our lives. - I think chemistry has a great role in modern life.

Chemistry and occupational choice (COC)	Extent to which student use the information learned in the chemistry classroom for the work in the forward	- I do not believe that chemistry knowledge will be useless after my graduation. - I believe that I do not need chemistry knowledge for my career.

All items were classified into four subscales, consisted of Interest in Chemistry Lesson (ICL) (6 items), Understanding and Learning Chemistry (ULC) (10 items), The Importance of Chemistry in Real Life (ICR) (5 items), and Chemistry and Occupational Choice to Chemistry (COC) (4 items). The sample items and description of each subscale are shown in Table 1.

Another, perception questionnaire (Tao and et al., 2009), developed in Thai by Pinatuwong and Srisawasdi (2014), separated into six subscales, consisting Perceived Learning (PL) (3 items), Perceived Ease of Use (PEU) (2 items), Flow (3 items), Perceived Usefulness (PU) (3 items), Enjoyment (2 items), and Perceived Satisfaction (PS) (5 items). The sample items and description of each subscale are shown in Table 2.

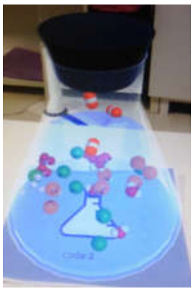
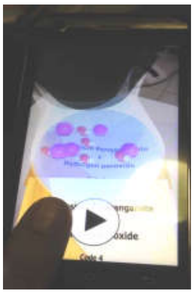
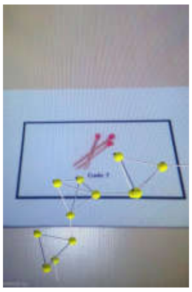
Table2: Subscale descriptions and sample item for the students' perception questionnaire.

Subscale	Description	Sample items
Perceived learning (PL)	Extent to which student can get the new understanding, subjective evaluation of learning by learners themselves.	-The augmented reality increases my learning efficiency. -The augmented reality will help me understand the things I learned.
Perceived ease of use (PEU)	Extent to which using to easy and help to science easier.	-The augmented reality is easy to use. - Using the augmented reality to complete course related tasks are easy.
Flow	Extent to which a state of deep concentration in which thoughts, intentions, feelings, and all of the senses are focused on the same goal	-I was very involved in the augmented reality. - I lost track of time when I played.
Perceived usefulness (PU)	Extent to which students feel happy and attentiveness.	-It is interesting to use games. - I was totally immersed in the augmented reality.
Enjoyment (E)	Extent to feeling of student when used AR.	-I had fun playing the augmented reality for learning science. - I feel relaxed to use augmented reality for learning science.
Perceived satisfaction (PS)	Extent to which the individual awareness of how well a learning environment supports academic success.	-The use of the system makes this learning activity more interesting. - I like to learn new skills by using augmented reality.

3.4 Learning material

In this study, the design of AR technology was related to chemistry concept of rate of reaction. In the AR, it presents 3D model of molecule, and 2D representation of experimental graphs about described theory of chemical reaction will be shown on smart phone screen, which detected AR on the paper marker. The AR engaged student to visualize macroscopic, microscopic, and symbolic representation of chemistry phenomena, and it linked the macroscopic representation from real-life phenomena or laboratory, and also provided information which are three level of representation in chemistry as mentioned. Table 3 illustrates the AR learning material in chemistry of rate of reaction and its descriptions.

Table 3: An illustration of AR learning material in chemistry of rate of reaction and its description.

Topic	Sample of AR	Descriptions
Definitions of rate of reaction		This AR visualizes scientific phenomena of chemical reaction, where the beginning of reaction is fast but it is slow when time up. User could triple touch area of AR display for resetting.
Theories of rate of reaction		This AR visualizes chemistry phenomena about activation energy and activated complex theory. This AR function consists of 3D model and animation. When user uses mobile phone to scan AR markers on paper, it will appear 3D model and also display a button, which can double touch on it, then an animation of experimental graph will appear.
Effect of factor on rate of reaction		This AR visualizes chemical effect regarding nature of substances, surface area, concentration, catalyst and retarder, and temperature. This picture shows the chemical effect of nature of substance. In this picture, when user scans the AR marker, which is match, on paper using mobile phone, the chemical structure of red phosphorus will appear on the mobile phone screen.

3.5 Data Collection and Analysis

This research aims to examine the correlation between attitudes toward chemistry and students' perception toward AR in context of chemistry phenomena, and to investigate the efficacy of AR with student's perception related to their gender. Before their interaction with the AR, the students were administered the pretest questionnaire about attitude toward chemistry lesson in 20 minutes. After that, the students were administered the posttest questionnaire to measure their perception of AR for chemistry learning in 20 minutes. They interacted with the AR in 50 minute during an inquiry-based lesson. Pearson's bivariate correlation was used to examine the correlation and repeated-measure MANOVA was used to investigate the difference of perception among gender.

4. Results and Discussion

4.1 Correlation between students' attitude toward chemistry lesson and their perception

In this part, the results are presented by calculation of statistics on the correlation between students' attitude toward chemistry lesson student before interact with AR and students' perceptions after student interact with AR. Table 4 shows Pearson's correlation of attitude toward chemistry lesson, including interest in chemistry lesson (ICL), understanding and learning chemistry (ULC), importance of chemistry in real-life(ICR), chemistry and occupational choice (COC) in ATCLS, and perceived learning (PL), perceived ease of use (PEU), flow (F), perceived usefulness (PPF), enjoyment (E) and perception satisfaction (PS) in the perception questionnaire. Mean and standard deviation are also presented in Table 4.

Table 4: Descriptive and correlation for attitude toward chemistry lesson and perception toward augmented reality.

Subscale	ICL	ULC	ICR	COC	PL	PEU	F	PPF	E	PS
ICL	1									
ULC	.594**	1								
ICR	.411**	.314**	1							
COC	.486**	.468**	.422**	1						
PL	.136	.238*	-.008	.212*	1					
PEU	.104	.159	-.023	-.029	.480**	1				
F	.048	.233*	-.183	.052	.384**	.455**	1			
PPF	.088	.156	-.035	.052	.551**	.559**	.421**	1		
E	.005	.002	-.082	-.048	.388**	.536**	.231*	.519**	1	
PS	-.002	.067	-.107	.051	.545**	.601**	.386**	.683**	.594**	1
Mean	18.10	30.07	17.83	13.27	13.00	8.54	11.91	12.69	8.69	21.86
SD	3.415	4.146	2.877	2.307	1.398	1.172	1.694	1.633	1.077	1.315

***p<0.01*
**p<0.05*

The result in Table 4, showed that (1) understanding and learning chemistry (ULC) was related to perceived learning (PL) and perceived flow (F), (2) occupational choice (COC) was related to the perceived learning (PL), (3) importance of chemistry in real-life(ICR) invers correlation with all subscale of perception toward augmented reality,(4) interest in chemistry lesson (ICL) not related with subscale of perception toward augmented reality (PL, PEU, F, PPF, E), (5) understanding and learning chemistry (ULC) not related with subscale of perception toward augmented reality (PEU, PPF, E, PS). So, the augmented reality can use for the most of student even if they have a negative or positive attitude toward chemistry.

The finding from previous study never seen research about revealed that attitude toward chemistry lesson and perception toward augmented reality. But have research about the effect of motivation during interaction with the augmented reality (Di Serio and et at., 2013; Ibáñez et at., 2014). This study indicated that student's perception toward augmented reality via mobile learning does not depend on attitude toward chemistry. Although students may have negative or positive attitude toward chemistry, they can learn chemistry by using augmented reality via mobile phone.

4.2 Comparing students' perception by gender

In this part, the results showed that calculation of statistic on the correlation (repeated-measure MANOVA in SPSS 23.0) between students' gender and students' perception. Table 5 result indicated that the gender does not significantly impact on students' perception toward augmented reality. That means both male and female students can learn chemistry by using augmented reality.

Consider Table 5, the results of participant (30 males, 60 Females) for repeated-measure MANOVA from genders' effect for perception toward augmented reality, six subscales score consists of PE, PEU, F, PPF, PE and PS were significant differences across time.

Table 5: Descriptive and correlation for gender and perception toward augmented reality.

Subscale	Gender	N	Mean	SD	F	Sig.	η^2
Perceived Learning (PL)	Males	30	12.87	1.505	.406	.525	.005
	Females	60	13.07	1.351			
Perceived Ease of Use (PEU)	Males	30	8.50	1.358	.064	.801	.001
	Females	60	8.57	1.079			
Flow (F)	Males	30	11.67	1.807	.937	.336	.011
	Females	60	12.03	1.636			
Perceived playfulness (PPF)	Males	30	12.30	1.822	2.598	.111	.029
	Females	60	12.88	1.508			
Perceived Enjoyment (PE)	Males	30	8.47	1.252	1.935	.168	.022
	Females	60	8.80	0.971			
Perceived Satisfaction (PS)	Males	30	21.27	2.196	2.976	.088	.033
	Females	60	22.15	2.335			

The statistic MANOVA indicated that effect of gender for students' perception on PE (F= .406, partial η^2= .005), PEU (F= .064, partial η^2= .001), F (F= .937, partial η^2= .011), PPF (F= 2.598, partial η^2= .029), PE (F= 0.168, partial η^2= .022) and PS (F= 2.976, partial η^2= .033) was .525, .801, .336, .111, .168, and .088 respectively. In addition to comparison graph between mean value and subscale can simplified for understanding as shown in Figure 2.

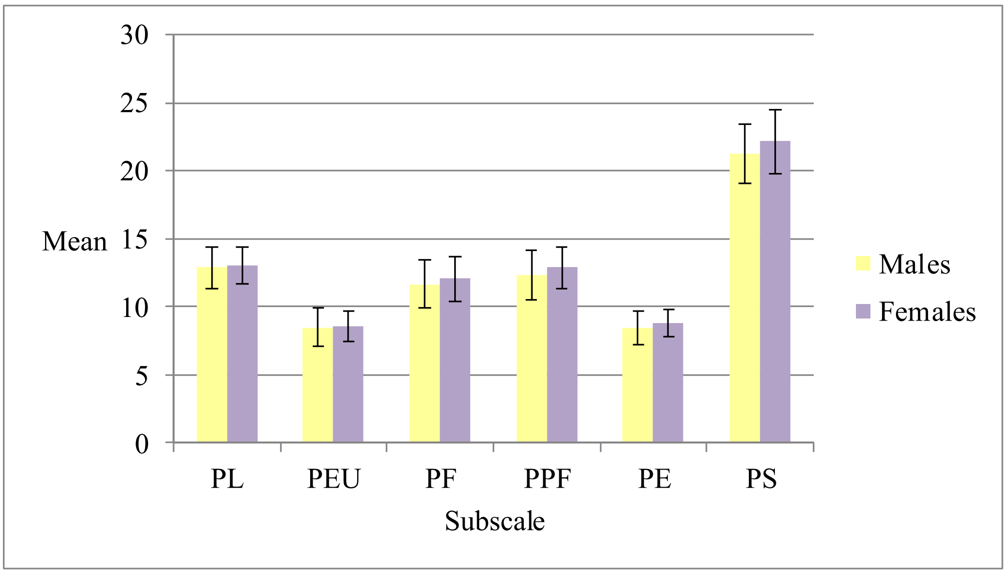


Figure 2. Compare genders' effective between mean scores and subscale of perceptions toward augmented reality.

The finding from previous studies never seen research about revealed that gender and perception toward augmented reality. But there have research about the effect gender with technology (Dorji et. al, 2015). The results pointed out that the students' perception through learning material did not significant to gender, that mean both genders could improve their perceptions toward augmented reality.

5. Conclusion

This study reported impacts of augmented reality investigating correlation between attitude toward chemistry and students' perception toward augmented reality via mobile learning. The augmented reality can use for the most of student even if they have a negative or positive attitude toward chemistry. And students male or female, they can learn chemistry by augmented reality. Moreover, finding highlights the importance of this pilot study are AR help students truly understanding and imaging of the chemical phenomena at sub-microscopic level, saw immediately of phenomena, mixed between result of graph from laboratory and invisible phenomena by their mobile phone and this innovative AR was designed for mobile and ubiquitous learning 1:1. In next study would be more beneficial to combine AR and laboratory activities in teaching rate of reaction, would be analysis data about regression and Structural Equation Modeling to offer more insights on the cause-effect relationships among the constructs.

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