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Using Mobile Augmented Reality for Chemistry Learning of Acid-base Titration: Correlation between Motivation and Perception

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Abstract: The comprehension of micro-worlds has always been focused and challenged in chemistry learning. High school students' imaginative abilities are not yet mature. As a result, they could able to visualize in microscopic level correctly during the beginning stage of chemistry learning. This study was targeted to support students' imagination by visualized the composition and behavior of substances in microscopic (molecular) level. Moreover, the study involved the pedagogical design and development of a series of mobile augmented reality (AR) application for enhancing chemistry learning of Acid-Base. This study examined influence of motivation toward chemistry on perception toward the mobile AR. In interacting with the AR, students could visualize a set of 3D model of molecular substance using smartphone scanning markers. The result showed that intrinsic and career motivation significant correlated with flow and enjoyment of learning experience with the AR. As such, this implied that chemistry learning activity with the use of mobile AR should consider ways to promote students' motivation before implementing the activity. In additions, this paper suggests how to use this finding for designing an ebook of Acid-base and titration experimentation for chemistry learning in school science.

Keywords: Ebook, augmented reality, motivation, perception

1. Introduction

From past to present, chemistry still be a difficulty subject which is abstract and complex by its nature. For students' perspective, they perceive to chemistry which is not relate in daily life, that chemistry is chemical substance, toxic, smoke, pollution, e.g. Thus, it is reason to cause students' question that "Why do I have to learn chemistry?" This is just students' perspective to chemistry. For the nature of chemistry which is rather abstract and invisible. This is a barrier to learn and cause to tell that it is difficult subject. Although, the chemistry learning activities attempted to link the subject matter with how the world works, the students still have numerous learning difficulties and misconceptions on the subject. Moreover, they only link their own existing conception to the new concepts leading to fragmented and fractured understanding (Gilbert & Boulter, 2000). Because of high school students' imaginative abilities are not yet mature. As a result, they could not able to visualize micro-particles correctly during the beginning stage of chemistry learning. Students could not distinguish between macroscopic and sub-microscopic level. The students have also difficulty linking observable phenomena (macroscopic level) to molecular level (microscopic level) interaction (Chang & Linn, 2013). Especially, these students are often required to envision across micro-and macro-worlds, which can be extremely challenging. Both the composition and the behavior of substances are a critical concept in chemistry learning, as it is the foundation of further learning about chemistry. This problem necessitates improving in the learning strategies and tools used in chemistry learning.

In the current, there are many technologies which could support students' visualization and imagination skill which are necessary skills for chemistry learning. Not only supporting learning but also technology could play a huge part in motivating, involving, inspiring. Today, students are highly visual, preferring pictures and video to words and speech. Merging in visual learning tools rise students' engagement, by adding variety to the learning environment with technology. Each new technology is introduced with the potential to utility children's learning (Wartella & Robb, 2007). In 2010, the U.S. Department of Education released the National Education Technology Plan to promote student-centered learning with technology as a way to improve students' achievement (Moeller & Reitzes, 2011). Many research indicate that technology enhance students' comprehensive in science learning and impacts in school classroom as being a powerful cognitive tool.

In science learning, many researcher have been investigated the impact of using various technologies to support students' conceptual understanding, visualization and to promote instructional competency of the 21st century teacher. A research in Thailand revealed that the intervention of simulation-based inquiry with DSLM can be effective in fostering radical conceptual change in students. The results from this study conclude that the simulation-based inquiry learning environment based on DSLM could be an alternative method for developing conceptual understanding of light refraction (Srisawasdi & Kroothkaew, 2014). For example international context show that The Microcomputer-based Laboratory (MBL) is an example of a student-centered learning environment that provides new opportunities to engage secondary-level chemistry students in meaningful learning and higher-order thinking through inquiry. MBL promotes student discussion, planning, measuring and taking responsibility for their learning processes (Aksela, 2011).

The interesting technology which could simulates quite naturalistic about the composition and the behavior of the substances is augmented reality (AR). AR is an extension of Real-world to Virtual-world which provides a seamless interface for users that combine both the real world and the virtual world. AR is a new technology which could simulate 2D and 3D object in macroscopic level, microscopic level and symbolic. Although, there are many research indicate that the AR could improve and support students' learning and motivation. For example, Cai and Xu (2014) were investigated about the impact of the AR on students' achievement, experience meaningful and interesting in chemistry which they found that The AR tool is beneficial in improving middle school students' cognitive test performance on corresponding content, and has relatively larger influence on low-achieving students. Additionally, students generally hold a positive attitude toward the AR tool and enjoyed the exploration experience. With the application and instruction form, teachers could apply this AR tool in inquiry-based learning in their own classes. However, we did not know that student (Both positive and negative motivation toward chemistry) will perceive from learning with the AR. Therefore, we want to investigate the influence of motivation toward chemistry on perception toward augmented reality after interacted with the AR and the correlation between motivation toward chemistry and perception toward augmented reality within educational augmented reality learning.

So, this research was aim to develop the AR technology to support students' comprehension and visualization skill with investigating correlation between motivation toward chemistry and perception toward augmented reality within educational augmented reality learning. This study is pilot study which was goal to investigate that how students perceive toward augmented reality within educational augmented reality learning.

2. Literature Review

2.1 Augmented Reality (AR)

Augmented Reality (AR) is an extension of Real-world to Virtual-world which provides a seamless interface for users that combine both the real world and the virtual world. In the past two decades, the applications of augmented reality (AR) have been increasingly receiving attention. Moreover, according to the 2011 Horizon Report, AR, with its layering of information over 3D space, creates new experiences of the world. With these new prospects of information access, the prevalent employment of AR has been in marketing, social engagement, or entertainment (Johnson et al. 2011). In addition to these consumer uses, the 2011 Horizon Report also suggested that AR should be adopted in the next 2–3 years to provide new opportunities for teaching, learning, research, or creative inquiry. By examining article publications on Google Scholar, Martin et al. (2011) reported that AR 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.

2.2 Motivation toward chemistry

Scientific motivation refers to the motivation of students to learn science within their emotional which stimulate, control and support in science learning behavior. Thus, Scientific motivation could be achieved to learners when activate their behaviors with asking the questions, doing experiments, and collaborative learning (Schunk, Pintrich & Meece, 2008; Glynn et al., 2011). Researchers stated that Scientific motivation consists of five motivational constructs: intrinsic motivation, an internal state of satisfaction to learn science because it will be good or beneficial thing for itself; self-determination, the controlling of students' belief that they have when learning science; self-efficacy, students could bring their belief connect and manage to achieve learning science; career motivation, students learn science to get a good work in the future; and grade motivation, learning science to have a good score (Glynn et al., 2011). The following research hypothesis was another one which the researchers expected to examine in this study.

2.3 Perception toward augmented reality

2.3.1 Perceived Learning

Perceived learning relates to a retrospective evaluation of the learning experience and can be defined as a set of beliefs and feelings one has regarding the learning that has occurred (Caspi & Blau, 2011). The perceived learning is about the new information was obtained and person can get the new understanding, subjective evaluation of learning by learners themselves. Researchers mentioned that perceived learning is connected to emotion as flow, enjoyable, and satisfaction (Chu & Hwang, 2010).

2.3.2 Perceived Ease of Use

Perceived ease of use refers to the degree to which a person believes that using a particular system would be free of effort. This follows from the definition of "ease" which is freedom from difficulty or great effort. Effort is a finite resource that a person may allocate to the various activities for which learner is responsible (Radner & Rothschild, 1975). All else being equal, we claim, an application perceived to be easier to use than another is more likely to be accepted by users.

2.3.3 Flow

Flow is a state of deep concentration in which thoughts, intentions, feelings, and all of the senses are focused on the same goal (Csikszentmihalyi, 1990; Barzilai & Blau, 2014). The experience of flow would happen when person who take part in challenge situations or activities that need skills. Flow depends on a chance to concentrate, an immediate feedback, a sense of control, and a clarify goal (Barzilai & Blau, 2014).

2.3.4 Perceived playfulness

Perceived Playfulness is the extent to which the individual perceives that learner's attention is focused on the interaction with the global. It is curiosity during the interaction and the interaction intrinsically enjoyable or interesting (Moon & Kim, 2001).

2.3.5 Enjoyment

Enjoyment is the condition of having and using technology, e.g. educational computer game that is good or pleasant. The enjoyment of player is a key goal, related with an easy to use of game and enjoyment was found to have valuable in explaining objective to use applications (Giannakos, 2013).

When learners which act as players of game fail to pass the game task, they would get disappointment and attempt to replay again.

2.3.6 Satisfaction

Satisfaction is the individual awareness of how well a learning environment supports academic success (Lo, 2010). It is relevant to instructional method that learners can think and learn, so their satisfaction can help to get how academic success. At the moment to learn with educational computer game, if it gets positive response from learners that means they reach to positive learning experience with also. In an addition, satisfaction can yield positive of learning performance and can improve learning outcome (Giannakos, 2013).

3. Purpose

In this study, the researchers conducted an exploration to investigate correlation between students' motivation toward chemistry and perception toward augmented reality after interaction with augmented reality in the topic of acid-base reaction. Especially, the research questions were answer:

- How were the influences of motivation toward chemistry on perception toward augmented reality after interaction with augmented reality?
- Is it suitable to implement the augmented reality in a Thai school?

4. Method

4.1 Participants

This study was conducted with participation of 77 high school students (17 years of aged) in a local public school at northeastern region of Thailand. Participant in this study have not experienced yet facing augmented reality in Science learning but they have good experience with mobile device. They already completed a regular chemistry class but they have not taught about acid-base reaction yet before participated in this study.

4.2 Instruments

This research used two instruments for determining students' motivation toward chemistry and perception toward augmented reality via the AR. First, the motivation toward chemistry is the questionnaire developed from Scientific Motivation Questionnaire (SMQ) consisting of 25 items. All items were classified into five scales, including intrinsic motivation (five items), career motivation (five items), self-determination (five items), self-efficacy (five items) and grade motivation (five items). The sample items and description of each scale are provided in table 1. Second, the perception toward augmented reality is questionnaire developed from Technology Perception Questionnaire (TPQ) which was developed to use only in this study consisting of 18 items which are divided into six scales, including perceived learning (three items), perceived ease of use (two items), flow (three items), perceived playfulness (three items), enjoyment (two items) and satisfaction (five items). To develop a Thai version of the questionnaire, the original English version was translated identically in Thai language. The sample items and description of students' perception questionnaire are provided in table 2. One expert was recruited to identify communication validity of the items. On each item of chemistry motivation questionnaire and students' perception questionnaire, respondents were assigned to rate how much the respondent agree with into five scale, from 1-strongly disagree to 5-strongly agree.

Table 1: Subscale description and sample items of the Chemistry Motivation Questionnaire

Subscale	Description	Sample items
IM	Which involves learning chemistry for its own sakes	Learning chemistry is interesting.
CM	Which involves learning chemistry as a means to an end	Understanding chemistry will benefit me in my career.
SD	Which refers to the power or ability to make a decision for oneself without influence from outside	I put enough effort into learning chemistry.
SE	Which refers to students' confidence that they can achieve well in chemistry	I believe I can master chemistry knowledge.
GM	Which refers to the debilitating tension some students experience in association with grading in chemistry	I like to do better than other students on chemistry tests.

4.3 Learning Material

In this study, the design and development of the technology material which will bring it to support learning, called "the augmented reality (AR)" was related to content of acid-base. 3D model of molecule will be shown if smart phone detect on AR marker The AR provides secondary information which represents the animation of 3D model of molecule in microscopic and symbolic levels to support students' visualization and linked to macroscopic level which in this learning will shows a solution in the beaker before students observe the micro-particle via the AR. Figure 1 illustrates the 3D structure and behavior of the molecule.

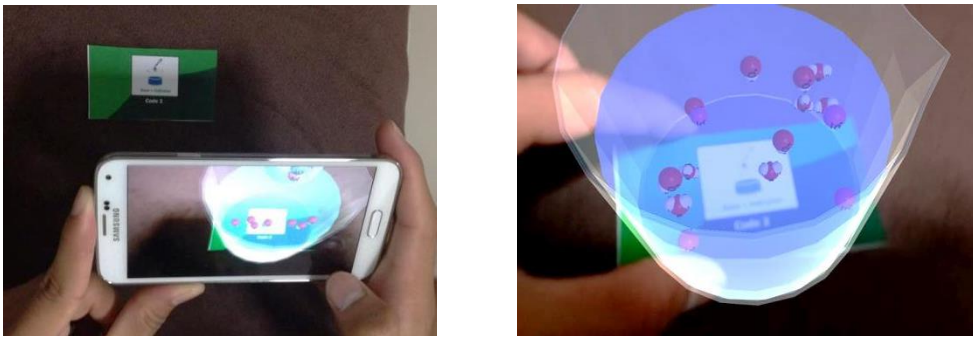

Figure 1 illustrates the 3D structure and behavior of the molecule. (Left shows viewpoint from observer which we will see both the marker and display in mobile phone. Right shows 3D structure and behavior of the molecule in mobile phone which we could move both mobile phone and marker to adjust.)

Table 2: Subscale description and sample items of the students' perception questionnaire

Subscale	Description	Sample items
PL	Extent to which students can get the new understanding, subjective evaluation of learning by learners themselves.	The AR allows me to complete my studies faster. The AR increases my learning efficiency. The AR will help me understand the things I learned.

PEU	Extent to which using to easy and help to science easier.	The AR is easy to use. Using the AR to complete course related tasks are easy.
F	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 AR. I lost track of time when I interacted. When I interacted I did not think of anything else.
PP	Extent to which students feel happy and attentiveness.	It is interesting to use AR. I feel like exploring more information when I use AR. I was totally immersed in the AR.
E	Extent to feeling of students when used game-like simulation.	I had fun playing the AR for learning science. I feel relaxed to use AR for learning science.
S	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 would like to learn with the system in the future. I would like to know if the innovative approach can be applied to other courses to improve my learning performance.

4.4 Data Collection and Analysis

The intervention class consists of 77 students. Before providing the augmented reality, students was surveyed the motivation toward chemistry. The technology perception questionnaire survey was provided to the students after they interacted with the augmented reality material. The data from two scales was analyzed the relation in each variable with Pearson's correlation in SPSS. The result of analytic with Pearson's correlation illustrate the relation of motivation toward chemistry (intrinsic motivation, career motivation, self-determination, self-efficacy and grade motivation) and perception toward augmented reality (perceived learning, perceived ease of use, flow, perceived playfulness, enjoyment and satisfaction). The influent of motivation toward chemistry on perception toward augmented reality via interaction with the augmented reality (AR) was analyzed to investigate. Figure 2 illustrates students' interaction with the mobile AR of acid-base.

Figure 2. An illustrations of students' interaction with acid-base AR using mobile phone

Figure 3 shows the procedure of the experiment. Before the interaction with the augmented reality, the students took the pre-test questionnaire (the motivation toward chemistry is the questionnaire). During the learning activity, stage 1 teacher shows two solutions in a beaker which labels as "Beaker 1 and Beaker 2" and provides the first question "What do you see in Beaker 1 and Beaker 2?" that students will answer in macroscopic level. After that, teacher guides students to visualize and imagine micro-particles and provides the second question "What is in Beaker 1 and Beaker 2?" and then, teacher mixes two solutions from Beaker 1 and Beaker 2 into Beaker 3 as a mixed-solution together with provides the third question "What will happen in Beaker 3 in microscopic level?". Students will imagine and predict the model and behavior of the micro-particle from demonstration in each group (15 minutes). Then stage 2, students observe by material learning (the augmented reality) in each group to find what is a model of molecule in microscopic level and to be able to understand how solution molecules behave in the beaker. 3D model of molecule will be shown if smart phone detect on AR marker (30 minutes). Stage 3, after observed with AR material they discuss in their group, compare the micro-particle from prediction step with observation step and explain the model and behavior of the molecule in microscopic level (30 minutes). After finished the learning activity, the students took the perception toward augmented reality questionnaire to investigate the correlation between motivation toward chemistry and perception toward augmented reality (15 minutes).

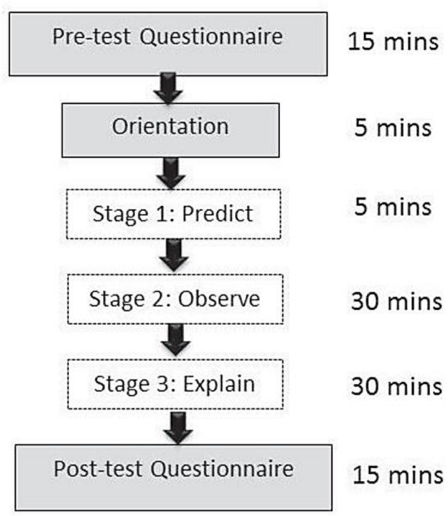

Figure 3 shows the procedure of the learning activity

The statistical data analysis techniques selected for this study were Pearson's correlation. The Pearson's correlation in SPSS was used to investigate the correlation between motivation toward chemistry and perception toward augmented reality.

5. Results and Discussion

5.1 Correlation between Motivation and Perception

In order to investigate correlation between motivation toward chemistry and perception toward augmented reality, Table 1 shows Pearson's correlation of Intrinsic Motivation (IM), Career Motivation (CM), Self-determination (SD), Self-Efficacy (SE) and Grade Motivation (GM) in the motivation toward chemistry Questionnaire (MTCQ) and Perceived Learning (PL), Perceived Ease of Use (PEU), Flow (F), Perceived playfulness (PPF), Enjoyment (E) and Satisfaction (S) in the perception toward augmented reality questionnaire (PTARQ). Mean and standard deviation are also presented in table 3.

Table 3 : Descriptive and correlation motivation toward chemistry and perception toward augmented reality.

Scale	IM	CM	SD	SE	GM	PL	PEU	F	PPF	E	S
IM	1										
CM	.709**	1									
SD	.466**	.472**	1								
SE	.324**	.249*	.492**	1							
GM	.392**	.441**	.472**	.504**	1						
PL	.067	.070	.094	.121	-.158	1					
PEU	.212	.169	.134	.173	.111	.590**	1				
F	.282*	.238*	.282*	.197	.070	.593**	.596**	1			
PPF	.183	.071	-.061	.147	-.001	.246*	.307**	.380**	1		
E	.229*	.229*	.095	.217	-.045	.473**	.602**	.522**	.373**	1	
S	.111	.175	.164	.210	-.014	.708**	.663**	.597**	.287*	.716**	1
Mean	16.56	16.87	16.91	15.35	18.12	13.00	8.61	11.90	12.97	8.55	21.60
SD	3.504	3.618	3.499	4.167	3.433	2.084	1.359	2.257	3.727	1.535	3.388

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

Regarding Pearson's correlation analysis of each scale from MTCQ, Intrinsic Motivation (IM) was positively related to Career Motivation, Self-determination, Self-Efficacy, and Grade Motivation. Career Motivation was positively related to Self-determination, Self-Efficacy and Grade Motivation. Self-determination was positively related to Self-Efficacy and Grade Motivation. Self-Efficacy was positively related to Grade Motivation. All scale positively related together, this result indicate that students have motivation to learn chemistry.

The result of PTARQ, Perceived Learning, Perceived Ease of Use, Flow, Perceived playfulness, Enjoyment, and Satisfaction were related together. From the pronouncement, it suggests that if students have only one scale of Perceived Learning, Perceived Ease of Use, Flow, Perceived playfulness, Enjoyment, and Satisfaction. They have motivation to learn via the mobile AR application. Considering Table 2, Intrinsic Motivation and Career Motivation were related to Flow and Enjoyment, but there were no significantly related to Perceived Learning, Perceived Ease of Use, Perceived playfulness, and Satisfaction, when students learned via the mobile AR. Self-determination was related to Flow but was no related to Perceived Learning, Perceived Ease of Use, Perceived playfulness, Enjoyment, and Satisfaction, when students learned via the mobile AR. Self-Efficacy and Grade Motivation were related to Perceived Learning, Perceived Ease of Use, Flow, Perceived playfulness, Enjoyment, and Satisfaction, when students learned via the mobile augmented reality. Thus, the AR could use for all students even if they have a negative or positive motivation toward chemistry.

The findings from this result indicated that perception toward augmented reality does not depend on motivation toward chemistry. Although students negative or positive motivation toward chemistry, they could learn chemistry by augmented reality.

6. Conclusions and limitations

6.1 Conclusions

The result of this study indicated the influence of motivation toward chemistry on students' perception to learn in setting of inquiry-based augmented reality learning environment that students' motivation toward chemistry has a partial impact on their perception toward mobile augmented reality. There are two dimensions, i.e. Flow and Enjoyment, which were significant related to Intrinsic Motivation, Career Motivation and Self-determination. That is, students' feeling of enjoyment and perceiving of flow of learning experience depend on the feeling of learning science for its own sake, and as a means to an end. Thus, we could use the AR for participants who have both positive and negative effect. Although they like or dislike to learn chemistry, they still have a positive perception toward augmented reality after learning with the AR. Finally, it is suitable to implement the augmented reality in a Thai school. But instructor has to design and develop correctly material to elimination of students' misconception.

6.2 Limitations

Besides providing the result of using the AR for chemistry learning in the present paper, the results investigated about the correlation between motivation and perception from the intervention with using the AR in some parts of acid-base. However, due to well-implemented investigations of AR in science learning is still a little number used in chemistry learning and Thai context. So, it may be a limitation about the articles reviewed from scholar database. Some model of the AR might be copyrights about technical graphic or business demonstrations of the AR in science learning which might limit the representation of state-of-the-art AR applications. Although, the AR could support students' visualization and imagination skills, but it is not suitable on complex mechanism or many steps of reaction in science learning. In addition, this is just some content with using the AR in science learning. In the future, it deserves to explore the possibilities of using the AR with others content or others perspective which suitable applied in science education to elaborate the efficiency of this contemporary technology.

Although there are many researchers indicated that teaching and learning with AR technology can improve students' motivation, visualization, and imagination skills, but a few study implemented the combination of AR technology and hands-on microcomputer-based laboratory. In additions, the challenge is how to immerse the AR into classroom instruction or into text book. Moreover, the most challenge which researcher is interested to design and develop the AR to support students' learning is how to immerse the AR into e-book. Based on the finding of this study, we will design and develop the AR in ebook about acid-base content use model-based inquiry (MBI) approach for improving chemistry learning in quasi-experimental design that include different-intervention groups of students. One group will provide the AR in ebook with MBI instruction and another gain traditional instruction. The mixed research methodology quantitative method of non-equivalent control group design with method of phenomenological research design will carry out in future research.

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