Motivation is Important When They Learn Chemical Equilibrium with Computer-simulated Experimentation: A Pilot Study

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Abstract: Chemical equilibrium is important and fundamental chemistry concept for studying advance chemistry topics. A numerous researches reported that students often hold alternative conceptions of science and encounter learning difficulty because of complexity and abstraction of scientific concepts. Researchers seek to discover effective way to assist students learning of science concepts meaningfully. This paper presents an examination of relationship between students' motivation toward chemistry and their perceptions toward the chemistry learning of chemical equilibrium through interacting with a computer-simulated experimentation, called Chemical Equilibrium Simulation (CE-SIM). Thirty males and forty females 11th grade students participated in this study. The result of study indicated that intrinsic motivation was significantly correlated to all constructs of perception toward computer-simulated experimentation of chemical equilibrium. Based on this finding, science teachers should concern and consider students' career motivation, self-determination, self-efficacy, and grade motivation before using CE-SIM in chemistry learning of chemical equilibrium. This implied that chemistry motivation is important for chemistry learning of chemical equilibrium through the use of computer-simulated experimentation.

Keywords: simulation, chemical equilibrium, perception, chemistry motivation

1. Introduction

In recent year, the increasing use of computer and technology is rapidly growth in science education (Vreman-de Olde, 2013). Technologies were used to be effective tools in the classroom teaching process and they become a commonplace in science-based education (Srisawasdi and Sornkhatha, 2014; Pyatt and Sims, 2011). Due to features of technology, the support of students' visualization and imagination skill is important for science learning in school science level. Moreover, technological tools could promote learning motivation and inspiration for students. Educational researchers mentioned that implementing technology-based learning environment could raise students' cognitive engagement and learning performance. (Wartella and Robb, 2007). A numerous research has found that technology can improve students' conceptual understanding of science and impacts the transformation of teaching and learning in school science classroom as being a powerful pedagogic tool in science education.

In science-based education, chemistry is an important discipline in science that nature of chemistry content is abstract and complex. As such nature, students need to use imagination for learning of chemistry (Eilam, 2004; Leite, Mendoza and Borsese, 2007). In chemistry education, the concept of chemical equilibrium is very important for studying advance chemistry topics, such as acid-base interaction, electrochemistry, and so on. However, in Thai context a numerous researches show that students often hold alternative conceptions of science and encounter learning difficulty because of complexity and abstraction of scientific concepts (Chaiyen, 2007). Because of its abstraction and complexity, enhancing of chemistry learning has an inter-relationship among three chemistry representations, including macro-, micro- and symbolic representations. Another reason is difficulty about incomplete reaction, reversibility and dynamics. (Quilez, 2004)

Currently, computer animation and simulation are powerful tools which can make unobservable phenomena being visible representation and could support students' conceptual learning in chemistry. Researches indicated that computer animation and simulation can help student reducing alternative- or misconceptions, and revise and improve conceptual understanding of scientific concepts (Srisawasdi and Kroothkeaw, 2014; Suits and Srisawasdi, 2013). Moreover, Suits and Srisawasdi (2013) mentioned that instructional computer simulation could support students; favorable perceptions of science learning through visualizing scientific phenomena both macroscopic, microscopic, and symbolic levels of chemistry representation.

Accordingly, this pilot study aims to investigate correlation between students' motivation toward chemistry, before interact with an computer-simulated experimentation, called Chemical Equilibrium Simulation (CE-SIM), and students' perception toward computer-simulated experimentation, after interacting with the CE-SIM of eleventh-grade students To address the aim of this study, the following specific question will be answered: Is there a significant correlation between students' motivation toward chemistry and students' perception toward the CE-SIM among eleventh-grade Thai students?

2. Literature review

According to the rapid growth of computers and technologies in the practice and progression of science education community, computer simulation offers students to learning of science through inquiry-based process (Rutten, 2012; Srisawasdi and anjaburee, 2015; Vreman-de Olde, 2013). Many attributes of computer simulation are potentially useful for promoting conceptual development in science and inducing cognitive mechanism of conceptual change (Srisawasdi and Kroothkeaw, 2014; Srisawasdi and Panjaburee, 2015; Srisawasdi and Sornkhatha, 2014). Currently, inquiry-based learning with computer simulations is generally seen as a promising area for conceptual change in science (Smetana and Bell, 2012). Suits and Srisawasdi (2013) mentioned the advantage of computer simulations that they could support positive perceptions and visualize scientific phenomena both macroscopic, microscopic, and symbolic level of chemistry representation. Based on visual-aids learning with simulations, its visualize features facilitate the integrated cognitive process of new knowledge and existing knowledge framework, which are important components of learning from the constructivist perspective, and improve conceptual understanding in scientific phenomena (Cook 2006; Wu and Shah 2004). With regarding benefits of computer simulation in science learning, inquiry-based learning with simulations is, currently, a promising area for science-based instruction to foster learners' mental interaction with the physical and social world in order to develop science literacy.

To address conceptual learning problems in chemistry outlined in the previous section, simulation-based inquiry learning has been becoming a pedagogical approach for enhancing students' conceptual learning and development in school science (Srisawasdi and Kroothkeaw 2014; Srisawasdi and Sornkhatha 2014). Researchers found that simulation-based inquiry learning works with remedial by producing change to the alternative conceptions held by learners, improving the performance of gaining intuitive domain knowledge, promoting more qualitative knowledge than formalized knowledge, and achieving a more theoretical focus and coherent understanding of the concepts (Srisawasdi and Panjaburee, 2015).

3. Method

3.1 Study Participants

In this pilot study, 71 eleventh-grade students (31 males and 40 females), aging 15-17 years old, in a secondary public school at northeastern region of Thailand participated the use of computer-simulated experimentation of chemical equilibrium for chemistry learning. All of them have basic skills in using information and communication technology. They were served in basic chemistry course about chemical equilibrium and they had no experience with the use of computer-simulated experimentation in science before. In additions, they had no learning experience in chemistry of chemical equilibrium yet.

3.2 Learning Material

Table 1: The goals of the sub-topics in chemical equilibrium in this study.

sub-topics	Description of main chemistry concepts
Chemical Equilibrium	This concept refers to incomplete, reversibility, dynamics reaction and definition of chemical equilibrium.
Lechateliers' Principle : Change in concentration	This concept refers to effect of disturbing equilibrium by changing concentration of substance or product in reaction on equilibrium state.
Lechateliers' Principle : Change in temperature	This concept refers to effect of disturbing equilibrium by changing temperature of reaction on equilibrium state.
Lechateliers' Principle : Change in pressure	This concept refers to effect of disturbing equilibrium by changing pressure of reaction on equilibrium state.

The Chemical Equilibrium Simulation (CE-SIM) is computer-simulated experimentation on chemistry concept of chemical equilibrium. This simulation comprises 4 main chemistry concepts: chemical equilibrium; Lechateliers' principle — change in concentration; Lechateliers' principle — change in temperature; and Lechateliers' principle — change in pressure. Table 1 describes the goals of each main chemistry concept used in this study.

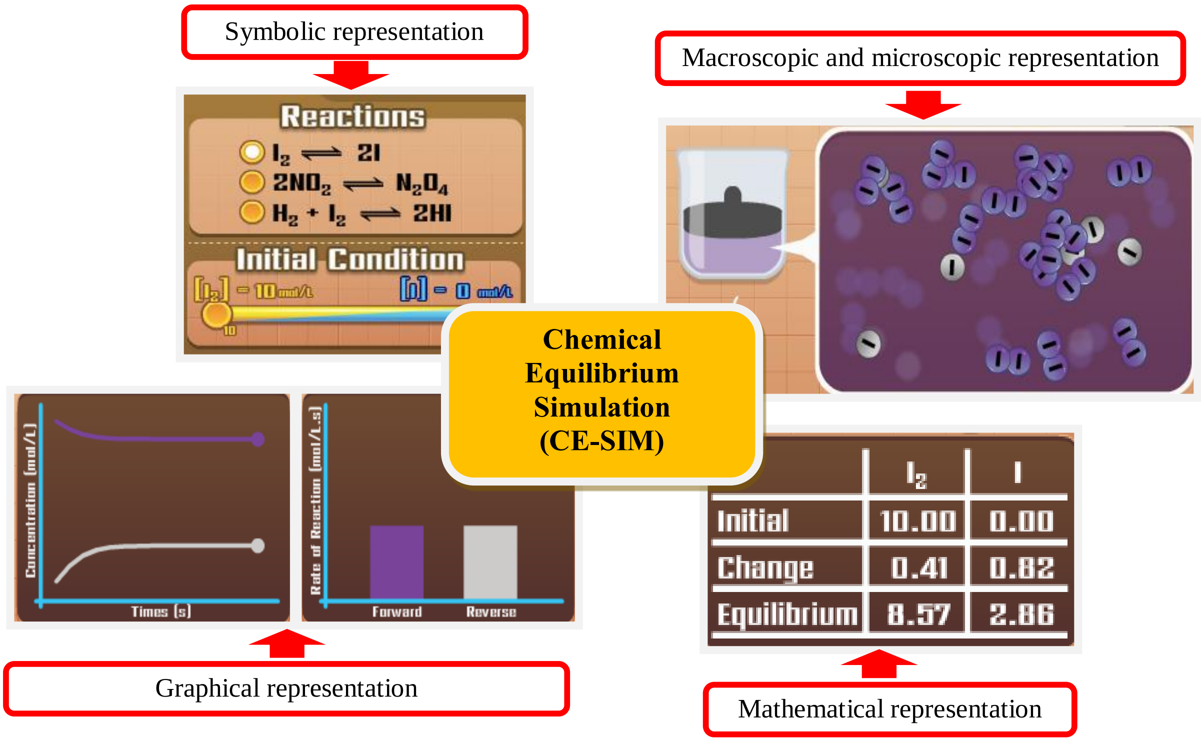

Figure 1. Representational components of the Chemical Equilibrium Simulation (CE-SIM)

To enhance chemistry learning of chemical equilibrium, the CE-SIM has been designed and created to include: (a) macroscopic level of chemical representation which presents color of observable phenomena that varies follow concentrations of substance and product in solution; (b) microscopic level of chemical representation which presents movement, collision and reaction of molecules; (c) symbolic level of chemical representation which presents chemical equations and models of molecules; (d) graphical representation which simplifies experimental data, trend line of graph between concentrations of substance and product with time, and bar graph between rate of reactions (forward and revers reaction); and (e) mathematical representation which displays amount of initial substance and products at the same time for supporting the construction of chemistry understanding related the target scientific phenomena. In additions, the CE-SIM was designed data table of substance concentration and product concentration in each step of reactions that can be used for engaging in calculation part such as equilibrium constant. Figure 1 illustrates representational components of CE-SIM

3.3 Instruments

In this study, two instruments were used to examine the relationship between students' motivation toward chemistry learning and perception toward computer-simulated experimentation. First, A 25-item chemistry motivation questionnaire (Glynn et al., 2011), developed in Thai version by Srisawasdi (2015), was used in this study. According to Glynn et al. (2011)'s suggestion, the Nanoscience Motivation Questionnaire (Srisawasdi, 2015) was revised by changing the word "nanoscience" to "chemistry" for using as a discipline-specific version of the questionnaire, and was used in this study to explore secondary school students' motivation to learn chemistry. The questionnaire consists of five subscales: Intrinsic Motivation (IM), Career Motivation (CM), Self-determination (SDT), Self-efficacy (SEC), and Grade Motivation (GM), as shows the sample items of each subscales in Table 2. Another, 18-item 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 3. For both questionnaire, all of items were rated on 5-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree. Table 2 and 3 illustrates sample items of the questionnaires used in this study and its reliability.

Table 2: Sample items of the motivation toward chemistry learning questionnaires and its reliability.

Sub-scales	Sample items	α
Intrinsic Motivation	• Learning chemistry is interesting. • Learning chemistry coherent with my diary life.	0.79
Career Motivation	• I would like to work about chemistry. • I think that is chemical knowledge useful for career progression in the future.	0.81
Self-Determination	• I use many strategies for learning chemistry. • I spend a long time to learning chemistry.	0.81
Self-Efficacy	• I am confident about understanding difficult chemical concepts. • I am confident I can pass chemistry test.	0.89
Grade Motivation	• I can get a good grade in chemistry courses. • I participate in chemistry courses to perform better than other students.	0.85

Table 3: Sample items of the perception toward computer simulation questionnaires and its reliability.

Sub-scales	Sample items	α
Perceived learning	• The Simulation allow me to complete my studies faster. • The Simulation will help me remember the things I learned.	0.80
Perceived ease of use	• The Simulation are easy to use. • Interacting with the Simulation is unambiguous and easy to understand.	0.82
Flow	• I really got into the Simulation. • I was very involved in the Simulation.	0.75
Perceived playfulness	• It is interesting to use Simulation. • I was totally immersed in the Simulation.	0.74
Enjoyment	• I had fun playing the Simulation. • Interaction with the Simulation was pleasant.	0.84
Satisfaction	• I like to learn with the simulation. • I would like to learn with the Simulation in the future	0.77

3.4 Data Collection and Analysis

Before the participants interact with CE-SIM, the motivation toward chemistry learning questionnaire was used to measure their pre-motivation toward chemistry learning for 10 minutes. Then, they interact with CE-SIM and answer three questions about chemical equilibrium: How do molecules behave when reaction reach equilibrium?, How do rate of reactions (forward and revers reaction) when reaction reach equilibrium? and How do concentrations of substance and product when reaction reach equilibrium? Total time to complete for this step was approximate 30 minutes. After interacting the CE-SIM, their post-perception toward computer simulation were examined by the perception toward computer simulation questionnaire for 10 minutes. The correlation between pre-motivation toward chemistry learning and post-perception toward computer simulation were investigated by Pearson's coefficient. Figure 2 illustrates a flow step of data collection.

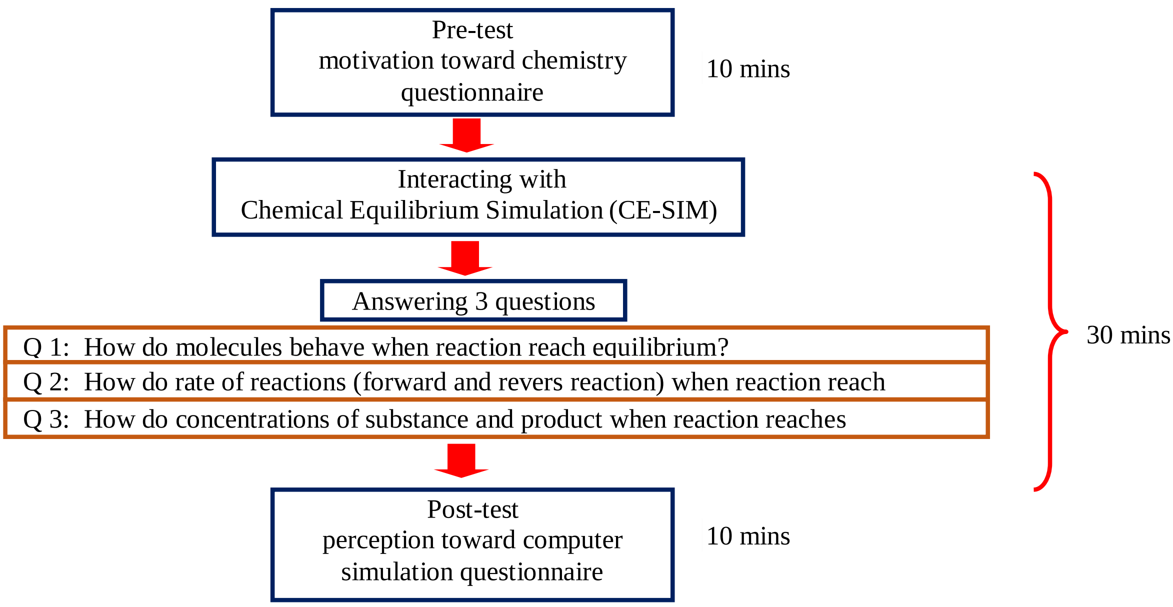

Figure 2. A flow steps of data collection in this study

4. Results and Discussion

Pearson's correlation was used to analyze relationship between motivation toward chemistry (IM, CM, SDT, SEC, and GM) before student interact with CE-SIM and perception toward computer simulation (PL, PE, F, PP, EJ, and S) after student interact with CE-SIM as shown in Table 4. Result showed that (1) Intrinsic Motivation (IM) relate together sub-scale of perception toward computer simulation, (2) Career Motivation (CM) relate together sub-scale of perception toward computer simulation except that do not relate to Perceived Learning (PL) and Satisfaction (S), (3)Self-Determination (SDT) that do not relate to 3 sub-scale were Perceived Playfulness (PP), Enjoy (EJ) and Satisfaction (S), (4)Self-Efficacy (SEC) showed no relation with Perceived Learning (PL), Enjoy (EJ) and Satisfaction (S), (5)Grade Motivation relate together sub-scale of perception toward computer simulation except do not relate to Enjoy (EJ). Table 4 illustrates correlation between motivation toward chemistry before students interact with simulation and perception toward computer simulation.

Table 4: Correlation between motivation toward chemistry before student interact with CE-SIM and perception toward CE-SIM.

Scale	IM	CM	SD	SE	GM	PL	PE	F	PP	E	S
IM	1										
CM	.645**	1									
SD	.498**	.485**	1								
SE	.612**	.513**	.448**	1							
GM	.315**	.274*	.235*	.532**	1						
PL	.345**	.227	.268	.184	.078	1					
PE	.545**	.429**	.258*	.383**	.181	.724**	1				
F	.398**	.343**	.263*	.300*	.133	.780**	.748**	1			
PP	.276*	.246*	.209	.180	.126	.791**	.712**	.733**	1		
EJ	.430**	.358**	.195	.278*	.334**	.736**	.777**	.769**	.731**	1	
S	.309**	.212	.192	.174	.158	.768**	.691**	.742**	.848**	.802**	1
Mean	18.49	19.07	16.59	16.38	18.17	15.03	11.44	14.79	11.15	11.55	15.56
SD	3.125	3.357	3.036	3.457	3.939	2.863	2.260	2.792	1.990	2.190	2.844

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

The findings from this study were as followings:

- Students' intrinsic motivation has effect to perception from learning by computer simulation.
- Students who have high or low motivation toward chemistry (except in intrinsic motivation sub-scale) could perceive learning from computer simulation. For example, students' answers in Frist question: When the reaction reached to equilibrium, reaction of iodine I_2 (g) still forward react to I (g) and iodide I also backward react to I_2 (g). Then the amount of I_2 (g) and I (g) stayed the same. Considering to the color of the reaction, it looked like the reaction was not change. (Student ID#8) It indicated student could observe and understood incomplete, reversibility of chemical equilibrium. In addition, student showed that he could integrated between microscopic level and macroscopic. In Second question: When the reaction reached to equilibrium, the concentration of I_2 (g) and I (g) have no tendency to change. According to the amount of I_2 (g) and I (g) molecules in the model still remained the same and it related to the constant concentration graph. (Student ID#24) It indicated student could descript a part of definition of chemical equilibrium and related between microscopic representation with the concentration graph.
- Students who have high or low motivation toward chemistry (except in Intrinsic Motivation sub-scale) could satisfaction from computer simulation.

5. Conclusion

The result of this study provided understanding correlation between student's motivation toward chemistry before interacting with CE-SIM and student's perception after interacting with CE-SIM. The finding indicated that Intrinsic Motivation (IM) relate together sub-scale of perception after interacting with computer simulation. Thus, we should consider students' intrinsic motivation before using CE-SIM in teaching and correlation between student's motivation toward chemistry with student's perception learning and Satisfaction is no significant. It mean student who have high or low motivation toward chemistry (except in intrinsic motivation sub-scale) could perceive learning and satisfaction from CE-SIM.

A previous study by Srisawasdi and Kroothkeaw (2014) used simulation-based open inquiry and they found that the students could develop student's conceptual learning in science inquiry. Based on the findings of this study, researcher will design next study for improving conceptual understanding and integrating knowledge by using Chemical Equilibrium Simulation-based open inquiry in quasi-experimental design that includes two different-intervention groups of students. One group will provide simulation-based open inquiry instruction and another acquire traditional instruction (5E). The mixed research methodology combined quantitative method of non-equivalent control group design with qualitative method of phenomenological research design will carry out in future research.

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