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Students' Motivation of Science Learning in Integrated Computer-based Laboratory Environment

Niwat SRISAWASDI[a*], Rungtiwa MOONSARA[b] & Patcharin PANJABUREE[c]
[a]*Faculty of Education, Khon Kaen University, Thailand*
[b]*Nampongsuksa School, Thailand*
[c]*Institute for Innovative Learning, Mahidol University, Thailand*
*niwsri@kku.ac.th

Abstract: Absolutely, teaching of science by the way of memorizing of scientific facts, what science is, and how to do science is not work for motivating student into meaningful learning in science and understanding science in the way it is. Currently, computerized technological tool is so commonplace in the practice and advancement of science education community in order to engaging student learning in science by doing, not memorizing it. The tool has been proved its potential support in instructional sciences in science classroom. According to the potential abovementioned, this paper reported an effect of integrated computer-based laboratory environment, a harmonization of hands-on computer-based experiment and interactive computer simulation, on 123 of 11th grade students in three groups: 49 science-major students; 37 technology-focused non-science students; and 37 language-focused non-science students. On a purpose, the study has implemented a series of open-inquiry science learning activity in a unit of science of fluid such as capillary action, surface tension and contact angle phenomena. The Science Motivation Questionnaire II (Glynn et al., 2011), was used to investigate their motivation toward learning of science. Results show the learning environment impacted a movement of the students' motivation toward learning of science. This implied that the teaching of science by Integrated Computer-based Laboratory Environment could be used to motivate potentially student learning in science both science and non-science major in secondary education.

Keywords: Computer simulation, hands-on experiment, inquiry, motivation

1. Introduction

Most of high school students in science courses find the subject boring, difficult and generally unnecessary for their living and future, especially for non-science-oriented careers. Traditionally, students are emphasized to develop the accumulation of propositional knowledge, correct explanation, and scientific skills, that it increasingly seen as an inadequate basis for future study and it is also inappropriate basis for developing of scientific literacy (Gilbert, 2006; Srisawasdi & Suits, 2012). Moreover, students are taught with isolated facts and they cannot form the connection of them and science teachers usually deliver the science in a manner of uninteresting thing to the student (Gilbert, 2006). This situation might provide student lack of transfer what they learned and none sense of why they should learn. Otherwise, there was traditional scientific knowledge instead of contemporary knowledge of science. The scientific knowledge was often only simple demonstrations of previously presented scientific facts. These facts do not present authentic scientific investigation to students and often rely on topics and experiments that are distant from authentic scientific inquiry in the contemporary research laboratory. As a result, students may not obtain actual valuable scientific experience from inquiry processes, and in reality, may appreciate science as a foreign thing because they cannot relate to socio-cultural, economic milieu surrounding, and particular important of scientific problems (Srisawasdi, Kerdcharoen & Suits, 2008; Srisawasdi, 2012a). Many researchers feel that this difficulty stems from the passive role the students play in a traditional class (Zoller, 2000). Absolutely, teaching of science by the way of memorizing of scientific facts, what science is, and how to do science is not work for motivating student into meaningful learning in science and understanding science in the way it is. If this is the case, then we must clearly modify the way we teach in order to develop students who are enthused about science and who really understand the material. Even students headed for non-science-oriented careers need to have an understanding and appreciation of the role science plays in their lives.

It is widely agreed that in order to achieve this end, science teaching must be shifted from traditional schooling to more constructivist-oriented instruction. Inquiry-based learning is a constructivist-informed approach process which is concerned about the cognitive development of the learner and constructivist ideas of nature of science. Inquiry learning has its origins in the practices of scientific inquiry and places a heavy emphasis on posing questions about the natural world, investigating the phenomena by gathering and analyzing data, and constructing evidence-based arguments in order to develop a rich understanding of concepts, models, theories, and principles (Krajcik & Blumenfeld, 2006; Kuhn, Black, Keselman & Kaplan, 2000) as a set of interrelated processes. Currently, computerized technological tool is so commonplace in the practice and advancement of inquiry-based science education in order to engaging student learning in science by doing, not memorizing it. The tool has been proved its potential support in instructional sciences in science classroom. Computer technologies are receiving increased attention from the science education community because of excitement about their potential to support new forms of teaching and learning and computerized classroom learning environments have the potential to overcome the management difficulties normally associated with inquiry-based learning and constructivist teaching. They can help transform the science classroom into a learning environment where students are engaged with its facilitation to actively construct deep understanding of science concepts and process through inquiry (Tinker & Papert, 1989; Linn, 1998; Novak & Krajick, 2006).

In this paper, we illustrate innovative computer-based instructional materials that have been developed from scientific laboratory research related to the field of contemporary scientific knowledge production such as self-cleaning surface and also report a result on the use of integrated computerized laboratory environment for promoting student's science motivation, both science major and non-science major secondary school student.

2. Technology-enhanced Inquiry in Science

The use, of technologies, held great promise for school science education and it was seen as an increasingly high educational priority (Thomas, 2001). As an instructional approach, modern technologies had become commonplace, in the integration of inquiry within the science classroom (Songer, 1998). The crucial idea, in promoting the students' involvement in the potential of scientific inquiry, was the use of technology to support their active inquiry. The use, of technological tools, was intended to facilitate learning and could advance teaching and learning tremendously (Waight & Abd-El-Khalick, 2007). Kim, Hannafin and Bryan (2007) guided the use of technology as a learning tool towards enhancing students learning science through inquiry. They emphasized that the tool should (1) support mindful investigations; (2) serve as meta-cognitive scaffold for building and revising scientific understanding; and (3) facilitate collaborative construction of scientific knowledge.

Engaging learners into more flexible of scientific inquiry through conducting computer-based laboratory experiment is more emphasizing in recent science education (Srisawasdi, 2012b, 2012c). Therefore, science teachers who have a critical role in implementing inquiry-based learning, especially in case of open-ended inquiry, need to know and practice to build up increasingly open-inquiry science learning process for students. Recently, the meaning of open inquiry is quite not clear yet and inquiry practitioners are still discussing about its characterizations. Buck, Bretz and Towns (2008) described the term of "open inquiry" in a way that can be used by both secondary school practitioners and university researchers as an investigation where instructor provides the inquiry question or problem and basic background, but the remaining characteristics are left open to the student, in where learners have to develop their own procedure, analysis, communication, and conclusions to address an instructor provided question. In addition, Srisawasdi (2012b) adapted specifically the idea of open inquiry into context of laboratory work with computer-based learning environment for science classroom. The matrix of open-inquiry science process for students' learning in computer-based laboratory environment presents in Figure 1.

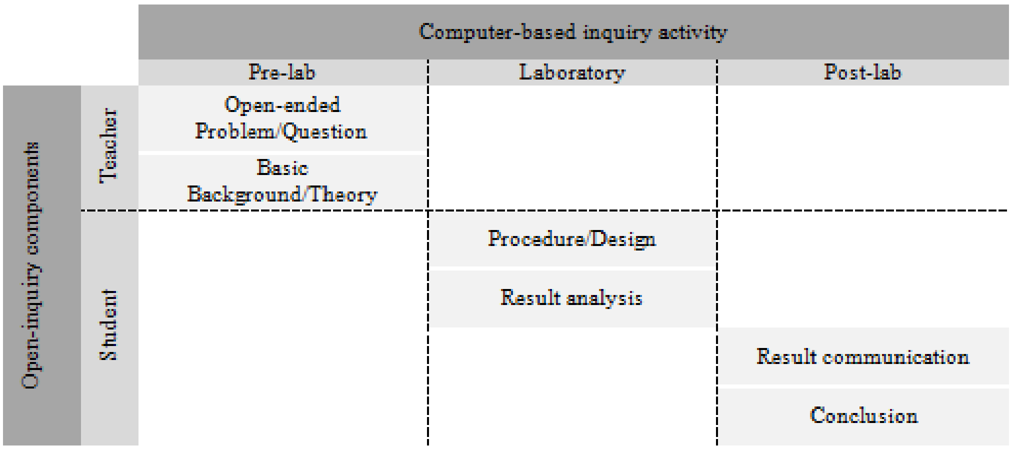

Figure 1. A matrix of open-inquiry science learning with computer-based laboratory environment (Srisawasdi, 2012b)

3. Methods

3.1 Study Participants

The participants for this study included 123 of 11th grade students in three groups: 49 science-major students; 37 technology-focused non-science students; and 37 language-focused non-science students. They attended a physics course for basic education level and were signed up voluntarily to participate in this study. All of them did have satisfactory basic ICT skills they had not any experience with using ICT for science learning before.

3.2 The Integrated Computer-based Laboratory Environment

The integrated computer-based laboratory environment is a type of science learning environment which uses two learning sources such as actual and virtual science laboratories to drive student learning in science and features by effectively incorporating computer-simulated science experiment as virtual source into hands-on science experiment as actual source. In this study, the computer-simulated science experiment and hands-on science experiment was sequentially exposed to student in a supportive manner in turn for their learning as display in Figure 2.

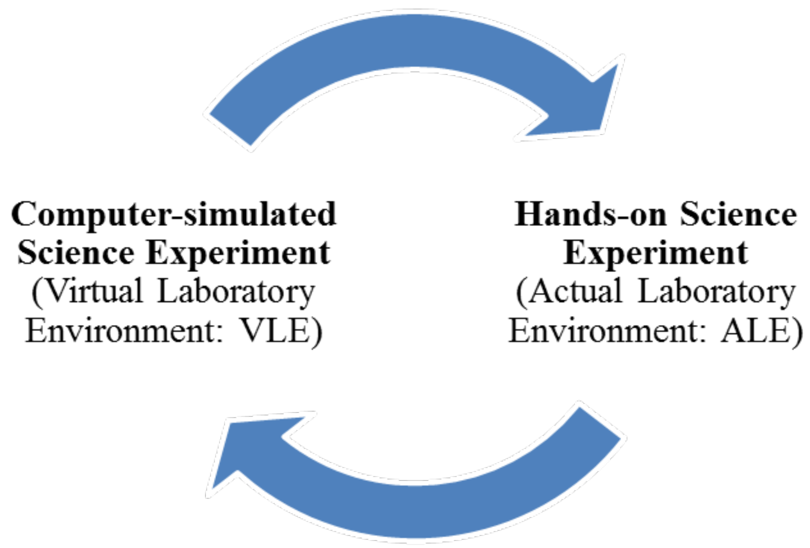

Figure 2. A representation of the in turn nature for integrated computer-based laboratory environment

3.3 Domain of Experimental Learning Events

The integrated computer-based laboratory learning experience, of contact angle measurement, consisted of three sessions including cohesive and adhesive force, hydrophilic and hydrophobic surface, and water contact angle phenomenon, as display in Table 1.

Table 1: Details of the integrated computer-based laboratory activities about surface wettability

Lab	Concept	Description	Scientific Phenomenon
Lab Activity 1	Cohesive and adhesive force; hydrogen bonds	This lab design to provide independent inquiry opportunity in order to discover factors which related to the happening of capillary action phenomenon.	Capillary action
Lab Activity 2	Hydrogen bonds; hydrophilicity and hydrophobicity	This lab design to provide independent inquiry opportunity in order to discover factors which related to the happening of surface wetting situations.	Hydrophilic/ Hydrophobic substances
Lab Activity 3	Cohesive and adhesive force; hydrophilicity and hydrophobicity; hydrogen bonds	This lab design to provide independent inquiry opportunity in order to discover factors which related to the happening of surface wetting and dewetting situation.	Contact angle phenomenon

3.4 Data Collection

For investigating the students' science motivation on their experimental learning experience of integrated computer-based laboratory environment in this study, the students were asked to respond to a 25-item survey instrument of Science Motivation Questionnaire II (Glynn et al., 2011) at both before and after participating the environment. The instrument was a Likert-type scale containing items that present five motivation components: Intrinsic Motivation (IM), Career Motivation (CM), Self-determination (SD), Self-efficacy (SE), and Grade Motivation (GM). Students respond to each item on a five-point-scale of temporal frequency ranging from "never" (0 point) to "always" (4 points). Table 2 presents example statements of item on the survey instrument.

Table 2: Scale description and sample item of the Science Motivation survey instrument

Scale construct	Construct explanation	Example of a construct item
IM	Which involves learning science for its own sakes	Learning science is interesting.
CM	Which involves learning science as a means to an end	Understanding science will benefit me in my career.
SD	Which refers to the control students believe they have over their learning of science	I put enough effort into learning science.
SE	Which refers to students' confidence that they can achieve well in science	I believe I can master science knowledge.
GM	Which refers to the debilitating tension some students experience in association with grading in science	I like to do better than other students on science tests.

3.5 Data Analysis

For analysis of the students' science motivation, their responses to the 25-item survey instrument were scored and the scores was analyzed and described quantitatively. The arithmetic mean and standard deviation were used to score their responses. The means were inferentially compared using independent samples t-tests.

4. Results

Table 3 shows the mean and standard deviation of each constructs of the science motivation including Intrinsic Motivation (IM), Career Motivation (CM), Self-determination (SD), Self-efficacy (SE), and Grade Motivation (GM) on conventional laboratory environment and integrated computer-based laboratory environment and also their comparisons. The statistical analyses of the data reveal that there are statistically significant differences on all constructs (IM, CM, SD, SE, GM) of science motivation for the student in science major. For the student in nonscience major emphasizing technology, there are statistically insignificant differences on GM only. The result also shows statistically significant differences on SD and SE for students in nonscience major emphasizing language, except IM, CM, and GM.

Table 3: Statistical descriptions and results of comparison of science motivation constructs between integrated computer-based laboratory environment and conventional laboratory environment for three groups of student

Motivation Construct	Science Major			Nonscience Major (Emphasizing technology)			Nonscience Major (Emphasizing language)		
	Conven-tional	Integrated	*p*-value	Conven-tional	Integrated	*p*-value	Conven-tional	Integrated	*p*-value
Intrinsic Motivation (IM)									
M	13.37	16.07	.000*	13.43	15.29	.010*	14.13	14.79	.367
SD	3.48	2.43		3.24	2.72		3.07	2.97	
Career Motivation (CM)									
M	14.00	16.07	.001*	13.00	14.43	.043*	12.26	13.50	.120
SD	3.46	2.43		3.15	2.71		4.10	2.67	
Self-determination (SD)									
M	11.89	14.39	.000*	11.89	14.75	.000*	11.09	13.86	.002*
SD	2.91	2.92		3.57	2.71		4.46	3.09	

Motivation Construct	Science Major			Nonscience Major (Emphasizing technology)			Nonscience Major (Emphasizing language)		
	Conven-tional	Integrated	*p*-value	Conven-tional	Integrated	*p*-value	Conven-tional	Integrated	*p*-value
Self-efficacy (SE)									
M	10.63	14.13	.000*	11.48	13.50	.029*	11.09	13.86	.002*
SD	3.47	3.53		4.09	3.58		4.46	3.09	
Grade Motivation (GM)									
M	14.37	16.48	.003*	14.78	16.00	.087	12.80	14.32	.076
SD	3.69	2.94		3.62	2.40		3.87	3.28	

* *p* value< 0.05

In a summary for Table 3, the integrated computer-based laboratory environment could positively promote better science major students' science motivation than conventional laboratory environment. Especially, the positive on self-determination and self-efficacy of science motivation is also achieved for both nonscience major students. In an addition, the nonscience major student emphasizing technology is positively promoted in intrinsic and career motivations by the integrated computer-based laboratory environment. Nevertheless, the integrated computer-based laboratory environment could not motivate both of nonscience major students in science grade expectation.

In order to compare science motivation on each construct among different groups of student after interacting with the integrated computer-based laboratory environment, Table 4 show the results of comparison.

Table 4: Statistical descriptions and results of comparison of science motivation construct between science and nonscience major students

Motivation Construct	Group	Statistical Comparison: ANOVA Mean(SD)	ANOVA *p*-value	Pair-wise comparison
IM	Science Major (N=49)	a=16.40(2.51)	.125	a>b a>c b>c
	Nonscience Major (Emphasizing technology) (N=37)	b=15.46(2.62)		
	Nonscience Major (Emphasizing language) (N=37)	c=15.27(2.96)		
CM	Science Major (N=49)	a=16.07(2.43)	**.004***	**a>b*** **a>c*** b>c
	Nonscience Major (Emphasizing technology) (N=37)	b=14.46(3.11)		
	Nonscience Major (Emphasizing language) (N=37)	c=14.14(2.91)		
SD	Science Major (N=49)	a=14.39(2.92)	.905	a<b a>c b>c
	Nonscience Major (Emphasizing technology) (N=37)	b=14.54(2.83)		
	Nonscience Major (Emphasizing language) (N=37)	c=14.24(2.81)		
SE	Science Major (N=49)	a=14.13(3.51)	.863	a>b a<c b<c
	Nonscience Major (Emphasizing technology) (N=37)	b=13.81(3.56)		
	Nonscience Major (Emphasizing language) (N=37)	c=14.27(3.03)		
GM	Science Major (N=49)	a=16.48(2.94)	**.023***	a>b **a>c*** b>c
	Nonscience Major (Emphasizing technology) (N=37)	b=16.16(2.68)		
	Nonscience Major (Emphasizing language) (N=37)	c=14.73(3.21)		

In a summary for the Table 4, the integrated computer-based laboratory environment has impact indifferently on IM, SD, and SE for all student groups. This means the laboratory environment could involve their learning science for its own sakes. Moreover, it made believe and confidence in their own performance over their learning of science in the same for all groups. However, the impact of the environment on CM and GM was different for the student groups. The result indicated that the perceiving of career motivation for science and non-science major students was significantly different, and the perceiving of grade motivation, particularly, for science and non-science major emphasizing language was also significantly different. This means that the laboratory environment provided the involvement of learning science as a means to an end and the debilitating tension which students experience in association with grading in science for science major student greater than non-science major students.

5. Conclusion

This paper reported on the use of integrated computer-based laboratory environment to promote student's science motivation by comparing of science and non-science major student in the context of Grade 11 secondary school student. On the comparing of between conventional laboratory environment and integrated computer-based laboratory environment, all groups of student (both science and non-science major student) were getting promotion on their own self-determination and self-efficacy. Particularly, the science major students were completely getting promotion on their motivation towards science learning by the use of integrated computer-based laboratory environment. This implied that the laboratory environment could be used effectively to transform science motivation for science major and non-science major emphasizing technology students. For non-science major emphasizing language students, they were motivated on their own believe and confidence that they can perform and achieve well in science only. This implied that the laboratory environment supported credibility of learning in science. In an effort to better serve changing science learning environment into more motivated learning environment especially for both science and non-science major student, the finding illustrates that integrated computer-based laboratory environment could be particularly considered as a core attributes for motivating student learning in science. It should be used to help taking them into loving in learning of science.

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