A COMPARATIVE STUDY ON SELF-EFFICACY FOR PERFORMING LEARNING INQUIRY TASKS AND ATTITUDES TOWARD LEARNING CHEMISTRY THROUGH INQUIRY-BASED LABORATORIES IN GRADES 9-12 STUDENTS AT CONCORDIAN INTERNATIONAL SCHOOL, THAILAND

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Abstract: The purpose of conducting this research was to determine students' self-efficacy as well as attitudes toward learning chemistry of middle and high school students before and after learned inquiry-based laboratories. The inquiry-based laboratory offered many benefits to students without difficulties of planning and performing laboratory for science classes. The inquiry-based laboratory process was comprised of developing a hypothesis, designing an experiment, and interpreting data. The attitudes toward learning chemistry were favorable views about laboratory skills, lectures, and real-world applications of the students. The students' self-efficacy and attitudes toward learning chemistry were collected through valid and reliable survey called Student Perceptions in Chemistry Evaluation (SPiCE) created by Winkelmann, Baloga, Marcinkowski, Giannoulis, Anquandah, and Cohen (2014). Pre- and post-evaluations were given to grades 9-12 students (n=48) after finishing the pre-lab session and post-lab session respective. Results indicated no response on students' self-efficacy and attitudes toward learning chemistry. Discussions of what factors might affect the results were presented along with recommendations for teachers and future researchers.

Keywords: Self-efficacy, Inquiry-based laboratory, Attitudes toward Chemistry.

Introduction

Science laboratory experiments are based on observing and/or conducting experiments in the laboratory room or in the field. The laboratory experience which includes laboratory activities, people, and materials plays a distinctive role in science curriculum and education. It enables students to vividly understand the theory and concept of science. The purpose of learning through laboratory experiences is to build practical, cognitive, and affective skills. Laboratory experiences directly provide

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hands-on experiences for students and allow students to have an opportunity to learn practical skills. Additionally, laboratory experiences can strengthen student's cognitive skill. Laboratory activities encourage students to know, understand, and apply conceptual and theoretical knowledge to use in the real-world situation. Affective skills can be acquired by learning laboratory experiments as well. If students have affective learning skills, they will show enthusiasm, motivation, and positive attitudes toward science. A study by Winkelmann, Baloga, Marcinkowski, Giannoulis, Anquandah, and Cohen (2014) reported the benefits of learning research-inspired modules on cognitive and affective skill development. The study showed the improvement of confidence among women and men, science and engineering students after they learned research-inspired modules. The authors also found that the research-inspired modules increased knowledge gains and future career possibilities of students in Science, Technology, Engineering, and Mathematics (STEM) education fields compared with the traditional laboratories method. However, students having high confidence in their ability (self-efficacy) to learn science might not participate in science. According to the study, the authors indicated additional factors; choices of college classes and careers, attitudes about chemistry, and students' anxiety in lab rooms, that could cause some students to leave the STEM major.

In the participating school (Concordian International School), the number of students who chose to study science subjects for their IB diploma program and for STEM fields declined gradually. After observing the number of students who took science subjects (Chemistry, Biology, & Physics) for Diploma Program during 2011-2014, the researcher has found that the number of students has declined each year since 2011. Most students took one or two science subjects for the two-year Diploma Program (11^{th} -12^{th} graders). There was only one student who studied three subjects for one year and none of them took three subjects for two years. On the other hand, the number of students who took other subjects such as languages and arts has increased each year. After preliminarily asking students who studied languages and art subjects, the researcher found that most of them have thought that science subjects were too difficult to understand. Science subjects were hard to be applied and analyzed in terms of concepts and theories. Moreover, even science majors said that the lessons were unrelated to the real world.

Research Objectives

The objectives of this study are:

1. To determine the level of Concordian International School students' self-efficacy in learning inquiry tasks of grades 9-12 students studying chemistry on pretest and posttest.
2. To determine the level of Concordian International School students' attitudes toward learning chemistry of grades 9-12 students on pretest and posttest.
3. To determine the level of Concordian International School students' attitude toward laboratory skills of grades 9-12 students studying chemistry on pretest and posttest.

4. To determine the level of Concordian International School students' attitude toward lectures of grades 9-12 students studying chemistry on pretest and posttest.
5. To determine the level of Concordian International School students' attitude toward real world applications of grades 9-12 students studying chemistry on pretest and posttest.
6. To determine if there is a significant difference of Concordian International School students' self-efficacy in learning inquiry tasks of grades 9-12 students studying chemistry between pretests and posttests.
7. To determine if there is a significant difference in Concordian International School students' attitudes toward learning chemistry of grades 9-12 students on pretests and posttests.
8. To determine if there is a significant difference in Concordian International School students' attitude toward laboratory skills of grades 9-12 students studying chemistry between pretests and posttests.
9. To determine if there is a significant difference in Concordian International School students' attitude toward lectures of grades 9-12 students studying chemistry between pretests and posttests.
10. To determine if there is a significant difference in Concordian International School students' attitude toward real world applications of grades 9-12 students studying chemistry between pretests and posttests.

Theoretical Framework

Self-Efficacy

Self-efficacy as defined by Bandura (1993) was the belief in own abilities to accomplish goals or tasks. Bandura (1997) explained that self-efficacy could be influenced by four processes namely 1) mastery experience, 2) vicarious experience, 3) verbal or social persuasion, and 4) physiological and affective states. People who have perceived self-efficacy believe in their abilities and felt confident after they have learned and experienced things by practicing problem solving and learning concepts. Vicarious experience defined people who saw others with similar background and capabilities performing tasks as perceived self-efficacy ones. They believed that every task could be accomplished and every difficult problem could be solved. People who had verbal or social persuasion were also influenced by a positive feedback on their performances. This social belief could drive and motivate people to complete tasks. Lastly, physiological and affective states were processes that explained how to effectively cope with stress. Whenever people had physiological and affective states face with stress, they could manage difficulties wisely.

Inquiry Learning

The inquiry learning was developed from constructivist learning theory (Cullen, 2015). It involved developing a hypothesis, designing a procedure, and interpreting data, and working collaboratively. When students started doing the inquiry-based laboratory, they were expected to read through sample questions from selected topics assigned by teachers. The sample questions helped students to develop their own

designed laboratory. Then students selected topic, developed their own hypothesis, and planed a procedure. In the next section, students tested hypothesis and collected data. Finally, students evaluated their data with lab mates, other groups, and teachers and started writing their lab report. Teachers and teacher assistants were questioners and facilitators to students. They should not provide an answer to students directly.

The researcher recognized that the implementation of this inquiry laboratory differed from classroom to classroom based upon teachers, students (grades 9-12), and topics. However, the inquiry-based laboratory had specific characteristics. It was different from traditional laboratory (verification experiment) as following:

1. Students worked collaboratively in groups of three to four members.
2. Students had control over their experiments completely. They designed their own experiment by starting with selecting topic, developing a hypothesis, designing a procedure, testing the hypothesis, collecting data, and writing a lab report.
3. Students worked during class hour with facilitation presented by teachers and teacher assistants.

Methodology

Research Design

The study used a comparative design by surveying the students' self-efficacy in performing inquiry-based laboratory as well as attitudes toward learning chemistry. Quantitative data were collected from the survey to find mean (M) and standard deviation (SD) of students' self-efficacy in learning the inquiry skills, attitudes toward learning chemistry, attitude toward laboratory skills, attitude toward lectures, and attitude toward real world applications. Then two statistical values (M & SD) were calculated by using paired samples t-test, two-tailed from data analysis program.

Population

The population was comprised of middle and high school students from grades 9-12 studying at Concordian International School, Thailand in academic year of 2015-2016. All 9^{th} and 10^{th} grade students took three science subjects: chemistry, biology, and physics. Then, students who want to attend into the STEM field at the University level would select a science class in grades 11 and 12. They were able to enroll in one, two, or all science subjects (chemistry, biology, and physics) depending on their interests.

Sample

Students from grades 9-12 were samples of this study. Grades 9-10 students learned chemistry subject for one semester. Grades 11-12 were attending at least one science subject course from three science subjects namely chemistry, biology, and physics in 2015-2016 academic years. According to the school science curriculum, the chemistry became a selected subject for grades 11 and 12 students. Therefore, there were 48 samples that represented the whole population; students from grades 9-12 chemistry classes at Concordian International School, Thailand. All students were

invited to evaluate the pre-lab activities and post inquiry laboratory activities. In April, 2016, all responses from these samples were collected.

Collection of Data

As a part of consent, the principal of Concordian International School gave the researcher a permission to conduct the study.

- After receiving the school approval in November, 2015, the researcher introduced the SPiCE to students (grades 9-12) during homeroom 20 minutes before class.
- The SPiCE was distributed for the first time in January, 2016, after each class finished practicing pre-lab activities. The SPiCE was administered to students during homeroom to ensure the highest return rate which was 100 % in this study.
- From January, 2016 to April, 2016 the same group of students performed the inquiry-based laboratory. The same SPiCE was distributed after they finished practicing the inquiry-based laboratories considered as the post lab session of this research. Students were asked to fill out the SPiCE during homeroom 20 minutes before class.
- Then the SPiCE responses were collected and analyzed for the results in May, 2016.

Data Analysis

The SPiCE surveys were divided into two parts: pre-laboratory session and post inquiry-based laboratory session. To find out the level of student's self-efficacy to perform inquiry tasks and attitudes toward learning chemistry, the two values; Mean (M) and Standard deviation (S.D.) were calculated from the SPiCE. Data analysis program was used to statistically analyze the responses. The researcher determined M and S.D. of students' agreement on questions of pre and post lab questionnaires. Then the two statistical values (M & S.D.) from the pre-lab session were compared to those of post lab session by using paired samples t-test, two-tailed from data analysis program

Results

Findings associated with each aspect of the research objectives were presented as following:

The results regarding to students' self-efficacy in learning inquiry tasks were illustrated in Table 1.

Table 1: Mean Score (M) and Standard Deviation (S.D.) of Pre/Post Analyses of Self-Efficacy Subscale in Learning Inquiry Tasks by Grade Level

Grade	Test	M	S.D.	Interpretation	n
9	Pre	3.38	0.39	Moderate	21
	Post	3.58	0.55	High	
10	Pre	3.28	0.37	Moderate	16

Table 1: Mean Score (M) and Standard Deviation (S.D.) of Pre/Post Analyses of Self-Efficacy Subscale in Learning Inquiry Tasks by Grade Level

Grade	Test	M	S.D.	Interpretation	n
	Post	3.34	0.24	Moderate	
11	Pre	3.50	0.36	Moderate	6
	Post	3.42	0.51	Moderate	
12	Pre	3.53	0.48	High	5
	Post	3.43	0.56	Moderate	
Total	Pre	3.42	0.26	Moderate	48
	Post	3.44	0.33	Moderate	

The total pre and post score of attitudes toward learning chemistry were calculated and shown in Table 2.

Table 2: Mean Score (M) and Standard Deviation (S.D.) of Pre/Post Analyses of all Attitudes toward Learning Chemistry of Grades 9 to 12 Students (n = 48)

Variable	Test	M	S.D.	Interpretation
Attitudes toward learning chemistry	Pre	3.41	0.56	Neutral
	Post	3.45	0.57	Neutral

The results relating to students' attitudes toward laboratory skills were illustrated in Table 3.

Table 3: Mean Score (M) and Standard Deviation (S.D.) of Pre/Post Analyses of Attitude toward Laboratory Skills by Grade Level

Grade	Test	M	S.D.	Interpretation	n
9	Pre	3.51	0.39	Satisfied	21
	Post	3.50	0.77	Neutral	
10	Pre	3.40	0.90	Neutral	16
	Post	3.42	0.61	Neutral	
11	Pre	3.51	0.82	Satisfied	6
	Post	3.48	0.71	Neutral	
12	Pre	3.72	0.76	Satisfied	5
	Post	3.75	1.11	Satisfied	
Total	Pre	3.56	0.64	Satisfied	48
	Post	3.53	0.70	Satisfied	

The results relating to students' attitude toward lectures were illustrated in Table 4.

Table 4: Mean Score (M) and Standard Deviation (S.D.) of Pre/Post Analyses of Attitude toward Lectures by Grade Level

Grade	Test	M	S.D.	Interpretation	n
9	Pre	3.49	0.35	Neutral	21
	Post	3.39	0.42	Neutral	

Table 4: Mean Score (M) and Standard Deviation (S.D.) of Pre/Post Analyses of Attitude toward Lectures by Grade Level

Grade	Test	M	S.D.	Interpretation	n
10	Pre	3.49	0.42	Neutral	16
	Post	3.48	0.23	Neutral	
11	Pre	3.19	0.34	Neutral	6
	Post	3.21	0.42	Neutral	
12	Pre	3.38	0.55	Neutral	5
	Post	3.84	0.65	Satisfied	
Total	Pre	3.38	0.27	Neutral	48
	Post	3.48	0.33	Neutral	

The results regarding to students' attitude toward real world applications were illustrated in Table 5.

Table 5: Mean Score (M) and Standard Deviation (S.D.) of Pre/Post Analyses of Attitude toward Real World Applications by Grade Level

Grade	Test	M	S.D.	Interpretation	n
9	Pre	3.30	0.27	Neutral	21
	Post	3.22	0.55	Neutral	
10	Pre	3.27	0.40	Neutral	16
	Post	3.35	0.28	Neutral	
11	Pre	3.20	0.42	Neural	6
	Post	3.06	0.58	Neutral	
12	Pre	3.41	0.48	Neutral	5
	Post	3.68	0.35	Satisfied	
Total	Pre	3.28	0.22	Neutral	48
	Post	3.33	0.35	Neutral	

Table 6: Result of Paired-Sample T-test Analysis of Self-Efficacy Subscale and Attitude Subscales from Grades 9 to 12 Students (n=48)

Variable	Pre-test		Post-test		t	Significance
	M	S.D.	M	S.D.		
1. Self-efficacy	3.42	0.26	3.44	0.33	-0.287	0.793
2. Attitudes toward learning chemistry	3.41	0.56	3.45	0.57	-0.592	0.556
3. Attitude toward laboratory skills	3.56	0.64	3.53	0.70	0.581	0.580
4. Attitude toward lectures	3.38	0.27	3.48	0.33	-0.287	0.793
5. Attitude toward real world applications	3.28	0.22	3.33	0.35	-0.354	0.747

Table 6 indicated that 1) there was no significant difference of Concordian International School students' self-efficacy in learning inquiry tasks of grades 9-12 students studying chemistry between pretests and posttests. 2) There was no significant difference in Concordian International School students' attitudes toward learning chemistry of grades 9-12 students between pretests and posttests. 3) There was no significant difference in Concordian International School students' attitude

toward laboratory skills of grades 9-12 students studying chemistry between pretests and posttests. 4) There was no significant difference in Concordian International School students' attitude toward lectures of grades 9-12 students studying chemistry between pretests and posttests. 5) There was no significant difference in Concordian International School students' attitude toward real world applications of grades 9, 10-12 students studying chemistry between pretests and posttests.

Conclusions

Research findings could be concluded and presented in the following paragraphs.

The result showed that the inquiry-based laboratories had no impact on students' self-efficacy toward learning inquiry tasks for all grades 9-12 students. It implied that students' belief in their abilities to formulate a hypothesis, design an experiment, and interpret lab results did not change after studying the inquiry-based laboratories.

Secondly, the attitude toward laboratory skills level of all students mostly remained unchanged after learning the inquiry-based laboratory. The results indicated that students' attitude toward understanding purpose of laboratories, laboratory procedures, and laboratory techniques did not change after the implementing of the first inquiry-based laboratory of this semester.

Moreover, the researcher found that there was no impact of the inquiry-based laboratories on attitude toward lectures in grades 9 to 12 students. The result indicated that the lectures were not interested and benefit for students since they showed a generally negative response.

Finally, the results showed no impact on students' attitude toward real world applications after grades 9 to 12 students learned the inquiry-based laboratory. According to the result, the real-world relevancy of the inquiry-based laboratory was not relevant to all students (grades 9-12).

In summary, the students' self-efficacy in learning chemistry, attitude toward laboratory skills, attitude toward lectures, and attitude toward real world applications neither increased nor decreased significantly after the implementation of the first inquiry-based laboratory for one semester.

Discussion

The lack of impact of the inquiry-based laboratory on students' self-efficacy toward learning chemistry and attitudes toward learning chemistry could be resulted from five factors: factors affecting self-efficacy, disconnecting laboratory works with lectures, timing for conducting survey, teachers' experience in the inquiry, and student readiness.

Regarding self-efficacy, contrary to expectations and previous research, the self-efficacy of grades 9-12 students did not change after learning inquiry-based laboratories. According to the study of Winkelmann et al. (2014), the four factors affecting self-efficacy belief were prior knowledge, self-interest, attitude about chemistry, and anxiety in labs. The researcher did not study self-efficacy of students based on these factors because the sample in this study was small. As reported in this study, the reliability of the pre- and post-tests were 0.67 and 0.61 respectively. This low reliability indicated that this study needed to collect more data to make the results more reliable.

Regarding attitudes toward learning chemistry, contrary to expectations, the lack of impact of the inquiry-based laboratory on attitude toward laboratory skills, lectures,

and real-world applications of grades 9-12 students were observed in this study. However, it was important to note that the inquiry-based laboratory was a part of chemistry course. The lecture (teaching theories) played an important role in learning chemistry. It was undeniable that connections between the laboratory and the lecture should be relevant. Two parts should be complementary and support what students learned in the other. A disconnection between the lab and the lecture might have a negative impact on students' learning. In this study, each grade level had different results. The negative findings on the study might result from the connection issue between the laboratory and the lecture.

Another factor, timing for conducting survey has been reported as a predictor of success in learning inquiry. According to the research procedure, the surveys were conducted after the first implementing the inquiry-based laboratory of this semester. The researcher believed that if students became accustomed to the inquiry-based laboratory, they would be able to handle their assigned experiments confidently and understandably. However, negative results to this study were observed. So, this question; When would be the best time to do the research survey on participants in this study? should be answered in the further studies.

Moreover, teachers played an important role in the inquiry learning. The teachers having experiences in teaching the inquiry-based laboratory had enormous impact on students' cognitive development (critical thinking skills), and affective development (attitudes, motivation, and interest). Therefore, teacher experiences in teaching inquiry-based laboratories should be observed and identified for the study. The chemistry teacher for this study had 2 years experiences in teaching and had no experience in teaching inquiry learning before.

Fifth, according to Piaget's concrete operational stages of cognitive development, grades 9-12 students should understand abstract chemistry concept and theories as well as think logically and reasonably. However, this theory did not align with what happened in the real situation. Student readiness was a student's understanding and knowledge towards the learning topics and a student's ability to connect prior knowledge with laboratory works. If students had high readiness, they should be able to contribute positive responses to this study.

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