A COMPARATIVE STUDY OF GRADE 8 SCIENCE STUDENTS' ACADEMIC ACHIEVEMENT UNDER TEACHER-CENTERED LEARNING METHOD AND INQUIRY-BASED LEARNING METHOD AT THE DEMONSTRATION SCHOOL OF RAMKHAMHAENG UNIVERSITY IN BANGKOK, THAILAND

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Abstract: The purpose of this study was to compare students' academic achievement under two different teaching methods which were teacher-centered learning method and inquiry-based learning method. Two groups of Grade 8 students of The Demonstration School of Ramkhamhaeng University (DSRU), Bangkok, Thailand comprised the sample for this research. The study was conducted over a period of seven weeks from February 2019 to April 2019. The science achievement scores were analyzed by means, standard deviations, a paired sample t-test and an independent samples t-test (one-tailed). The findings of the study did not show a significant difference between teacher-centered learning method and inquiry-based learning method. Recommendations have been suggested for the school, teachers, students and future researchers.

Keywords: Teacher-centered learning method; Inquiry-based learning method; Comparative study; Pre-test; Post-test; Academic achievement

Introduction

The Thailand National Education Act 1999 announced science as one of the core subjects in Thai schools. Science and technology are absolutely necessary in presenting advanced solutions to the challenges of today's society (Gluckman, 2011). In order to compete in today's high-tech society, students need to expand their skills and abilities in STEM education - science, technology, engineering and mathematics - to higher and more competitive levels. STEM subjects must be taught in the classrooms from primary to university level. Thus, Thailand can accomplish continuous economic

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development (Boonruang, 2015). To develop Thai students' science skills, it is essential to generate their motivation for learning science and use different teaching-learning methods in order to evaluate those which best fit individual classes (Fredrickson, 2017).

The Demonstration School of Ramkhamhaeng University is located in Bangkok, Thailand. The school provides an English Program (EP) for students where English is the medium of instruction in all except Thai language classes. The teaching approach in DSRU is basically teaching-centered learning method where the teacher is the center of attention and students take notes, with minimal teacher-student and student-student interaction. As Thais, the students are non-native English speakers, but they are communicatively fluent in English.

The researcher has worked at DSRU for one year as a math-science teacher and has observed the students' struggle in learning science. Therefore, introducing a new learning method could provide an opportunity for students to learn science in a more tangible and challenging context.

Research Objectives

The following research objectives were used in this study.

1. To determine Grade 8 students' academic achievement for learning science under teacher-centered learning method in pre-test and post-test at The Demonstration School of Ramkhamhaeng University in Bangkok, Thailand.
2. To determine if there is a significant difference in Grade 8 students' academic achievement for learning science under teacher-centered learning method between pre-test and post-test at The Demonstration School of Ramkhamhaeng University Bangkok, Thailand.
3. To determine Grade 8 students' academic achievement for learning science under inquiry-based learning method in pre-test and post-test at The Demonstration School of Ramkhamhaeng University in Bangkok, Thailand.
4. To determine if there is a significant difference in Grade 8 students' academic achievement for learning science under inquiry-based learning method between pre-test and post-test at The Demonstration School of Ramkhamhaeng University in Bangkok, Thailand.
5. To determine if there is a significant difference in Grade 8 students' academic achievement for learning science under teacher-centered learning method and inquiry-based learning method between their post-tests at The Demonstration School of Ramkhamhaeng University in Bangkok, Thailand.

Theoretical Framework

This study was carried out on the basis of two major theories.

Skinner's Behaviorism Theory.

Skinner's behavioral learning theory is formed on the idea that learning and reinforcement can direct human and animal behavior (McLeod, 2017). Learning happens where new behaviors or any change in behaviors are obtained by constructing connections between stimuli and responses (Bransford, Brown & Cocking, 2000). The reinforcement can be positive such as praise and rewards in classrooms or negative results in some form of punishment. Positive reinforcement encourages desirable learning behaviors while negative reinforcement discourages undesirable learning behaviors. These types of classrooms are ruled by teachers. Teachers control the whole learning and teaching process and are responsible for managing the students' behaviors. This method is called teacher-centered learning method and its effectiveness relies on the teachers 'directions and reinforcement feedback.

Bruner's Constructivist Theory.

Bruner's social constructivism learning theory (1961) argued that education is not to provide knowledge but to facilitate students' thinking for themselves in constructing meaning so as to develop their problem-solving skills. Bruner suggested that learners build their own knowledge and do this by organizing and categorizing information using a cognitive coding system. He believed that teachers should not teach information by rote learning as is often the case in teacher-centered classrooms, but instead facilitate the learning process, guiding students in developing their own thinking. In order to approach this, teachers should design lessons that give the information students need and help them discover the relationships among items of information. To do this, students should ask questions and discover and evaluate what they learn. It underlines how students develop the scientific concepts by using a series of inquiry processes. In order to help, or facilitate, students in developing their understanding of scientific concepts, an inquiry-based learning method, utilizing the BSCS 5E Instructional Model was used in this study.

The 5E Model was introduced by the Biological Sciences Curriculum Study in 1987 to promote active learning. In this model, the focus area is on engaging, exploring, explaining, elaborating, and evaluating (Duran & Duran, 2004). Engagement creates interest and curiosity.

Literature Review

Science Education.

Science has an important role in human life providing technological devices and products that make peoples' lives easier and better. Science subjects in schools help students think of different opportunities for their future careers and enable them to become effective members of their society and help them develop successful ways of thinking (United Nations Educational, Scientific and Cultural Organization, 2010). Through learning science, students will understand how the universe works. Science helps students understand the functioning of the human body system, space, and recent technologies. Students develop decision-making and problem-solving skills and learn new concepts in science education. Science answers students' questions about their environment and helps them reason out the phenomena around them, thus satisfying their curiosity. Science creates interest and students who are highly motivated and have high science academic achievement have develop powerful critical thinking abilities (Hom, 2014).

Twenty-first Century Skills and STEM Education.

The word STEM stands for science, technology, engineering, and mathematics and represents a curriculum which integrates the four disciplines into a learning pattern in order to meet real-world needs (Hom, 2014). To pursue this matter, Thai students are required to achieve important and essential work skills and be creative and innovative. The STEM approach draws students to apply knowledge in daily life challenges. New solutions and processes can bring advantages to their lives. STEM learners will be ready to function in many sectors such as industry, energy, agriculture, and transportation (Boonruang, 2015).

Given that the education system of Thailand, unlike that of several of its neighboring countries, which unlike Thailand had been colonized, has developed largely nativistically following its own cultural imperatives, the education reform movement over the past few decades has had a mixed record of success, especially in introducing student-centered teaching-learning methods (Michael, 2018). As well, insufficient awareness and knowledge about STEM education has made it difficult for many schools in Thailand to implement it. It requires time for teachers and education influencers to comprehend the necessity of this new approach. Utilizing activities to improve students' problem-solving skills and challenge them is a must. In order to trigger economic status enhancement, STEM education must be aligned with 21st century skills development (Manosuttirit, 2016).

The Thai Education System.
The Thai Ministry of Education provides twelve years of free education from pre-school to high school and 9 years of compulsory attendance (Ministry of Education Thailand, 2008). The education system in Thailand is composed of 12 years of education which is six years of elementary school, three years of middle school and three years of high school. Thai students have the Ordinary National Educational Test (O-NET) at the end of Prathom 3 and 6, and Mattayom 3 and 6 in order to test their knowledge and thinking skills and evaluate their academic achievement. Science is one of the subjects in O-NET (Office of the Basic Education Commission, 2008).

The Basic Education Core Curriculum.
The Basic Education Core Curriculum B. E. 2551 (A.D. 2008) is a blueprint for teachers and students to lead them to improvement and create an environment where students can develop their learning. The necessity and purpose of the Basic Education Core Curriculum is to prepare students for living in the 21st century (21ST Century Skills, 2016).

Science and the Basic Education Core Curriculum.
Science is an essential and broad subject that is taught from the beginning of the school years. It can help students develop their critical thinking and problem-solving skills. It also helps students develop a better understanding of other related subjects (Beckett, 2013). Some Thai students find science education as a problem because they think they cannot relate it to daily life (Chiu, 2016). The Thai education system has had difficulty in helping Thai students develop their critical thinking skills and educating them to think as individuals (Tangkitvanich, 2013). The statistics of the average scores of the 2016 O-Net national examination indicated that Grade 9 students' average general science score was 34.99% where university demonstration school's students did better in the O-Net tests and their average score for general science was 53.71% (Fredrickson, 2017).

Skinner's Operant Conditioning Theory of Learning.
Teacher-centered instructional theory derives from behaviorism and emphasizes the recognizable and assessable characteristics and features of human behavior (McLeod, 2017). Behaviorism stipulates that behavior can be conditioned as a result of stimuli (O'Donohue &Kitchener, 1998). B. F. Skinner, as the father of operant conditioning believed that behavior is likely to be repeated when it is followed by pleasant consequences and is likely not to be repeated when the result of behavior is unpleasant (McLeod, 2015).

Teacher-Centered Learning Method.

Teacher-centered learning method is concerned with how knowledge is transmitted to and assimilated by students (Thamraksa, 2011). Learning happens in a classroom between teacher and students, students and their environment and students themselves (Johnson, Johnson & Smith, 1991), but in this method teachers consider themselves as the major source for learning (Novak & Gowin, 1984). When students face a large amount of material to memorize and feel overwhelmed, they lose their interest and find the subjects stressful and boring (Phungphol, 2005).

Bruner's Constructivist Theory of Development.

Bruner's Constructivist Theory of Development is a student-centered approach where learners build knowledge and are active rather than passive. In this method, learners generate meaningful knowledge through connecting new knowledge with their previous knowledge. When learners experience something new, they naturally process the knowledge through schemata which helps them integrate prior knowledge and beliefs to understand the information (Prince & Felder, 2006).

Student-Centered Learning Method.

The student-centered teaching approach consists of active learning, cooperative learning, inquiry-based learning method, project-based learning method, problem-based learning method and discovery learning method. There are four major principles that the student-centered approach embraces: creativity, mobility, dynamics and cognitively agitating (Froyd & Simpson, 2008). Through this approach, the role of the teacher is not diminished but rather changes to accommodate and encourage active student participation in the learning process (Froyd & Simpson, 2008). According to the National Foundation for Educational Research (NFER) (2011), students tend to better learn science through a practical approach as they find the subject to be more interesting.

Inquiry-Based Learning in the Science Classroom.

This approach enables students to find the answers on their own. In the science classroom, a central question is used as the core of a teaching/learning module. Students seek to answer the central question. Through this process, students learn from discussions, experiments and activities which are facilitated by the teacher. This approach increases students' engagement and minimizes memorization of the flow of information which is provided by teachers. Inquiry-based learning uses hands-on learning, but it does not mean all the lessons relating to the central question can be gained through experience. It is

integrated with reading materials and/or doing some research (Answers That Are a Little Out of Reach, 2015).

The BSCS 5E Instructional Model.

The Biological Science Curriculum Study 5E (The BSCS 5E) instructional model is useful for designing science lessons based on cognitive psychology. The BSCS 5Es model is composed of 5 phases; engage, explore, explain, elaborate, and evaluate. Each phase has a particular purpose and provides instructional goals for teachers and a better understanding of knowledge and skills for students. This model is used to formulate the sequence of lessons and programs and organizing them (Bybee, 2009).

Conceptual Framework

Figure 1 shows the relationship among the variables. The researcher used Grade 8 students' pre-test and post-test scores to investigate whether there was any significant difference between Grade 8B where teacher-centered learning method was applied and Grade 8A where inquiry-based learning method was used.

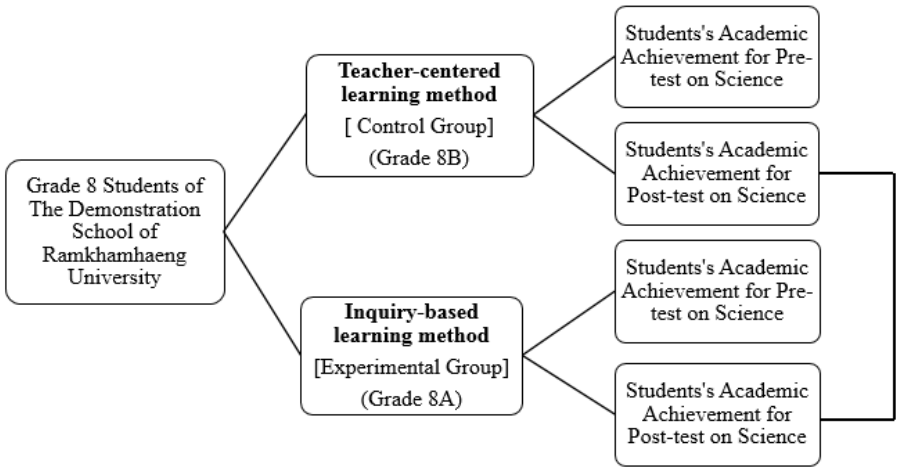

Figure 1. ***Conceptual framework.***

Methodology/Procedures

Population and Sample

The population and sample of this study were 29 students enrolled in Grade 8 EP science class at DSRU, Bangkok, Thailand. An independent samples t-test was conducted to determine whether there was a significant difference between the means of two groups of students in their science academic achievement in their final test scores of the first semester, 2018 (see Table 1).

Table 1. *Statistical Analysis of Grade 8A and 8B First Semester Scores*

Grade	*n*	*M*	*SD*	*t*	*Df*	*p*
8A	16	84.38	12.50	.329	27	.745
8B	13	82.70	15.09			

Table 1 indicates the Grade 8A students' analysis (t (27) = .329 and p = .745*)* recorded that there was no significant difference between academic achievement of two group students in science subject which means no difference in their science background. Therefore, the researcher chose 8A as experimental group and 8B as control group randomly.

Research Instruments

The researcher used a test as the primary data collection instrument for this study. This test was created by the researcher which was used to collect the pre-test and the post-test scores. The test was mainly designed on Chapter 7 (Forces and Motions) and Chapter 8 (Wave, Sound and Light) of the Grade 8 science textbook. The test items covered both lower order and higher order thinking skills of Bloom's taxonomy. Lower order thinking skills emphasize remembering, understanding, and applying and higher order thinking skills involve analyzing, evaluating and creating (Anderson & Sosniak, 1994). The test consisted of two sections: Part I was a multiple-choice section (20 items). Part II was composed of computational and explanatory questions (5 items). The difficulty of the questions for part I in pre-post test scores was examined. An item difficulty index higher than .75 indicates an easy question and under .25 means the question was difficult. The difficulty index indicates that some items were difficult for students to answer. Therefore, the researcher believes that this could affect the result in objective five as well.

The pre-posttest was reviewed and validated by three senior science teachers with more than 10 years of teaching experience in DSRU. A test of the reliability of the test was done by five students of Grade 9 with similar science background knowledge. The result showed that the test was reliable as it was .72. Table 2 indicates the interpretation of science achievement scores recognized by DSRU.

Table 2. *Interpretation of Grades 8A and 8B Science Achievement Scores Used by DSRU*

Percentage of Marks	Interpretation
80-100	Excellent
75-79	Very Good
70-74	Good

Percentage of Marks	Interpretation
65-69	Moderate
60-64	Satisfactory
55-59	Low
50-54	Poor
0-49	Failing

Research Findings

The findings of the study are presented according to the research objectives.

Research Objective One

Table 3 presents the means and standard deviations of the pre-test and post-test under teacher-centered learning method.

Table 3. *Means and Standard Deviations of the Teacher-Centered Learning Method Pre-test and Post-test (n=13*)

Control group	*M*	*SD*
Pre-test	10.69	1.109
Post-test	16.04	1.038

According to the findings shown in Table 3, the pre-test (M= 10.69) was lower than the post-test (M= 16.04). This indicates that the students achieved higher after the instruction.

Research Objective Two

The research objective two was also the research hypothesis of the study. Table 4 shows the findings of the t-test.

Table 4. *Paired Samples t-test of the Control Group Pre-test and Post-test (n=13)*

Control group	*n*	*M*	*SD*	*t*	*df*	*P*
Pre-test	13	10.69	1.109	- 12.064	12	*.000
Post-test	13	16.04	1.038			

Note. An Asterisk (*) indicates a significant difference between the pre-test and the post-test. Significant level was set at p=.05.

Table 4 exhibits the analysis recorded that t (12) = -12.064 and p < .001. This objective was directly linked to the research hypothesis and there was a significant difference of Grade 8 students' achievement level under teacher-centered learning method between pre-test and post-test in science class at DSRU, Bangkok at the level of .05.

Research Objective Three

Table 5 presents the means and standard deviations of the pre-test and post-test under inquiry-based learning method.

Table 5. *Means and Standard Deviations of the Inquiry-based learning Method Pre-test and Post-test (n=16*)

Experimental group	*M*	*SD*
Pre-test	10.50	1.366
Post-test	16.94	1.731

According to the findings shown in Table 5, the pre-test (M=10.50) was lower than the post-test (M=16.94). This indicates that the students achieved higher after the instruction.

Research Objective Four

Research objective four was the second research hypothesis of the study. Table 6 presents the findings of the t-test.

Table 6. *Paired Samples t-test of the Experimental Group Pre-test and Post-test (n=16)*

Experimental group	*n*	*M*	*SD*	*t*	*df*	*P*
Pre-test	16	10.50	1.366	- 18.227	15	*.000
Post-test	16	16.94	1.731			

Note. An Asterisk (*) indicates a significant difference between the pre-test and the post-test. Significant level was set at p=.05.

Table 6 exhibits the analysis of the experimental group recorded that t (15) = -18.227 and p < .001. The result shows, there was a significant difference of Grade 8 students' achievement level under inquiry-based learning method between pre-test and posttest in science class at DSRU, Bangkok at the level of .05.

Research Objective Five

Research objective five was also the third research hypothesis of the study. Table 7 presents the findings of the t-test.

Table 7. *Independent Samples t-test (One-Tailed) of the Post-tests (n=29)*

Group	*n*	*M*	*SD*	*T*	*Df*	*P*
Experimental group	16	16.94	1.731	1.574	27	.127
Control group	13	16.04	1.038			

Table 7 exhibits the analysis recorded that t (27) = 1.574 and p = .127. This objective was directly linked to the research hypothesis and according to the

finding there was no significant difference of Grade 8 Students' achievement level under teacher centered-learning method and inquiry-based learning method in science class at DSRU, Bangkok at the level of .05.

Discussion

An interesting finding of this study was that both control group and experimental group showed improvements in the post-test scores after the 7-week instruction in comparison to the pre-test scores which indicated the benefits of both instructional methods for students.

Teacher-centered Learning Method.

The research findings for research objective two indicated a significant difference of Grade 8 students' academic achievement level under teacher-centered learning method between the pre-test and the post-test in science. The researcher believes that providing appropriate activities could improve students' academic achievement. The research objective was also the research hypothesis one.

Inquiry-based Learning Method.

The research findings for Grade 8 students' academic achievement for learning science under inquiry-based learning method showed higher achievement in their post-test after the instruction. The mean scores of the post-test were higher than the pre-test. The research findings for research objective four indicated a significant difference of Grade 8 students' academic achievement level under inquiry-based learning method between pre-test and post-test in science. The findings of this research objective showed improvement which supported research hypothesis two.

The findings of research objective five rejected research hypothesis three. Four weeks of the experiment were during the summer course. The summer course is compulsory at DSRU, but students are not formally evaluated. Therefore, perhaps for many of the students, the classes were less serious and in the experimental group the students did not attend classes regularly. The other reason that could affect the result was due to students' interest and eagerness in learning science in the control group. The students in the experimental group experienced the inquiry-based learning method for the first time and significant change in attitude towards learning takes a long time to occur and manifest. The relatively short duration of the experiment, therefore, likely affected the outcome, i.e., no significant difference between the groups' pre and post-test results. For the control group, it can be noted that the teacher also used appropriate teacher-centered learning instruction for teaching science which covered all the concepts in the curriculum and explained them well.

Students in the experimental group, which was exposed to the inquiry-based learning method did not achieve higher scores compared to the control group. This study took 7 weeks and a part of it had fallen during summer course. DSRU's policy mandated that the evaluation of students during the summer course would not affect on their overall grades; hence, the researcher believes this could be the reason that students had not been serious about the post-test scores. The item difficulty index of the pre-posttest indicated that some items were difficult for students to answer. Therefore, the researcher believes that this could affect the result in objective five as well. The control group showed an improvement in their post-test scores which means that the students also gained knowledge. It may be understood as a strength of the study.

According to the National Foundation for Educational Research NFER (2011), students tend to choose a practical method to learn science as it makes the subject more understandable and engaging. Moreover, it also arouses the students' curiosity. Science is an essential and fundamental part of STEM education and by applying inquiry-based learning method, the students are enabled to develop the 21st century skills such as analytical thinking, solving problems and creating innovations (Boonruang, 2015).

The inquiry-based learning method could boost the students' engagement in science class as well as develop their higher order thinking skills which eventually leads to higher academic achievement. The lessons for the experimental group used the BSCS 5E Instructional Model consisting of five phases that draw on the learners' experience and learning process. It embraces engage, explore, explain, elaborate, and evaluate. This model creates an opportunity for learners to apply their previous knowledge for better understanding of new concepts through activities (Duran & Duran, 2004).

An open-ended question was given at the beginning of every class to enable students to participate in brainstorming by bringing up more questions. They searched for answers, collected the information and data, and highlighted the necessary and useful information. They reasoned out answers with proofs and evidence. They also solved problems by using critical thinking skills and shared their findings and evaluated the answers. Students believed that learning was fun. They learned how to create a system where eggs do not break if they fall. They learned about the use of waves in telecommunications and also medical treatments by actively experimenting with optical fibers. They also built a kaleidoscope and a periscope and related their work to real-world contexts. These activities allowed the students to collect the information, understand, analyze, apply, and solve the problems. This way, the students became more thoughtful and motivated in inquiries.

The previous research findings also determined the effectiveness of the inquiry-based learning method as well as this research study which found higher means in the post-test scores. Towns and Sweetland (2008) noted that inquiry-based learning method creates a mindset of becoming lifelong learners. It provides opportunities for learners to choose their own learning style and lead their learning by creating schemas and building knowledge. Upadhya and Lynch (2019) found that despite no difference between the student-centered science learning method and the teacher-centered science learning method, students demonstrated higher motivation in the student-centered classroom than the teacher-centered classroom. The researchers discussed that the reason could be due to the time constraint or the students' ability to adjust to the lessons (Upadhya & Lynch, 2019). Gorowara and Lynch (2017) found improvements in the science achievement for both teacher-centered learning method and inquiry-based learning method. The researchers noted a large mean difference in the inquiry-based learning method and indicated the success of this method and preference for it (Gorowara & Lynch, 2017).

Recommendations

The recommendations of this study will be directed to the following groups.

Recommendations for School Administrators

School administrators should encourage the teachers, parents and students toward an effective implementation of the inquiry-based science learning method which can lead to a better science achievement result. This matter can be achieved by allocating professional development programs for the teachers and holding parents' meetings.

Recommendations for Teachers

Teachers at DSRU should become more familiar to STEM education and student-centered methods. Professional development programs and the school's support can help the teachers make a difference in their classes to develop students 21st century skills.

Recommendations for Students

The researcher suggests students learn questioning and inquiring techniques and challenge each other by proposing new ideas. The inquiry-based learning method can help them develop their laboratory skills, critical thinking, creativity, and communication skills.

Recommendations for Future Researchers

Future researchers should consider length of instruction, English language skills, administrative collaboration, parental encouragement, and students' attitudes towards science learning. The researcher also suggests exploration in other subjects and grade levels.

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