

## **THE UTILIZATION OF INTEGRATION OF STEM EDUCATION APPROACH WITH FIVE STEPS LEARNING PROCESS TO ENHANCE LEARNING ACHIEVEMENT AND PROBLEM SOLVING ABILITIES**

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**Abstract:** This study is aimed (1) to compare learning achievement and problem solving abilities after using STEM Education approach with five STEPs Learning Process between before and after the learning, and (2) to compare learning achievement and problem solving abilities of grade ten students after using Stem Education approach with five STEPs Learning Process with the set 70 percent criteria. The participants were 40 grade ten students who studied in the second semester of 2018 academic year from school of Saint Gabriel's Foundation using cluster sampling. The research instruments were, (1) Stem Education approach with five STEPs Learning Process lesson plan, (2) Learning Achievement Test, and (3) Problem Solving Abilities Test. The data were analyzed using mean, standard deviation, t-test for dependent sample, and t-test for one sample.

The results indicated that (1) The Posttest mean scores of learning achievement and problem solving abilities of grade ten students after learning with the STEM Education approach with the five STEPs Learning Process were statistically significantly higher than the Pretest mean scores at the .01 level. And (2) The Posttest mean scores of learning achievement and problem solving abilities of grade ten students after learning with the STEM Education approach with the five STEPs Learning Process were statistically significantly higher than the set 70 percent criteria at the .01 level.

**Keyword:** STEM Education approach with five STEPs Learning Process, Learning Achievement, Problem Solving Abilities

### **Introduction**

Considering the quality of science education teaching in Thai school at present, there is not enough to supportive factors to encourage students to solve problems or create innovation. This finding is confirmed with the

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National Competitiveness Report by International Institute for Management Development (IMD, 2015-2017). Thailand has the educational competency ranking (Education) of 48, 52 and 54 from 61 countries. The result aligns with the report from the result of assessing student performance in problem solving by Programme for International Student Assessment: PISA, (PISA 2003 and PISA 2012) which indicated Thai students have lower problem solving abilities than standard criteria and the average score of problem solving abilities of Thai students is lower than the average score (Khueang-Nil, Preechan and Prademmojee, 2006)

From the observation of teaching and interviewing students in grade ten the researcher found that some chemistry content is too complex, abstract, difficult to understand, and cannot be used to gain connections with daily life especially, the content about Covalent bond. It has effects such as boredom and unhappiness in learning which leads to relatively low academic achievement that does not meet the criteria set by the school. According to the report of the school of Saint Gabriel's Foundation, the score of Ordinary National Educational Test: O-NET for the year 2016-2018 with an average score of 32.54, 33.44, 31.62 and 29.02 points respectively (National Institute of Educational Testing Service: NIETS, 2017). It was found that the average score of students was lower than 50 percent and had a tendency to decrease. It lead to the conclusion that the current teaching and learning science in Thai school of Saint Gabriel's Foundation is not as successful as they should be.

STEM Education is a teaching and learning approach in which science, technology, engineering, and mathematics (STEM) are purposely integrated. STEM stands for Science, Technology, Engineering and Mathematics. The learning approach is integrated between subjects in order to be connected with real life matters and the career path of the learner. It aims to develop important skill for living in society and bring new development or innovation to develop the capacity of the country, (Thongchai, 2013).The main advantage of STEM Education is the engineering design process used in learning management (Capraro et al., 2013). There are seven steps in engineering design process or Technological Process are 1) Identify problem and constraints; 2) Research; 3) Ideate; 4) Analyse Ideas; 5) Build; 6) Test and refine; and 7) Communicate and reflect. STEM Education is a form of learning approach that responds to the preparation of the new generation of Thai people in the 21st century. In accordance with five STEPs Learning Process which is a learning process that can develop students to achieve their goals, become qualified people with skills to search for knowledge, acquire the necessary basic knowledge to be able to think highly and communicate effectively.

The five STEPs Learning Process are: 1) Hypothesis Formulation; 2) searching for Information; 3) Knowledge Formation; 4) Effective Communication; and 5) Public Service. The process can develop learners to meet international standards as well as being able to develop them to be more aware of society changes and society firmly lead them to a knowledge-based. It gives guidelines aimed at developing children and youth to have a good mindset, a public mind and have competencies and skills in thinking (Ministry of Education, 2012).

Researcher studied the outcome of the implementation of the integration of STEM Education approach with five STEPs Learning Process to enhance learning achievement and problem solving ability of grade ten students. The research results can be an advantage as a guideline for the development of science education teaching.

### **Research Objectives**

There are four objectives for this study:

1. To compare learning achievement after using STEM Education approach with five STEPs Learning Process between before and after the learning.
2. To compare learning achievement after using STEM Education approach with five STEPs Learning Process after the learning with the set 70 percent criteria.
3. To compare problem solving abilities after using STEM Education approach with five STEPs Learning Process between before and after the learning.
4. To compare learning achievement after using STEM Education approach with five STEPs Learning Process after the learning with the set 70 percent criteria.

### **Research Hypotheses**

Ho1 There is no difference between pre-test and post-test on learning achievement after using STEM Education approach with five STEPs Learning Process.

Ha1 There is difference between pre-test and post-test on learning achievement after using STEM Education approach with five STEPs Learning Process.

Ho2 There is no difference between Learning achievement and the set 70 percent criteria after using STEM Education approach with five STEPs Learning Process.

- Ha2 There is difference between Learning achievement and the set 70 percent criteria after using STEM Education approach with five STEPs Learning Process.
- Ho3 There is no difference between pre-test and post-test on problem solving abilities after using STEM Education approach with five STEPs Learning Process.
- Ha3 There is difference between pre-test and post-test on problem solving abilities after using STEM Education approach with five STEPs Learning Process.
- Ho4 There is no difference between problem solving abilities and the set 70 percent criteria after using STEM Education approach with five STEPs Learning Process.
- Ha4 There is difference between problem solving abilities and the set 70 percent criteria after using STEM Education approach with five STEPs Learning Process.

### **Conceptual Framework**

#### *Conceptual Framework of STEM Education Approach*

There are seven steps in engineering design process or Technological Process that are applied (Capraro et al., 2013): 1) Identify problem and constraints; 2) Research; 3) Ideate; 4) Analyse Ideas; 5) Build; 6) Test and refine; and 7) Communicate and reflect.

#### *Conceptual Framework of five STEPs Learning Process*

The five STEPs Learning Process are (Ministry of Education, 2012): 1) Hypothesis Formulation; 2) Searching for Information; 3) Knowledge Formation; 4) Effective Communication; and 5) Public Service.

#### *Conceptual Framework of STEM Education Approach (Capraro et al., 2013) with five STEPs Learning Process (Ministry of Education, 2012)*

The researcher conducted the STEM Education approach with five STEPs Learning Process had 5 steps to manage learning as follows: 1) Step 1 Hypotheses formation to identify problem and constrain; 2) Step 2 Searching knowledge and research to information; Step 3 Knowledge formation by ideate and analyze idea to build, test, and refine; Step 4 Effective communication to communicate and reflect; and 5) Step 5 Communicate to public service

#### *Conceptual Framework of Learning Achievement*

In this study, analytic scoring was used in assessment of Covalent Bond Achievement learning test: Learning achievement test with 4 multiple choice item was used measure Bloom's cognitive domains as conceptualized from

Anderson's Taxonomy which comprises 6 levels. Those are 1) Remember, 2) Understanding, 3) Applying, 4) Evaluating, and 6) Creating. (Anderson, Lorin W., Krathwohl, & David R., 2001)

### *Conceptual Framework of Problem Solving Abilities*

In this study, analytic scoring was used in assessment of problem solving ability test: Problem solving abilities test with 4 multiple choice item was used measure the problem solving process of Weir consist 4 steps. Those are 1) Problem Identification, 2) Cause-Problem Analysis, 3) Problem Solution, and 4) Result Evaluation. (Weir, 1974))

## **Methodology**

This study has the nature of the Quasi-experimental research so as to deal with real situation of the teaching and learning science education in a secondary school. It is primarily focused to improve learning achievement and problem solving ability of the student. In order to accomplish the research objectives, the researcher utilized quantitative study method. The researcher designed a framework to enable a science education teaching development process in diagnosing, developing, and sustaining the outcome. Assessing and benchmarking the learning competency of the student is an effective approach to initiate and facilitate a change process in building a greater learning competency. Planning and successfully implementing the lesson plan were therefore important parts of the process of improving the learning achievement and problem solving abilities of the student.

### ***1. Population and sample***

#### **Population**

The participant of this study are grade ten students from Science-Mathematics study Plan, school of Saint Gabriel's Foundation, second semester of academic year 2018. The number of students is 135 students from 4 assorted classrooms.

#### **Sample**

Clustering Sampling technique was applied to get one classroom of 40 grade ten students from Science-Mathematics study Plan, school of Saint Gabriel's Foundation. 2nd Semester, Academic Year 2018.

## 2. *Research Instruments*

**The instruments utilized in the research were;**

- 2.1 The lesson plan for 14 period hours with the average suitability at 4.59, which were validated by 5 expert.
- 2.2 Achievement learning test of Covalent Bond that comprises 30 item with 4 multiple choice each and with *IOC* value 0.60-1.00, Difficulty index (*P*) 0.33-0.74, Discrimination (*B*) 0.21-0.47, and Reliability at 0.92 when determining the criteria-based by using the method of Lovett's method.
- 2.3 Problem solving abilities test of creating 5 situations, each situation has 4 multiple choice, a total of 20 item. And with *IOC* value 0.80-1.00, Difficulty index (*P*) 0.28-0.79, Discrimination (*B*) 0.26-0.63, and Reliability at 0.72 when determining the criteria-based by using the method of Lovett's method.

## 3. *Research Process*

- 3.1 The First Phase:** To try out the STEM Education approach with five STEPs Learning Process lesson plan, it was piloted study in grade 10 students at School of Saint Gabriel Foundation, in the second semester of Academic year 2018.
- 3.2 The Second Phase:** To try out the Learning Achievement Test and Problem Solving Abilities Test, it was a piloted study in grade 11 students at School of Saint Gabriel Foundation, in the second semester of Academic year 2018.
- 3.3 The Third Phase:** To implement the STEM Education approach with five STEPs Learning Process lesson plan, it was then tested with one classroom of 40 grade ten students from Science-Mathematics study, School of Saint Gabriel Foundation. The lesson plan took 14 hours to complete. There were activities in each plan with learning process as follow:

Introducing steps to implement learning activities through the STEM Education approach with five STEPs Learning Process. Launch the Pre-test on Learning Achievement Test and Problem-Solving Abilities Test to the students.

Action taking to implement the lesson plan and gathering data through activities to enhancing learning achievement and problem solving abilities.

Launch the post-test to students after learning the STEM Education approach with five STEPs Learning Process. Analyze data with descriptive statistics to conclude results of the research objectives.

#### 4. Data Analysis

- 4.1 Descriptive statistic were Percentage, Mean, Standard deviation
- 4.2 Statistic to test hypothesis is Dependent t-test and One sample t-test

### Findings

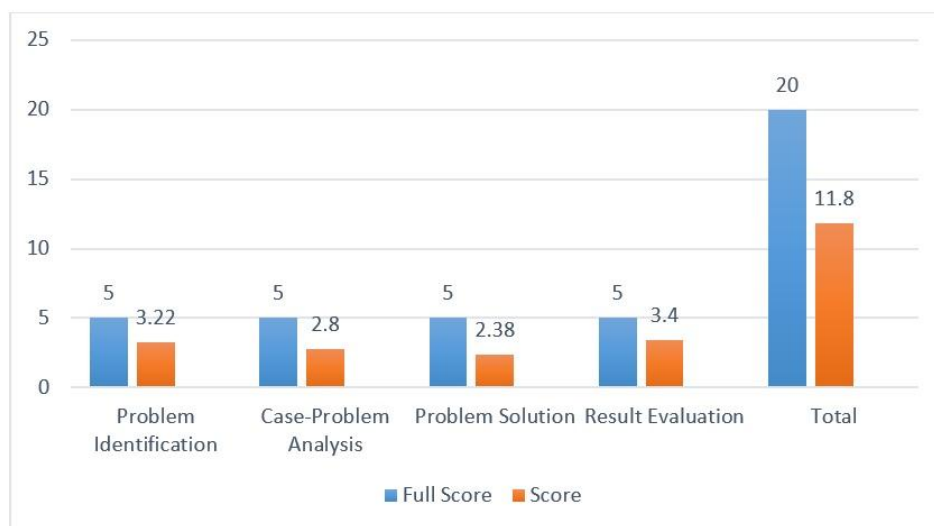
#### Diagnosis and Pre-test finding

The researcher diagnosed the science education contextual situation with both qualitative and quantitative methods. The researcher learned the context and situation of teaching by meeting and interviewing the student. Literature review, documentary research, and interviews with experienced science teachers and experts were done during the beginning of the academic year. The researcher diagnosed the extent of learning capacity by implementing a variety of means to gain preliminary data to locate areas of strength and weakness, and take steps to further develop it. A Pre-test was done to evaluate and gain better perception of the student competency in science.



**Figure 1: Pretest mean score of learning achievement before using Stem Education approach with 5 STEPs Learning Process.**

Before using STEM Education approach with five STEPs Learning Process the students had a mean score of learning achievement for each learning behavior objectives at 2.15, 4.7, 2.18, 3.58, and 0.32 respectively, and the average academic achievement score of the whole test was 12.93 points from the full score of 30 points.



**Figure 2: Pretest mean score of problem solving abilities before using Stem Education approach with 5 STEPs Learning Process.**

Before using STEM Education approach with five STEPs Learning Process the students have the average score of problem solving ability in each step of problem solving at 3.22, 2.80, 2.38 and 3.40, respectively, and the average problem solving ability score of the whole test was 11.80 points from the full score of 20 score.

### **Quasi-experiment intervention implementation**

The researcher conducted the STEM Education approach with five STEPs Learning Process had 5 steps to manage learning as follows.

#### ***Step 1 Hypotheses formation to identify problem and constrain***

The teacher facilitate on activity to encourage students to be motivated to study. The students practice their questioning skill before entering the lesson, teachers arrange students into groups of 5-6 people each for group discussion. The topic of discussion from the textbook and its connection related to reality. This science-based learning design demonstrates the linking of knowledge arising from the texts and events that occur in everyday life. From this stage, the researcher noticed that students were interested in asking questions



rationally. The students understood the problem became enthusiastic in expressing opinions, the teacher assigned them to identify problems, analyze problems, identify criteria and limitations to get them ready for the next step.

### ***Step 2 Searching knowledge and research to information***

Students determine the scope of content by seeking knowledge using technology to collect information. Teacher facilitated the group discussion about collecting the information of the interested subject. Self-learning to participate group study sharing was strongly recommended to enable the construction of knowledge under the care of teacher.

When students were able to specify the scope to study, the teacher allowed them to practice building covalent molecular shapes by using the Molecule Shape application on personal technology device. Students were able to apply their mathematical knowledge (Mathematics) to design inventions to solve problems from a given situation through integration of engineering process and technology utilization. They also were able to understand geometric shapes and angles related to molecular shape of covalent lentils.

From observing the learning behavior of students, it was found that students cooperated well in learning activities arrangement. Students were gradually able to create knowledge for themselves. There was an exchange of knowledge between friends in the group. In the first period of study Students could identify problems. They were able to identify the cause of the problem, analyze problems. However, some students were struggling to offer a solution and found it a big challenge to check the results by themselves.

### ***Step 3 Knowledge formation by ideate and analyze idea to build, test, and refine***

Students brought the knowledge obtained from data collection, to plan the operations and design ideas for creating inventions to determine the draft of the master work. They were able gradually to create knowledge by themselves and propose a solution to solve problems. Then proceeded to invent the work according to the draft through the engineering process. They tested and refined their piece of work with the teacher reminding them to consider available resources, limitation and respect their budget plan. The teacher accompanied the students as mentor of the project to ensure the process of build, test, and refine was done properly.

#### ***Step 4 Effective communication to communicate and reflect***

Students presented their work to solve problems from the situation. The teachers gave students the opportunity to ask questions, comment and suggest improvement. The listening and reflecting of the teacher as mentor and friend allowed the student to improve performance.

#### ***Step 5 Communicate to public service***

Students organize exhibitions to present their work and create video clip to share on the school's Facebook page. Resulting in students having a public mindset to share their knowledge to participate in social service.

#### **Post-test finding**

To determine the result of Quasi-experiment intervention implementation, the researcher compare the pre-test and post-test to know the development of the learning achievement and problem solving abilities after using STEM Education approach with five STEPs Learning Process.

Table 1: *pre-test and post-test comparison on learning achievement after using Stem Education approach with 5 STEPs Learning Process (total score = 30)*

<b>Sample</b>	<b>n</b>	<b><math>\bar{X}</math></b>	<b>SD</b>	<b><i>t</i></b>	<b><i>p</i> (1-tailed)</b>
Pre-test	40	12.93	3.576	20.409**	0.000
Post-test	40	22.43	2.194		

\*\* $p < .01$

Table 1 indicates that after using STEM Education approach with five STEPs Learning Process the student from grade ten have the mean score of learning achievement of 12.93 and 22.43, respectively. Learning achievement after learning was significantly higher than before learning at the level of .01. The null hypothesis Ho1 is rejected and Ha1 is accepted. Therefore, the researcher would conclude that there is difference between pre-test and post-test on learning achievement after using STEM Education approach with five STEPs Learning Process.

Table 2: *Learning achievement and the set 70 percent criteria comparison on learning achievement after using STEM Education approach with five STEPs Learning Process*

Sample	n	criterion	$\bar{X}$	SD	t	p (1-tailed)
Post-test	40	21	22.43	2.194	4.107**	0.000

\*\* $p < .01$

Table 2 indicates that after using STEM Education approach with five STEPs Learning Process the student from grade ten had a level of Learning achievement that was significantly higher than the set 70 percent criteria (score = 21 from 30 ) at the level of .01. The null hypothesis Ho2 is rejected and Ha2 is accepted. Therefore, the researcher would conclude that there is difference between Learning achievement and the set 70 percent criteria after using STEM Education approach with five STEPs Learning Process.

Table 3: *pre-test and post-test comparison on problem solving abilities after using STEM Education approach with five STEPs Learning Process*

Sample	n	$\bar{X}$	SD	t	p (1-tailed)
Pre-test	40	11.80	2.472	9.791**	0.000
Post-test	40	15.18	1.796		

\*\* $p < .01$

Table 3 indicates that after using STEM Education approach with five STEPs Learning Process the student from grade ten had the mean score of problem-solving abilities was 11.80 and 15.18, respectively. Problem solving abilities were significantly higher than before learning at the level of .01. The null hypothesis Ho3 is rejected and Ha3 is accepted. Therefore, the researcher would conclude that there is difference between pre-test and post-test on problem solving abilities after using STEM Education approach with five STEPs Learning Process.

Table 4: *problem solving abilities and the set 70 percent criteria comparison on learning achievement after using STEM Education approach with five STEPs Learning Process*

Sample	n	criterion	$\bar{X}$	SD	t	p (1-tailed)
Post-test	40	14	15.18	1.796	4.138**	0.000

\*\* $p < .01$

Table 4 indicates that after using STEM Education approach with five STEPs Learning Process the student from grade ten had problem solving abilities that were significantly higher than the set 70 percent criteria (score = 14 from 20 ) at the level of .01. The null hypothesis  $H_04$  is rejected and  $H_a4$  is accepted. Therefore, the researcher would conclude that there is difference between problem solving abilities and the set 70 percent criteria after using STEM Education approach with five STEPs Learning Process.

### **Reflection and Conclusion**

The researcher studied the impact of using STEM Education approach with five STEPs Learning Process to students' learning achievement. The findings indicated that STEM Education approach with five STEPs Learning Process had the main advantage of enabling the students to apply the engineering design process in their learning behavior. The approach was able to help improve the learning achievement. Though the content in chemistry subject was very complicate and it was necessary to make use of students' imagination to understand the concept, the process enabled the students to practice and perform experiment by themselves. The students had better enthusiasm and had much attention to actively construct their knowledge from investigations and think rationally. The STEM Education approach with five STEPs Learning Process emphasis on group study skill and the integration of the contents helped improve students giving them a deeper understanding of the purpose of the content and the things learned on the whole. It helped encourage students to think and realize the connection between knowledge, ideas and their surroundings so that they will be able to bring knowledge and experience that has been reorganized and create their own knowledge (Jesadawiroj S., 2015). Learning that starts with problems from everyday life and motivation from learning situations starting from problems to solving problems, allow students to discover STEM education skills through problem-solving methods and techniques that helps them find who they are. (Asunda, 2015)

When considering the learning behavior of students in step 3, creating knowledge to design ideas for creating test results and improving work results, students performed well in group brainstorming to formulate ideas to link their knowledge to discuss the molecular shape of covalent. They were able to formulate their knowledge about Valence Shell Electron Pair Repulsion, VSEPR that is used to predict the covalent molecular shape for better understanding. The research concluded that learning activities enable the students to solve problems by linking knowledge and science through the engineering process, resulting in new technology. Through learning arrangement according to STEM Education approach with five STEPs Learning Process, resulting in higher and more effective student achievement.

The impact of using STEM Education approach with five STEPs Learning Process to students' problem-solving abilities is another aspect the researcher gave attention. As the adapted process involved facilitating students to immerse themselves into real arrangement of science education study. After the students participated in group assignments, they actively discussed and brainstormed in their group to identify issues and problem. They made use of technology, mathematics and engineering process to investigate and search for needed information to create their innovation to use in daily life. Using the STEM Education approach with five STEPs Learning Process gradually allowed students to development in problem-solving skill. They became more enthusiastic in learning and were able to choose a solution based on their abilities and aptitude. They were able to think of solutions to problems using scientific knowledge integrated with technological knowledge, engineering and mathematics which considered the good basis for solving problems and a good learning solution.

The arrangement of activities that are integrated with the content of science and the development of problem solving abilities enables the students to explore, examine, and find ways to solve problems which is to cultivate the characteristics of the scientist to occur with the learner. "The student must be able to thinks, to act, and to design solution". However, the ability to solve problems is also an important goal in development which is a desirable feature for students in the 21st century skill for future life (Dechupa P. and Yindeesuk P., 2005). Therefore, the arrangement of activities that are integrated with the content of science and the development of problem solving abilities enables the students to explore, investigate and find ways to solve problems, cultivate the characteristics of scientists to occur with the body of learner.

This research tells us that it is essential to take into consideration that the using STEM Education approach with five STEPs Learning Process ensures an education of good quality. Science should be exciting for students, giving them skills and opportunities to improve their futures. However, to provide high-quality inspirational lessons, collaboration among the science teacher, other content teachers, and the special education teacher is an excellent starting point. The researcher recommend more research on integrating STEM Education approach with five STEPs Learning Process evidence should sit at the heart of good teachers and good teaching practice to create the biggest impact on student learning achievement at school.

### **Recommendation to the future researcher**

Teachers should arrange a senior off-site activity in the welfare community. Then the students will bring the knowledge from the activities to those students. The researchers have proposed the behavior and quality considerations of the students' work, it is found that female students tend to design their work, feel and have more details than male students, while male students tend to create a variety of jobs. And fast. In addition, students have designed a variety of works, including the selection of materials under a limited budget that allows students to have the opportunity to use creativity in the design work from the problems encountered in everyday life. The day of the student's next topic of research might need to be studied. Creative work related to the full study activities between male and female students.

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