Promoting problem solving and thinking competencies for the middle school students using STEM activities in the Moderate Class, More Knowledge project.

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Abstract. This study aimed to investigate the problem solving and thinking competencies of the students using STEM activities in “The Moderate Class, More Knowledge” project of the Thakhanthowittayakarn School, Thailand. The participants were 20 middle school students who were pleased to join the activities. The STEM activities applied in this study were adjusted from online resources and the STEM activities of the institute for the promotion of teaching science and technology (IPST). The five STEM activities were conducted in 20 hours, comprised of the following: young designer contest, mobility in the time of flood, balloon powered car, balloon rocket, and rubber band powered car. Multi-rater approach was used to investigate the students’ problem solving and thinking competency. Self-checklists, observer-checklists and teachers-questionnaire with five rating scales were used as the study instruments. The analysis method is based on a handbook of a competency appraisal for Basic Education students developed by the OBEC. Percentage, mean and standard deviation were reported; the students’ competencies were considered into three levels which were good, fair and unsatisfied. Findings revealed that 75% of the students were in good level, and the rest were in fair level for problem solving competency. According to thinking competency, 85% of the students were in good level and 15% were in fair level. The after action review (AAR) were also presented in this study. The result implied that STEM activities could be appropriate for fostering the students’ competencies.

1. Introduction
1.1 Background and rational
In recent years, a different set of skills - 21st century skills – have been increasingly empowers the nations. Consequently, teaching and learning in K-12 education has focused on preparing students for globalization and the 21st century workforce. Moreover, the growth of the international trade needs Science, Technology, Engineering and Mathematics’ (STEM) support. STEM has become the indicators that indicate the qualities of education in each country. It is necessary. [5, 12] Evidently, developing skillful and knowledgeable STEM graduates do not only support the growth of international trade but also enhance the qualities of social life. The knowledge and skills of STEM seem to be a crucial factor in order to develop the 21st Century skills which are 1) life and career skills 2) learning and innovation skills and 3) information, media and technology skills [16] Not surprisingly, the STEM education has played an important role in order to achieve the local
STEM education in Thailand was the development of learning achievement and integrated science explored the current situation of STEM teaching and learning for students who are skillful in Science, Technology, Engineering and Mathematic adopt high technology for professional careers and to improve knowledge and connect the process in order to create a productive result. Based on the real objects and evidences, students should be able to solve the problem, present skills in communication and able to make an appropriate decision to solve the various situations.

To achieve these goals, many projects are initiated especially in K-12 education. As such, policymakers, researchers and educators are implementing and examining potential strategies for fostering students’ efficiency. “The Moderate Class, More Knowledge” project is one of the educational policies led by the Office of the Basic Education Commission (OBEC) which is undertaken by the Thai Ministry of Education (MOE). This policy aimed to promote students learning through a variety of multi-media and styles in both inside and outside the classroom. The schools attending this project have to commit on a strict time management on teaching and learning for middle school students. The formal classroom schedule was reduced from 6-7 hours to 5 hours in each day, and the rest hour was replaced by learning through doing activities as the students’ needs. The activities will be set to support students’ efficiency in four domains as 4H Development which stands for head, heart, health and hands.

The Thakhanthowittayakarn School is one of the participants in this project. Therefore, 25 activities were set for students – learning four hours a week. As a significantly important STEM knowledge and the 21st century skills improvements, the researchers designed the STEM activity as a choice for the students who are interested in learning this area. According to activity-based learning, the 20 members of the activity have used these methods for five consecutive weeks and their skills in the form of problem solving and thinking competencies were assessed.

1.2 The purpose of the study
The purpose of this study is to investigate the problem solving and thinking competencies of the students using STEM activities in “The Moderate Class, More Knowledge” project of the Thakhanthowittayakarn School, Thailand.

2. Literature Review
To reach the purpose of the study, previous researches related to STEM education, activity-based learning and students’ competency in terms of problem solving and thinking competencies were reviewed. The context of the Moderate Class, More Knowledge project in the school was described in following details.

2.1 STEM education
The STEM education is composed of four fields which include Science, Technology, Engineering and Mathematics. It is not only limited in those areas but also involves social, economics, psychology and politics. It seems that the main aim of the STEM Education is not only to emphasize one’s performance or skills but also aims to enhance all performances of students to be able to adapt and adopt high technology for professional careers. That means students have to be knowledgeable and skillful in Science, Technology, Engineering and Mathematic.

In Thai context, there were many institutes that are using STEM education into high school classrooms. The IPST has established National STEM Education Centre (NSEC) in 2014 to promote STEM education as a new form for science education in Thailand. However, few researches have explored the current situation of STEM teaching and learning. The example of research relating to STEM education in Thailand was the development of learning achievement and integrated science
process skills of grade eight students through STEM education, entitled “Food and living” for the Faculty of Education, Mahasarakham University. The findings revealed that students reached 80 % of learning achievement and 79 % of integrated science process skills after the intervention using eight lesson plans [19]. Moreover, there was the development of STEM experiment laboratories based on the Royal-Initiated Projects for lower secondary students. The results showed that the students engaged with eight science activities could integrate scientific knowledge and science process skills related to the Royal-initiated projects through STEM education; and the students showed good attitudes in science [7]. Interestingly, there were few studies focusing on integrated STEM activity for outdoor classes.

2.2 Activity-based learning
Activity-based learning is a learning method through doing activity. This method allows students to learn and understand any concept from several activities such as games, hands-on activity or playing in groups. These activities were widely accepted as an effective method to encourage students to self-learning, construct their own unique ideas, support leadership and teamwork skills including social interaction [6]. The key features of the activity-based learning are: 1) Encourage students to be active in learning and thinking, 2) stimulate students to learn by themselves rather than listening or memorization. 3) Improve students' learning skills and keep continuous learning. 4) Support students' thinking and writing skills. 5) Foster students' satisfaction and their interest that (ABL) is better than passive learning. 6) Focus on students' responsibility for learning through reading, writing, discussion, and participation in problem solving [14]. There was a study anchored on the students' behaviors, discourse and learning in junior high school, related to science-based learning activity. The findings revealed more complex thinking and problem-solving skills both in their discourse and their responses on the follow-up learning probe [3]. In conclusion, the activity-based learning method is one of the effective methods that could be able to promote the student’s competency.

2.3 Students’ competency
Competencies are characteristics or individual abilities which are the key element in achieving success in works and also refer to knowledge or skills that lead to effective performance. According to David McClelland [9], the competency is composed of five elements which are skills, knowledge, self-concept, traits and motive. These students’ competencies are, comprising hidden characteristics and surface characteristics. The hidden characteristics composed of three elements: self concept (representing positive attitudes and values), traits (personal characteristics, for instance respect or leadership), and motive (an internal motivation that drives a person towards a goal such as achievement orientation). The surface characteristics are comprised of specific knowledge and learning skills, such as coordination, effective communication, problem solving and decision-making [11].

In Thailand, according to the OBEC [17], students’ competencies were defined into five competencies which are communication, thinking, problem solving, life-skills and technology skills. To achieve the purpose of this study, the problem solving and thinking competencies will be described as Thai curriculum definition. The students’ problem solving competency has defined as the ability to solve problems or obstacles based on reasoning, moral and information. Moreover, this competency refers to understanding the relationship and changing in society, seeking new knowledge and applying in several situations to prevent and solve problems. It has also included effective decision makings, taking accountability on themselves, society and environment. Meanwhile, the thinking competency has explained as the ability to think synthetic thinking, creative thinking, critical thinking and systematic thinking. These thinking abilities are employed to construct knowledge, information for making self-determination related to their lives and community as well.
3. Methodology
To investigate the students’ competency after learning with STEM activities in “The Moderate Class, More Knowledge” project for 20 hours. The methodology was employed as following;

3.1 Participant
The participants were 20 middle school students who were pleased to join the activities. In doing the activity, the students were grouped into five. The students have to attend for four days in each week with one hour in each day, to learn through STEM activity. Two teachers are responsible in teaching STEM activity, and another two teachers are tasked to be observers and then later reflect and discuss the method.

3.2 Concepts of STEM activity
The five STEM activities were conducted in this study, comprised of the following: young designer contest, mobility in the time of flood, balloon powered car, balloon rocket and rubber band powered car. The STEM concepts behind these activities were shown in Table 1.

Table 1. The STEM concepts in each STEM activity.

| STEM Activity                  | STEM Concepts             |
|-------------------------------|--------------------------|
|                               | Science                  |
|                               | Technology               |
|                               | Engineering              |
|                               | Mathematics              |
| The young designer contest    | Materials property       |
|                               | Drawing and sketching     |
|                               | Designing and problem solving in creating a skirt with the given constrains |
|                               | Solving linear equation with one variable |
| The mobility in the time of flood | Sink and float, and Buoyant force of liquid |
|                               | Drawing and sketching     |
|                               | Designing and problem solving in creating a float container with the given constrains |
|                               | Calculating area, surface area, and volume |
| The balloon rocket            | 1. Action and reaction force |
|                               | 2. Motion and fraction    |
|                               | Technological system      |
|                               | Engineering and problem solving process |
|                               | Measuring and calculating |
| The balloon powered car       | Action and reaction force |
|                               | Technological system and technology tools |
|                               | Engineering and problem solving process |
|                               | Measuring and calculating |
| The rubber band powered car   | Elasticity               |
|                               | Technological system and technology tools |
|                               | Engineering and problem solving process |
|                               | Measuring and calculating |

3.3 Instruments of the study
Multi-rater approach was used to investigate the students’ problem solving and thinking competency. To cover all five elements of the competency, self-assessment as rating scale, observer (friends)-checklists and scoring rubric by teachers were used as the study instruments. Raters and the instruments are shown in Table 2.
Table 2. The instruments of the study

| Element of competency       | Rater/Instrument          |
|-----------------------------|---------------------------|
| Skills, Knowledge           | Teachers/Scoring rubric   |
|                             | Friends/Checklist         |
|                             | Self-assessment/Rating scale |
| Traits, Motives, Self-concepts | Teachers/Checklist       |
|                             | Self-assessment/Rating scale |

3.4 Data collection
As the purpose of the study is focused on two competencies, the indicator in each competency was described. According to Problem solving competency, comprised of two indicator which were 1) using problem solving process which are analyzing problems, planning, implementing and evaluating and concluding and 2) the result from the solution. For thinking competency, two indicators were defined as 1) basic thinking and 2) advanced thinking. All indicators were assessed with the multi-rater and specific instrument. After finishing each STEM activity, teachers and observers have discussed to assess the students competencies, including teachers’ reflection. At the same time, the students assessed themselves and their friends after the activity as well.

3.5 Data analysis
There were two procedures in assessment the students’ competency as following; 1) assessment in each instrument of the competency and 2) assessment in total of the competency. Firstly, in each indicator, the result from each assessment was concluded and transformed into percentage scores. After that, the percentage scores were processed with another instrument. In total, the competency assessment was estimated by finding the average score by weigh rating score (the weight rating proportion for teacher assessment: self-assessment: friend assessment was 2:1:1). The example for finding the average score for problem solving competency has shown as following:

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\text{The average score} = \frac{(2 \times \text{teacher assessment score} \%) + (1 \times \text{self-assessment score} \%) + (1 \times \text{friend assessment})}{4}
\]

The average score of problem solving and thinking competency was interpreted as the rubric defined by the OBEC; which was developed based on cut-off scores method [7]. The rubric was discussed by Thai educators, teachers and directors to validate its quality. The students’ competency was defined into three level; good (more than 75%), fair (40% - 74%) and unsatisfied (less than 40%). The result from this study was reported in the form of the students’ percentage in each level. The after action reviews were presented also in this study.

4. Results and Discussion
Upon conducting the STEM activity for 20 students of Thakhanthowittayakarn School as the promoting the students’ competencies, the results are as follows. The students’ competencies were considered into three levels; good, fair and unsatisfied. Findings revealed that 75% of the students were in good level, and the rest were in fair level for problem solving competency. And as for the thinking competency, 85% of the students were in good level and 15% were in fair level as showed in Table 3. As indicated in the table, there were no students who were in unsatisfied level since most of them fell under the good category.
Table 3. the problem solving and thinking competencies

| Students No. | Problem solving competency | Thinking competency |
|--------------|----------------------------|---------------------|
|              | Total percentage score (%)| The competency level| Total percentage score (%)| The competency level |
| 1            | 78.0                       | Good                | 78.7                       | Good                |
| 2            | 75.6                       | Good                | 77.4                       | Good                |
| 3            | 76.7                       | Good                | 76.9                       | Good                |
| 4            | 77.3                       | Good                | 76.7                       | Good                |
| 5            | 77.6                       | Good                | 76.0                       | Good                |
| 6            | 76.6                       | Good                | 78.8                       | Good                |
| 7            | 76.0                       | Good                | 77.7                       | Good                |
| 8            | 75.3                       | Good                | 76.2                       | Good                |
| 9            | 76.1                       | Good                | 77.0                       | Good                |
| 10           | 76.2                       | Good                | 75.8                       | Good                |
| 11           | 73.8                       | Fair                | 77.6                       | Good                |
| 12           | 72.8                       | Fair                | 77.1                       | Good                |
| 13           | 71.2                       | Fair                | 72.8                       | Fair                |
| 14           | 75.1                       | Good                | 76.0                       | Good                |
| 15           | 75.6                       | Good                | 78.0                       | Good                |
| 16           | 73.5                       | Fair                | 72.9                       | Fair                |
| 17           | 75.6                       | Good                | 73.2                       | Fair                |
| 18           | 72.6                       | Fair                | 76.2                       | Good                |
| 19           | 76.8                       | Good                | 77.1                       | Good                |
| 20           | 75.2                       | Good                | 77.3                       | Good                |

It may be seen that the STEM activity which conducted in the study were doing great even without formal lecture. It is simply because they enjoyed what they were doing and did not feel any pressure about grading. The STEM activity allows them to do as they pleased but not excluding from its main objective, and of course, with visible results. This finding consequent with the study related to activity-based learning [14, 3] which mentioned that students’ problem-solving and thinking skills will be promoted through doing activity. In this research, both students and the teachers save a lot of time in learning STEM concepts – the students can now easily construct the ideas that the teacher is trying to convey and the latter will not have a hard time imparting the knowledge to the students. This goes to show that the STEM activity, if applied properly can ease the burden of the students in learning and thus make their new experiences fun and exciting. Problem-solving and thinking skills could be created if given the right combination and this study proves it. Solutions and answers are easier to achieve and most especially, the students are having fun – which make it them more excited every day.

5. Conclusion
Based on the results, it is concluded that in using the STEM activity, results are evident and the application of knowledge in real-life situation is one step easier and faster. Students are learning in a fun and productive way. There is no doubt that this method is effective for both the learners and the educators.
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