Research synthesis of STEM Education approach effected on students’ problem solving skills in Thailand

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Abstract. STEM education integrates concepts that are usually taught as separate subjects in different classes and emphasizes the application of knowledge to real-life situations. A lesson or unit in a STEM class is typically based around finding a solution to a real-world problem and tends to emphasize problem solving ability. So, the objective of this research is to synthesize research about STEM Education Approach effected on students’ problem solving skill in Thailand. Variables consisted of a unit of variable which included 17 variables. The collecting data tool is adjusted from the recording data form of the Office of Education Council in Thailand. Data were analyzed by frequency and percentage and were showed the result of STEM Education effected to problem solving skill analysing by one sample t-test, criterion and growth score for content analysis. The results showed that STEM Education Approach effected on students’ problem solving skills in Thailand research dated by 2009-2019 were published mostly in 2017. Naresuan University did the target research highest frequency. Researchers from Curriculum and Instruction, Early Childhood Education, Sciences Education, and Education major mostly produced the research and worked at the Office of the Basic Education Commission. Female researchers did the more research in STEM Education than male. Thesis in Master degree was done the most comparing with dissertation in Doctoral Degree. Common research objectives mostly focused on “study”. Experimental design was found mostly especially in one group pretest-posttest design. Sampling method was found the most in Purposive sampling. Frequent sample found was students and followed by teachers and expert. Upper secondary level was mostly found in Educational level of sample. The subject area found the most was Physics and followed by Biology. Lesson plans were mostly used in research instruments and analyzing methods mostly used descriptive statistic. The result of STEM Education effected to problem solving skills using one sample t-test found that students’ problem solving skills mean score in the post-test were higher than that in the pre-test after learning by STEM Education approach at both the 0.01 and 0.05 level of significance relating to the analyzing method by using mean and standard deviation and growth score.

1. Introduction

STEM is an acronym for Science, Technology, Engineering and Mathematics. Science is the study and understanding of the natural world. Technology refers to tools and simple machines that make work easier. Engineering is using tools to plan and design a solution to a problem and Mathematics is the
study and understanding of shapes, numbers, and patterns. Rather than teach each of these subjects separately, STEM integrates all subjects with hands-on projects and challenges. STEM encourages children to explore their imaginations, ask questions and solve problems on their own. STEM lessons are fun and hands on, as they allow children to learn while “playing.” Learning by doing is essential for young learners to grasp concepts. The connection to real world problems allows a deeper understanding of concepts. Most importantly, STEM lessons foster a love for learning as children strengthen their skills and gain self-efficacy when they complete challenges. Most lessons involve children working together as a team to solve relevant problems. This will ultimately show children how their studies can be applied to the real world. Furthermore, students need to collaborate and communicate with their peers to solve the problem [3].

Gagne’s defined problem solving as the “synthesis of other rules and concepts into higher order rules which can be applied to a constrained situation.” [1]. Problem solving also includes attitudinal as well as cognitive components. To solve problems, learners have to want to do so, and they have to believe they can. Motivation and attitudinal aspects such as effort, confidence, anxiety, persistence and knowledge about self are important to the problem solving process [2]. So problem solving skill is one of the most important skills in the 21st century education.

Hence, The Organization for Economic Cooperation and Development (OECD) contained problem solving skill in Programme for International Student Assessment (PISA) to be prepared for real-life situations in the adult world and, in Thailand, the Institute for The promotion of teaching science and technology published the result of the study of PISA through collaborative problem solving capacity that Thai students got 436 points lower than mean score at 500 points and also were in the 43rd ranks from 52 countries [4].

In Thailand, there were many research which studied about STEM Education effected on several skills, however, the researcher need to focus on problem solving skills to know how is it efficient to learners in Thailand by using research synthesis methodology. It is an important task that every researcher has to do in order to integrate previous research finding to the present research and can be employed in any areas of studied, and useful for accumulating knowledge and generating new evidences. [7]. Therefore, this research attempted to synthesize research about STEM Education Approach effected on students’ problem solving skills in Thailand.

2. Objectives of the study
This research aims to synthesize research about STEM Education Approach effected on students’ problem solving skills in Thailand.

3. Data of the study
3.1 The Keywords are STEM Education and Problem solving skill or ability.
3.2 Resource Information includes TDC (ThaiLIS).
3.3 Period of published research papers are not exceeding ten years in education field (2009-2019) Results of searching base were shown in Appendix.

4. Materials and Methods
The research methodology of this study was divided into three stages; Preparation, Data Collection, and Data Analysis [6].

4.1 Preparation
All available information were collected and analysed by focusing on STEM Education Approach effected on students’ problem solving skills which many scholars discovered in graduate researches in Thailand. The related literatures used in this study were chosen from TDC (Thai Digital Collection), ThaiLIS (Thailand Library Integrated System).
4.2 Data Collection
Variables consisted of a unit of variable which included 14 variables which are year of completed research, institute, major, office, gender, objectives, type of research, research design, sampling methods, status of sample, educational level of sample, subject area, research instruments, and analyzing methods. Collecting data tool was the recording data form for research synthesis which adjusted from the recording data form of the Office of Education Council in Thailand [4].

4.3 Data Analysis
This research synthesis uses content analysis that consists of the quantitative research using frequency, percentage for analyzing the research description and shows the result of STEM Education effected to problem solving skill analysing by one sample t-test, criterion and growth score.

5. Results
The data analysis results explain about the nature of 10 research. The details are shown in Table 1-18.

| Table 1. Percentage of research categorized by year |
|-----------------------------------------------|
| Year of completed research | Frequency | Percentage |
| 2015 | 2 | 20 |
| 2016 | 1 | 10 |
| 2017 | 7 | 70 |
| **Total** | **10** | **100** |

| Table 2. Percentage of research categorized by institute |
|----------------------------------------------------------|
| Institute | Frequency | Percentage |
| Kasetsart University | 1 | 10 |
| Prince of Songkla University | 2 | 20 |
| Chiang Mai University | 1 | 10 |
| Naresuan University | 3 | 30 |
| Mahasarakham University | 1 | 10 |
| Rajabhat Mahasarakham University | 2 | 20 |
| **Total** | **10** | **100** |

| Table 3. Percentage of research categorized by major |
|----------------------------------------------------|
| Major | Frequency | Percentage |
| Curriculum and Instruction | 2 | 20 |
| Early Childhood Education | 2 | 20 |
| Teaching Science and Mathematics | 1 | 10 |
| Sciences Education | 2 | 20 |
| Educational Technology and Communications Education | 1 | 10 |
| **Total** | **10** | **100** |

| Table 4. Percentage of research categorized by office |
|------------------------------------------------------|
| Office | Frequency | Percentage |
| Office of the Basic Education Commission | 7 | 70 |
| Office of the Higher Education Commission | 2 | 20 |
| Office of the Private Education Commission | 1 | 10 |
| **Total** | **10** | **100** |
Table 5. Percentage of research categorized by gender

| Gender   | Frequency | Percentage |
|----------|-----------|------------|
| Male     | 1         | 10         |
| Female   | 9         | 90         |
| **Total**| **10**    | **100**    |

Table 6. Percentage of research categorized by type of research

| Type of research   | Frequency | Percentage |
|--------------------|-----------|------------|
| Thesis             | 8         | 80         |
| Dissertation       | 2         | 20         |
| **Total**          | **10**    | **100**    |

Table 7. Percentage of research categorized by objectives of research

| Objectives of research | Frequency | Percentage |
|------------------------|-----------|------------|
| Study                  | 19        | 73.07      |
| Compare                | 3         | 11.53      |
| Design / construct/ develop | 3     | 11.53      |
| Analyze                | 1         | 3.84       |
| **Total**              | **26**    | **100**    |

Table 8. Percentage of research categorized by research design

| Research design                        | Frequency | Percentage |
|----------------------------------------|-----------|------------|
| Qualitative design (Schumuck)          | 2         | 20         |
| Experimental design                    |           |            |
| -One group pretest-posttest design     | 4         | 40         |
| -One group pretest-posttest time series design | 1     | 10         |
| -One-shot case study                   | 1         | 10         |
| Research and Development               | 2         | 20         |
| **Total**                              | **10**    | **100**    |

Table 9. Percentage of research categorized by sampling methods

| Sampling methods            | Frequency | Percentage |
|----------------------------|-----------|------------|
| Purposive sampling         | 8         | 80         |
| Simple random sampling     | 1         | 10         |
| Cluster random sampling    | 1         | 10         |
| **Total**                  | **10**    | **100**    |

Table 10. Percentage of research categorized by status of sample

| Status of sample                          | Frequency | Percentage |
|-------------------------------------------|-----------|------------|
| Students                                  | 8         | 80         |
| Mixed (Experts, teachers and students)    | 2         | 2          |
| **Total**                                 | **10**    | **100**    |
Table 11. Percentage of research categorized by educational level of sample

| Educational level of sample | Frequency | Percentage |
|-----------------------------|-----------|------------|
| Kindergarten                | 2         | 20         |
| Primary level               | 2         | 20         |
| Lower Secondary level       | -         | -          |
| Upper Secondary level       | 6         | 60         |
| **Total**                   | **10**    | **100**    |

Table 12. Percentage of research categorized by subject area

| Subject area                  | Frequency | Percentage |
|-------------------------------|-----------|------------|
| Physics                       | 3         | 30         |
| Chemistry                     | 1         | 10         |
| Biology                       | 2         | 20         |
| Computer Studies              | 1         | 10         |
| Sciences                      | 1         | 10         |
| Engineering                   | 1         | 10         |
| Other (local wisdom)          | 1         | 10         |
| **Total**                     | **10**    | **100**    |

Table 13. Percentage of research categorized by research instruments

| Research instruments                  | Frequency | Percentage |
|---------------------------------------|-----------|------------|
| Web-based instructional system        | 1         | 2.44       |
| Lesson plans                          | 9         | 21.95      |
| Questionnaires                        | 3         | 7.31       |
| Achievement Test                      | 7         | 17.07      |
| Problem solving ability/skills test   | 8         | 19.51      |
| Interviews                            | 4         | 9.75       |
| Observation form                      | 2         | 4.88       |
| Reflection note/journal               | 2         | 4.88       |
| Field-note                            | 4         | 9.75       |
| Focus group                           | 1         | 2.44       |
| **Total**                             | **41**    | **100**    |

Table 14. Percentage of research categorized by analyzing methods

| Analyzing methods                  | Frequency | Percentage |
|------------------------------------|-----------|------------|
| Growth score                       | 2         | 9.09       |
| Content analysis                   | 2         | 9.09       |
| Descriptive statistics             | 8         | 36.36      |
| Dependent t-test                   | 5         | 22.72      |
| Repeated ANNOVA                    | 1         | 4.54       |
| Correlation                        | 1         | 4.54       |
| Regression                         | 1         | 4.54       |
| Coefficient value                  | 1         | 4.54       |
| Effectiveness Index (E.I)          | 1         | 4.54       |
| **Total**                          | **22**    | **100**    |
Table 15. The result of STEM Education effected to problem solving skills using one sample t-test (N=4)

| Educational Level | sample | N   | mean  | standard deviation | df  | t-test | p-value |
|-------------------|--------|-----|-------|--------------------|-----|--------|---------|
| Upper Secondary level (1) | Pretest | 39  | 22.27 | 0.59               | 38  | 5.829**| .00     |
| Primary level (1) | Posttest | 38  | 28.56 | 0.85               |     |        |         |
| Upper Secondary level (2) | Pretest | 35  | 27.74 | -                  | 34  | 15.42* | .00     |
| Primary Level (2) | Posttest | 34  | 18.63 | -                  |     |        |         |
| Upper Secondary level (1) | Pretest | 37  | 14.35 | 2.77               | 36  | 22.11* | .00     |
| Primary Level (2) | Posttest | 36  | 22.49 | 2.60               |     |        |         |

**p<.01, *p<.05

Table 16. The result of STEM Education effected to problem solving skills using criterion standard (N=2)

| Educational Level | N   | sample | full marks | the percent criterion | Score of the percent criterion | mean | standard deviation | df  | t-test | p-value |
|-------------------|-----|--------|------------|-----------------------|--------------------------------|------|--------------------|-----|--------|---------|
| Primary level    | 33  | Posttest | 40         | 75%                   | 30                             | 32.67| 2.42               | 32  | 6.36** | .00     |
| Kindergarten     | 17  | Posttest | 20         | 70%                   | 14                             | 16.88| -                  | 16  |        | -       |

Table 17. The result of STEM Education effected to problem solving skills using mean and standard deviation (N=1)

| Educational Level | N   | sample | full marks | mean | standard deviation |
|-------------------|-----|--------|------------|------|--------------------|
| Kindergarten      | 19  | Pretest | 20         | 8.32 | 2.38               |
|                   |     | Posttest | 16.11      | 1.70 |                    |

Table 18. The result of STEM Education effected to problem solving skills using growth score. (N=1)

| Growth score | Problem solving ability (1st test) | Problem solving ability (2nd test) | Problem solving ability (3rd test) |
|--------------|-----------------------------------|-----------------------------------|-----------------------------------|
|              | Gain score | Relative Gain score | analysis result | Gain score | Relative Gain score | analysis result | Gain score | Relative Gain score | analysis result |
| mean         | 0.14       | 1.6                 | Low            | 3.93       | 63.39              | high            | 1.26       | 53.90              | high            |
| standard deviation | 0.72       | 11.47               |                | 0.94       | 14.33              |                | 0.70       | 27.19              |                |

Conclusion and Discussion

Conclusion

The results showed that STEM Education Approach effected on students’ problem solving skills in Thailand research were published mostly in 2017 at 70%. Naresuan University did the target research highest frequency at 30%. Curriculum and Instruction, Early Childhood Education, Sciences Education, and Education major did an average of 20%. The researchers from the Office of the Basic Education Commission produced the research mostly at 70%. Female researchers did the most at 90%.
Thesis in master degree was done the most at 80%. Common research objectives focused on “study” at 73.07%. Experimental design was found mostly especially in “One group pretest-posttest design” at 40%. Sampling method was found the most in Purposive sampling at 80%. Frequent sample found was students at 80%. Upper secondary level was mostly found at 60% of educational level of sample. The subject area found the most was Physics at 30%. Lesson plans were mostly used in research instruments at 27.95% and analyzing methods mostly used in the research were descriptive statistics at 36.36%.

The result of STEM Education effected to problem solving skills using one sample t-test found that students’ problem solving skills mean score in the post-test were higher than that in the pre-test after learning by STEM Education approach at both the 0.01 and 0.05 level of significance relating to the analyzing method by using mean and standard deviation and growth score.

Discussion
From the presented study, we have demonstrated that STEM Education Approach effected on students’ problem solving skills in Thailand research is increasing each year and there are variety of institutes, major and office, especially in term of major, researchers from 7 majors were interested in STEM Education Approach effected on students’ problem solving skills, for instance, Curriculum and Instruction, Early Childhood Education, Teaching Science and Mathematics, Sciences Education, Educational Technology and Communications, and Education. When we considered from gender, we found that female was the most number to produce this kind of research at 90%. Thesis was done in Master degree at 80% while dissertation in Doctoral degree was only 10%. The main purpose of the study focused on to study the result of STEM Education effected to solving problem skill and most of experiment were one group pretest posttest design and purposive sampling. Moreover, the sample frequently used with students in Upper Secondary level. There were several subject areas used in the experiment such as Physics, Chemistry, Biology, Computer studies, Sciences and Engineering. In Childhood Education, a researcher did the research about local wisdom in the community. This means STEM Education can be used in every educational level. When we considered about research instruments, we found that there were variety of research instruments used in these research although, the core instrument was lesson plan related to STEM Education approach and problem solving skills. But there were many kinds of instruments used to measure in quantitative and qualitative methods such as questionnaires, achievement test, problem solving skills test, interviews, observation form, reflection note, field-note and focus group. And there were also several analyzing methods used in these research.

By considering about the effect of STEM Education Approach on students’ problem solving skills, we found that STEM Education Approach can obviously promote students’ problem solving skills in several analyzing methods and the finding of every research was consistency [1] [3] [5]. However, there was a few research which studied in term of growth score which found that the students’ problem solving skill mean score in the post-test was higher than that in the pre-test after learning by STEM Education approach [7]. And from ten research, there were only two of those using content analysis to report the result of the study [1] [10].

From the findings of the research, STEM Education Approach can also promotes collaborative learning, thinking process and analyzing problem that can help students to develop their solving problem skills [7] and be prepared for real-life situations in the adult world [1]. Thus, we should support and promote the researchers to study by using variousness and suitability methods for the validity and accuracy of the research. And we can use the results of the research to develop our students and reach the goal of 21st Century Skills.

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