Research synthesis of STEM Education effected on science process skills in Thailand

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Abstract. STEM stands for Science, Technology, Engineering and Mathematics integrated to be an educational management approach. It also enhances students’ thirteen science process skills including observing, classifying, measuring, using numbers, using space/time relationship, inferring, predicting, communicating, identifying and controlling variables, defining variables operationally, formulating hypotheses, experimenting, interpreting data and drawing conclusion. These are divided into two groups: basic process skills consisting of the first eight processes and integrated process skills consisting of the last five processes. Nowadays, there are plenty of studies concerning the STEM Education effect on students’ science achievements in Thailand but not many focusing on science process skills. Therefore, the objective of this research is to synthesize the STEM Education effect on Thai students’ science process skills. The variables consist of two sets which are the description of research, and the effect sizes of research. The tool for collecting data is the recording data form for research synthesis. Data were analysed by frequency, percentage and meta-analysis. The results showed that 1) the description of research found that from 2010 until 2019 research referring to students’ science process skills on STEM Education published ten reports, mostly in 2016 and 2018 (40%), Maha Sarakham University and Rajabhat Maha Sarakham University equally usually produced the research referring to the students’ science process skills on STEM Education (30%), most researchers from the Office of the Basic Education Organization produced the research (90%), most were female researchers (80%), the research type was thesis in master degree (100%), the objective commonly found was to compare (44%), most of the research design found was in experimental design using One Group Pretest - Posttest Design (80%), always found sampling methods using cluster random samplings (50%), sample found mainly was students (100%), samples’ research level was equally both lower and upper secondary (50%) , used largely in science (50%) and repeated analyzing method found was descriptive statistics (27.02%) , and most of the science process skills were integrated skills (60%). 2) The effect sizes (d) of STEM Education effect on students’ science process skills was 1.69. The Standard Deviation (Sd) was 1.99. This means that the STEM Education can influence students’ science process skills.

1. Introduction
One of the essential learning outcomes in science education is science process skills. They play a vital role in scientific literacy. In the revised Thai science and technology curriculum, science process skills are harmonized within all the indicators of every science learning standard. Its aim is to develop
students’ abilities to apply knowledge to their higher education and daily lives, solve problems systemically, make decision using various types of data and investigate evidence. The students must possess both science process skills and 21st century skills [9]. The science process skills of Thai science and technology education compose of thirteen skills divided into two groups: basic and integrated process skills. There are eight basic process skills which are observing, classifying, measuring, using numbers, using space/time relationship, inferring, predicting, and communicating. The rest five are integrated process skills which compose of identifying and controlling variables, defining variables operationally, formulating hypotheses, experimenting and interpreting data and drawing conclusion [12]. In general, the basic science process skills are important for science learning, scientific enquiry and concept construction at the elementary and middle school levels. Yet, the integrated science process skills are more appropriate at the high school and higher education levels. Consequently, Akinbobola and Afolabi and Beaumont–Walters and Soyibo said the basic process skills are a prerequisite for the integrated skills [1][2].

STEM education is an educational approach integrating Science, Technology, Engineering and Mathematics focusing on problem solving in everyday life and professional undertaking. It provides learning experiences through activities or projects with regard to solving real life problems in order to develop the students’ experience, life skills, analytical thinking, problem solving skills and creativity for innovation. Therefore, the learners with experience of STEM activities or projects will be better prepared to work in demanding positions which require knowledge and skills in science, mathematics and technology [14]. In addition, the science process skills are able to make science learning easier, increase the students’ activities, increase the students’ responsibility towards learning when they conduct and teach students scientific methods or researches. Related with Karamustafaoglu (2011) and Hodosyova, Uta, Vanyava and Lapikova, they clarified that the importance of these skills for students include how to implement sciences in real learning and in everyday life, how to apply concepts, how to generate theories and rules in learning [7][8]. As a result, STEM education using activities or projects is able to enhance students’ science process skills influencing not only the students’ abilities but also the knowledge of particular subjects in which the skills are used.

However, we found that the results from the International Student Assessment (PISA) is undesirable since they were lower than the OECD average [16]. Likewise, the Ordinary National Educational Test (O-NET) in 2018 showed that all average scores of the students tests were less than 50% [15]. To raise the students’ science achievements, we had better adapt the science process skills to the entire content of science in learning. The science process skills will foster specific scientific knowledge and also increase the science achievements. Gezer (2015) and Dillashaw and Okey (1980) revealed that the students participating actively, integrating science to life, making learning meaningful, having responsibility for their learning and having science process skills would have efficient and significant achievements [3][4]. So as to promote the students’ achievements by using the science process skills on STEM Education in Thailand, the researcher had to study all research regarding the STEM Education in Thailand enhancing the students’ science process skills in the Thai Library Integrated System (ThaiLIS) of which were only ten reports during ten years (2010-2019). A small amount of research mentioning the students’ science process skills was found as they might have focused only on the effects of STEM Education teaching method lacking students’ science process skills.

Due to the small number of studies of the STEM Education effected on students’ science process skills in Thailand, Meta-Analysis was used due to the fact that it is a method of the research synthesis in order to decrease bias and systemize data analysis for a reliable conclusion. It includes making use of quantitative studies in related fields in the STEM Education effected on students’ science process skills using statistics in analyzing data to determine relationships and compare quantitative values between interesting variables that are students’ science process skills. This study is analyzed qualitatively for discussion of interesting results or issues, aimed at creating or generating some ideas for any educators who expect to encourage the students’ scientific achievements by putting
emphasis on the students’ science process skills. Thereby, the objective of this study was to synthesize research about the STEM Education effected on students’ science process skills in Thailand.

2. Objective of the study
This research attempts to synthesize research about the STEM Education effected on students’ science process skills in Thailand.

3. Data of the study
3.1. The keyword is the students’ science process skills on STEM Education.
3.2. Resource Information in the Thai Library Integrated System (ThaiLIS)
3.3. Period of published research papers are not exceeding a decade in educational field (2010 - 2019). There were only ten studies. Results of searching base in Appendix.

4. Material and Methods
The research methodology of this study could be divided into three stages adjusted from Srikoon S Bunterm T Samranjai J & Wattanathron J (2014) [13]: Preparation, Data Collection and Data Analysis.

4.1. Preparation
To study all available information based on the STEM Education effected on students’ science process skills discovered in scholars’ graduate research in Thailand. The related literature was used in this study chosen from the Thai Library Integrated System (ThaiLIS).

4.2. Data Collection
Variable contained two sets of data. The first set adjusted from Srikoon S Bunterm T Samranjai J & Wattanathron J (2014) [13] which was a unit of variable included 12 variables coded by 1) years of completed research, 2) institute, 3) office, 4) gender, 5) type of research, 6) objectives of research, 7) research design, 8) sampling methods, 9) educational level of the sample, 10) content, 11) analyzing methods and 12) science process skills. The second set, one variable was coded to type of independent and dependent variable and the analyzing results.

The tool for collecting data was the recoding data for research synthesis adjusted from the recording data form from the Office of Education Council in Thailand [11].

4.3. Data Analysis
This research synthesis was the quantitative research using frequency and percentage to analyze the research description. Meta-analysis was used to analyze the effect sizes of independent variables by the methods which was $ES = \frac{\bar{X}_E - \bar{X}_C}{SD_c}$ proposed by Glass [5].

5. Results
Results of this research are presented in two parts.

5.1. Description of research
Results from the analyzing data explain about the nature of ten researches. Details are shown in Table. 1 – 12.

| Year of completed research | Frequency | Percentage |
|----------------------------|-----------|------------|
| 2015                       | 1         | 10.00      |
| 2016                       | 4         | 40.00      |
| 2017                       | 1         | 10.00      |
| 2018                       | 4         | 40.00      |
Table 1 represented the completed research years of the studies referring to the STEM Education effect on students’ science process skills; were 40% both in 2016 and 2018 and 10% both in 2015 and 2017.

Table 2. Percentage of research categorized by institute

| Institute                             | Frequency | Percentage |
|---------------------------------------|-----------|------------|
| Maha Sarakham University              | 3         | 30.00      |
| Rajabhat Maha Sarakham University     | 3         | 30.00      |
| Burapha University                    | 1         | 10.00      |
| Rajabhat Sakonnakhon University       | 1         | 10.00      |
| Ubon Ratchathani University           | 1         | 10.00      |
| Sukhothai Thammathirat Open University| 1         | 10.00      |
| **Total**                             | **10**    | **100**    |

Table 2 showed that Maha Sarakham University and Rajabhat Maha Sarakham University equally published the most research on the STEM Education effect on students’ science process skills which were 30% and Burapha University, Rajabhat Sakonnakhon University, Ubon Ratchathani University and Sukhothai Thammathirat Open University equally published on the STEM Education effect on students’ science process skills which were 10%.

Table 3. Percentage of research categorized by office

| Office                             | Frequency | Percentage |
|------------------------------------|-----------|------------|
| Office of the Local Government Organization | 1         | 10.00      |
| Office of the Basic Education Organization | 9         | 90.00      |
| **Total**                         | **10**    | **100**    |

Table 3 revealed that 90% of the researchers who studied the STEM Education effect on students’ science process skills were from the Office of the Basic Education Organization and 10% were from the Office of the Local Government Organization.

Table 4. Percentage of research categorized by gender

| Gender   | Frequency | Percentage |
|----------|-----------|------------|
| Female   | 8         | 80.00      |
| Male     | 2         | 20.00      |
| **Total**| **10**    | **100**    |

Table 4 made known that most researchers who studied about the STEM Education effect on students’ science process skills were females; 80% and 20% were male researchers.

Table 5. Percentage of research categorized by type of research

| Type of research | Frequency | Percentage |
|------------------|-----------|------------|
| Thesis           | 10        | 100        |
| **Total**        | **10**    | **100**    |

Table 5 showed that all of the research about the STEM Education effect on students’ science process skills was thesis; 100%.
Table 6. Percentage of research categorized by objectives of research

| Objectives of research | Frequency | Percentage |
|------------------------|-----------|------------|
| To study               | 8         | 32.00      |
| To compare             | 11        | 44.00      |
| To use                 | 1         | 4.00       |
| To assess              | 1         | 4.00       |
| To create              | 2         | 8.00       |
| To analyze             | 1         | 4.00       |
| To develop             | 1         | 4.00       |
| **Total**              | 25        | **100**    |

Table 6 represented the percentage of the objectives of the research about the STEM Education effected on students’ science process skills respectively; 44% was to compare, 32% was to study, 8 % was to create and 4% were equally to use, to assess, to analyze and to develop.

Table 7. Percentage of research categorized by research design

| Research design                  | Frequency | Percentage |
|----------------------------------|-----------|------------|
| One Group Pretest – Posttest Design | 8         | 80.00      |
| Two Group Pretest – Posttest Design | 2         | 20.00      |
| **Total**                        | 10        | **100**    |

Table 7 uncovered the percentage of the research design about the STEM Education effected on students’ science process skills that 80% was One Group Pretest – Posttest Design and 20% was Two Group Pretest – Posttest Design.

Table 8. Percentage of research categorized by sampling methods

| Sampling methods                       | Frequency | Percentage |
|----------------------------------------|-----------|------------|
| Purposive Sampling                     | 3         | 30.00      |
| Random Assignment                      | 1         | 10.00      |
| Multistage Random Sampling             | 1         | 10.00      |
| Cluster Random Sampling                | 5         | 50.00      |
| **Total**                              | 10        | **100**    |

Table 8 showed the percentage of the sampling methods about the STEM Education effected on students’ science process skills were 50% from cluster random sampling, 30% from purposive sampling and 10% from both random assignment and multistage random sampling.

Table 9. Percentage of research categorized by educational level of the sample

| Educational level of the sample       | Frequency | Percentage |
|---------------------------------------|-----------|------------|
| Students in Lower Secondary Level     | 5         | 50.00      |
| Students in Upper Secondary Level     | 5         | 50.00      |
| **Total**                             | 10        | **100**    |

Table 9 displayed that the percentage of educational level of the sample about STEM Education effected on students’ science process skills was students studying in the upper secondary level which was 50%, and in the lower secondary level which was 50% equally.
Table 10. Percentage of research categorized by content

| Content   | Frequency | Percentage |
|-----------|-----------|------------|
| Science   | 5         | 50.00      |
| Physics   | 2         | 20.00      |
| Chemistry | 3         | 30.00      |
| **Total** | **10**    | **100**    |

Table 10 represented that the percentage of contents in the research about the STEM Education effect on students’ science process skills; science which was 50%, chemistry was 30% and physics was 20%.

Table 11. Percentage of research categorized by analyzing methods

| Analyzing methods                      | Frequency | Percentage |
|----------------------------------------|-----------|------------|
| Descriptive statistics                 | 10        | 27.02      |
| IOC                                    | 2         | 5.40       |
| Difficulty                             | 1         | 2.70       |
| Discrimination                         | 1         | 2.70       |
| One Way ANOVA                          | 2         | 5.40       |
| Simple Correlation                     | 2         | 5.40       |
| Multiple Correlation                   | 2         | 5.40       |
| Simple Linear Regression Analysis      | 1         | 2.70       |
| Hotelling’s $T^2$                      | 1         | 2.70       |
| Paired Samples t-test                  | 1         | 2.70       |
| Standardized Regression Validity (B)   | 2         | 5.40       |
| Efficiency Predictive Value (R$^2$)    | 2         | 5.40       |
| Independent t-test                     | 2         | 5.40       |
| Dependent t-test                       | 8         | 21.62      |
| **Total**                              | **37**    | **100**    |

Table 11 showed the percentage of the analyzing methods in the research of the STEM Education effect on students’ science process skills in order; 27.02% was descriptive statistics, 21.62% was dependent t-test and 5.40% was IOC, One Way ANOVA, Simple Correlation, Multiple Correlation, Standardized Regression Validity (B), Efficiency Predictive Value (R$^2$) and independent t-test equally and 2.70% was Difficulty, Discrimination, Simple Linear Regression Analysis, Hotelling’s $T^2$ and Paired Samples t-test equally.

Table 12. Percentage of research categorized by science process skills

| Science process skills     | Frequency | Percentage |
|----------------------------|-----------|------------|
| Basic Skills               | 2         | 20.00      |
| Integrated Skills          | 6         | 60.00      |
| Basic and Integrated Skills| 2         | 20.00      |
| **Total**                  | **10**    | **100**    |

Table 12 revealed the percentage of the science process skills used the research about the STEM Education effect on students’ science process skills; 60% was integrated skills, 20% were both basic skills and mixed basic and integrated skills.
5.2. Effect sizes of research

Effect sizes of research shown in Table.13.

| Independent Variable | N  | d   | s_d |
|----------------------|----|-----|-----|
| Science process skills | 2 | 1.69| 1.99|

Table. 13 showed the effect sizes (d) from students’ science process skills on STEM Education in Thailand on independent variable was 1.69. The Standard deviation (S_d) was 1.99. It concludes that the STEM Education has an effect on students’ science process skills.

6. Results and Discussion

The results showed that from the description of research, we found that from 2010 until 2019 research referring to students’ science process skills on STEM Education published ten reports, mostly in 2016 and 2018 (40%), Maha Sarakham University and Rajabhat Maha Sarakham University equally usually produced the research referring to the students’ science process skills on STEM Education (30%), most researchers from the Office of the Basic Education Organization produced the research (90%), most were female researchers (80%), the research type was thesis in master degree (100%), the objective commonly found was to compare (44%), most of the research design found was in experimental design using One Group Pretest - Posttest Design (80%), always found sampling methods using cluster random samplings (50%), sample found mainly was students (100%), samples’ research level was equally both lower and upper secondary (50%) used largely in science (50%) and repeated analyzing method found was descriptive statistics (27.02%) , and most of the science process skills was integrated skills (60%). The effect sizes (d) of STEM Education effected on students’ science process skills was 1.69. The Standard Deviation (S_d) was 1.99. This means that the STEM Education can influence students’ science process skills.

The lack of adequately developed science process skills is a problem for students in understanding scientific concepts and learning science [10]. Hence, every educator should provide a classroom climate such as cooperative learning or simulated multimedia which helps and supports develop science process skills related with Grace, Nakthong, Anuntasethakul and Yutakom [6]. Furthermore, the science process skills facilitated the science learning and students’ activities, increased the students’ responsibility for their learning, and fulfilled the students with the scientific methods or research as well as scientific achievements. The science process skills are also useful to the students as it lets them think about how to get information, to realize about problems and to formulate conclusions. These skills are suitable for all fields of science. Therefore, the important thing for the students is to learn how to implement sciences in real learning and in everyday life, to apply concepts and to generate theories and rules in learning [6][10].

The research regarding STEM Education on students’ science process skills we found in Thailand is scant. Therefore, we should advocate every institute to study this topic increasingly to develop the classroom climate using science process skills for students to gain effective scientific achievements with STEM Education and help students reach the goal of 21st Century Skills. According to the results, STEM Education using the STEM teaching approach can expand students’ science process skills. Provided the students were cultivated by active learning regarding science process skills, they can improve their scientific achievements as well as adapt to their daily lives in the modern world.

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Appendix

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