

Contribution of Integrated Learning through STEM Education in ASEAN Countries

Prasart Nuangchalerm^{1,*}, Veena Prachagool¹, R. Ahmad Zaky El Islami², Abdurrahman³

¹Department of Curriculum and Instruction, Mahasarakham University, Thailand

²Department of Science Education, Universitas Sultan Ageng Tirtayasa, Indonesia

³Department of Physics Education, Universitas Lampung, Indonesia

*Corresponding email: prasart.n@msu.ac.th

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Abstract: Contribution of Integrated Learning through STEM Education in ASEAN Countries.

Objectives: This article reviews and criticizes research reports on STEM education in the Association of Southeast Asian Nations or ASEAN countries. **Methods:** The study conducted through ACI database as an investigation source, a total of 24 articles were reviewed between the years 2013 and 2019. Data were analyzed by the main key of pedagogical practices, also is focused on the implementations of STEM education in an effective classroom. **Findings:** Findings showed that STEM education used in a variety of integrated pedagogical practices by different concepts and contexts. The process of STEM learning emphasizes on engineering process than the science process. It is generally drawn by 5D in a thematic approach: define, design, develop, debrief, and disseminate. **Conclusions:** Technology and design-based learning are calling for future research and the contribution of pedagogical practices in a diverse classroom.

Keywords: pedagogy, ASEAN, integrated learning, STEM education, pedagogical practices.

Abstrak: Kontribusi Pembelajaran Terpadu melalui Pendidikan STEM di Negara-negara ASEAN. **Tujuan:** Artikel ini mengkaji dan mengkritik laporan penelitian tentang pendidikan STEM di negara-negara ASEAN. **Metode:** Penelitian dilakukan melalui database ACI sebagai sumber investigasi dengan total 24 artikel yang dikaji berkisar antara tahun 2013 dan 2019. Data dianalisis melalui pedoman utama praktik-praktik pedagogis, juga difokuskan pada implementasi pendidikan STEM didalam kelas. **Temuan:** Temuan menunjukkan bahwa pendidikan STEM digunakan dalam berbagai praktik pedagogis terintegrasi dengan konsep dan konteks yang berbeda. Proses pembelajaran STEM menekankan pada proses rekayasa daripada proses sains. Secara umum digambarkan dengan 5D dalam pendekatan tematis yaitu: mendefinisikan, merancang, mengembangkan, menanya, dan menyebarluaskan. Pembelajaran berbasis desain dan teknologi menyerukan penelitian di masa yang akan datang dan kontribusi praktik pedagogis di ruang kelas yang beragam.

Kata kunci: pedagogi, ASEAN, pembelajaran terintegrasi, pendidikan STEM, praktik pedagogis.

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■ INTRODUCTION

The paradigm of reductionist view seems to be different and tends to be decreased than the previous education. Thematic view is now calling for the answering of surviving in the modern era, working based on multi-tool use, and technology-focused in collaboration. Learning in the new era should employ a thematic approach, the various tools and methods are mixed up to enhancing learners in the potential of thinking and doing. New youngsters are multi-taskers, information and communication technology-based learning and integration help them to have multiple competencies. Basically, human beings can learn and develop their potential as well as a support system and learning environments. The social and environmental changes lead us more than learn through recitation or content memorization only, but knowledge and understanding through hands-on and mind-on experiences are also formulate enduring understanding to us (Fan & Yu, 2019; Furtak & Penuel, 2019).

STEM education is discipline in science, technology, engineering, and mathematics which is an integration paradigm. STEM education helps learners to have necessary learning skills through STEM disciplines. Its advancements also make learners to meet innovations in science and technology. It takes responsibility to increase 21st century learning skills for new generation. In addition, STEM education allows learners to meet the goals of science education, especially scientific thinking, science literacy, and nature of science in their wide perspective (Stehle & Peters-Burton, 2019; Walan, 2019).

Frequently, word 'integration' is appeared in many medias and learning materials. The connection between thinking and doing through integrated learning influence to our lives. STEM education supports concept of integrated learning in the current of modern education. It emphasizes on design-based learning and creative problem

solving in the different problems. STEM education allows students learn by collaborating, designing, problem-solving, decision-making, and presenting through suitable communication. Engineering and technological processes to 5 distinctions (1) learners will integrate their knowledge and skills related to STEM education, (2) challenges learners to solve the problem or conditional phenomena, (3) activities stimulates learners' learning, (4) help learners to develop their necessary learning skills through activities or situations, and (5) situations or problems in learning activities relevant to daily lives (Breiner, et.al., 2012; Dejarnette, 2012).

STEM education is widely contributed to educational level and has become mandatory in all countries. It also is an interdisciplinary approach by basic 4 disciplines, enhances learning competency, and prepare learners in STEM career for the future. Association of Southeast Asian Nations or ASEAN countries have rapidly transformed in multi-cultural learning. However, interdisciplinary and integrated learning are not far from the curriculum setting in each country, instructional practices needs learners to have self-directed approach. While the learning outcomes of ASEAN learners can be considered by The Programme for International Student Assessment (PISA), Trends in International Mathematics and Science Study (TIMSS). The average score in the program of competition and learning competency are mostly lower than average. STEM education should be necessary for increasing score, and also learning paradigm in the world of cooperation-competition relations. The content recitation is less focused in the context of science learning, process of knowledge construction is emphasized to learners (Nuangchalerm & Elislami, 2018).

Accordingly, ASEAN contexts employ process of engineering design as pedagogical anchor in STEM education (Lou et.al., 2017; Lee et.al., 2019). It cannot be rejected the

responsibilities of teachers in STEM education improvement. They are key factor to engage students learn through integrated disciplines. They play a significant role in equipping students with relevant STEM knowledge, design and create their choice in which STEM career concerns. Nuangchalerm (2018) also, reported views of primary teachers in STEM education, they recognized STEM education is an integrated learning approach which concerns in 4 disciplines; science, technology, engineering, and mathematics only. They can bring STEM education into classroom by various methods of teaching i.e., project-based learning, inquiry-based learning, problem-based learning, and so on. On the other hands, they are still understood that STEM education focused on students' knowledge concurrent with core subjects and basic education curriculum.

STEM education is now recognized by many countries, and it has been viewed as foundational to economic growth by design-based learning and creative innovations. To gain further insights into the current situation on STEM education in ASEAN region, a search on the ACI using the search term STEM education was conducted on February-March 2019. The search was limited to only STEM education research by no limit years of publication. This study helps

science educators to understand STEM education and its contribution to ASEAN countries. Also, results are decision tools for making STEM education forward together in terms of definition and its extension. The results are not only focused on a quantitative report but also on the process of STEM learning and successful information is also explored. Science educators can bring findings STEM education to improve curriculum and instructional practices to suitable contexts.

METHODS

A systematic literature review was critically employed, STEM education in southeast Asia was a significant framework. The ASEAN Citation Index (ACI) database was used to search and accessed, it covered research report in ASEAN region. Keyword "STEM education" used for searching term by criticizing method and systematically access. The ACI database was selected because it collected and indexed articles of central regional database in ASEAN countries. It was designed and set up to index all the bibliographic records and the citations of all quality ASEAN scholarly journals (Sombatsompop et.al., 2011). Data were accessed through the ACI (<http://www.asean->

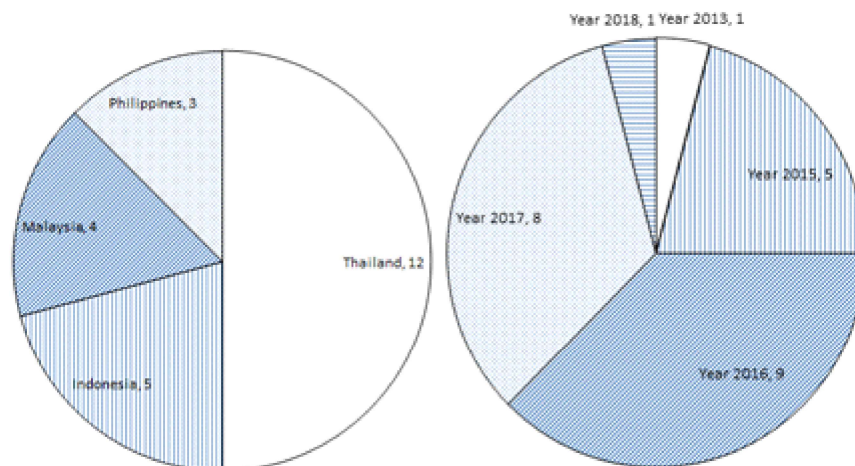


Figure 1. Country (a) and year (b) reports on STEM education in ASEAN countries

cites.org) by researchers. Then wording was filled to searching box, the STEM education in the keyword for making consideration. Researchers retrieve a high number of academically in which relevant to related articles. The criteria in selecting article set through full text available on ACI. The search was carried out on March 2019. Accession and methods of articles selection can be show in Figure 1.

Thailand had most report about STEM education, 12 publications were found. The

reports were found Indonesia (5), Malaysia (4), and Philippines (3) in the following. The most year of report presented in 2016 (9 publications), 2017 (8 publications), 2015 (5 publications), 2013 and 2018 (2 publications), but 2014 was not found. Then articles in which non-relevant search matches therefore narrowed down the results to 14 articles. The criteria for eliminating to narrow it by the research report for studying effective pedagogical practices in STEM education. The process can be shown in Figure 2.

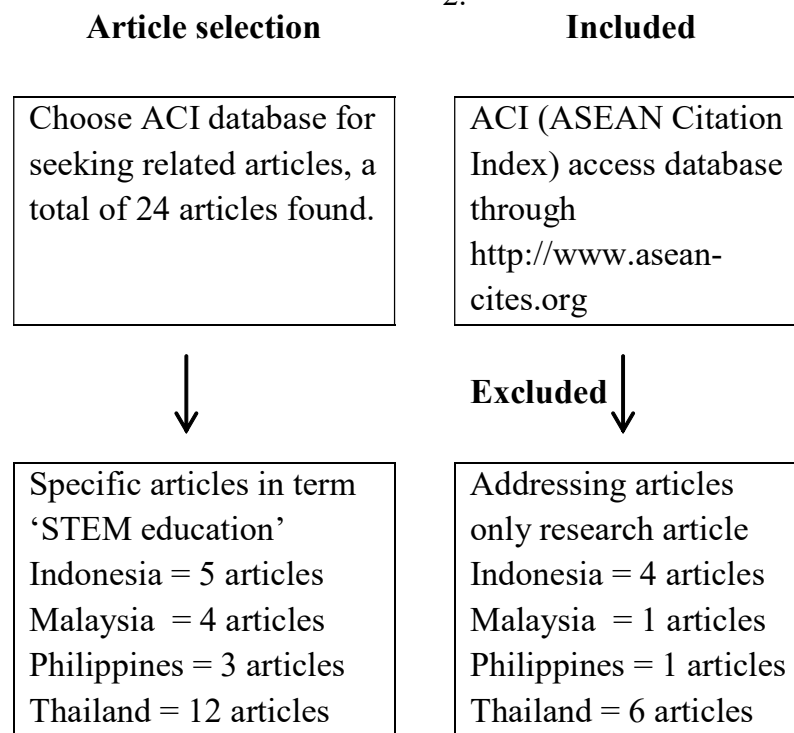


Figure 2. Procedural search of research report in STEM education

■ RESULTS AND DISCUSSION

There are 12 published articles which relevant to research report on STEM education in ASEAN countries. Thailand research accounted for 50% of the studies, while Indonesia (33.33%), Malaysia (8.33%), and Philippines (8.33%) accounted for ASEAN report by the related articles. It seems to less research report in STEM education in this region, the barrier to

access STEM reports due to a variety of language in different countries. ACI database accepted only premium journals even though some articles which is not indexed relevant to STEM education. However, the scope of this study needs to criticize only research report in STEM education. Most reports emphasized on STEM learning activities in different level of classroom, science subject is a significant content, and also teacher professional

development is discussed to encourage STEM education in respectively.

Based on empirical reports from 4 countries in ACI database, STEM education in ASEAN is slightly different from US articles. The engineering process is highlighted than science process because economical drive and educational policy believe that engineering can solve the problem and create suitable innovations. It is also simply explained to make and create new products. Due to science process in which educators familiar with inquiry-based learning, it emphasizes on process of constructive learning.

General process of STEM learning

In Thailand employed inquiry-based learning in science and mathematics in such a long time. Science education is promoted inquiry-based learning into basic curriculum (Prachagool&Nuangchalerm, 2019). The notion of inquiry-based STEM education is easy to understand by educators (Lai, 2018; Wilson, 2018; Abdurrahman et.al., 2019). That is, science education policy and related organizations launched STEM education with the

engineering process as a significant process. Most report from Thailand found in science subject that taught in elementary and secondary schools. Six components for explaining how STEM works and should be introduced to curriculum and instructional practices can be explained. Meanwhile some reports from Indonesia, the STEM learning approach more likely to convey ethnopedagogy aspects in constructing idea of students involvement in the generate science, engineering, and technology literacy (Abdurrahman et.al., 2019; Widayantiet.al., 2019).

The analysis of STEM articles by descriptions and the definitions of STEM learning that includes six general learning steps (see Table 1 for definitions): problem identification; related information search; solution design; planning and development; testing, evaluation and design improvement; and presentation. In general, these steps are similar to several other reports. It covers the processes behind most of STEM learning by ASEAN countries in which described in below.

Table 1. General STEM learning steps

General STEM learning	Definitions
Problem identification	The process of identifying problem that students perceived and also it can stimulating students’ curiosity through experiences or teachers simulate to their students. Teacher act as facilitator to address problem statement. This process helps students to generate hypotheses regarding the stated problem.
Related information search	The process of engaging students to have attractive information by stating documents which literatures or theory-based explanation to the problem. Students pay their searching and identifying information through a variety of methods and learning resources. They have to carefully read and critique in group discussion about related information.

Solution design	The process of designing process and product to solve the problem as well as students studied through related information. They have to make alternative choices for conducting an experiment in order to test a hypothesis. This process helps students to have creative problem solving based on thinking design and decision making.
Planning and development	The significant process of planning and preparing the exploration or experimentation. Students provide their responsibility to do experimentation together, collaborate investigation, sets an innovation to solve the problem. They also have to plan methods of data collection and analysis based on the innovative and experimental designs.
Testing, evaluation and design improvement	The process of science is generally employed, students have to test meaning of innovative design, methods of problem-solving, data collection and analysis. Necessary skills are mostly used, especially science process skills and 21 st century learning skills are developed through innovative testing, developing, and evaluating as well.
Presentation	The process of scientific communication and public understanding is conducted. Information or new knowledge from the previous process can be drawn its conclusions from the data. Students employed a simply methods to communicate with others. They have to describe methods and process in their solving design to public based on mind-on and hands-on experiences.

The process of STEM learning in ASEAN countries emphasizes on engineering process than science process. However, it seems to be mix-up process between science and engineering process. Science aims to produce new knowledge, engineering aims to produce new technology for solving the problem. Two disciplines cannot be separated because its nature of disciplines response constructive knowledge. The process of STEM learning is widely used, general process can be simple explained step by step in problem identification;related information search;solution design;planning and development;

testing, evaluation and design improvement;and presentation.

STEM Learning Management

The process of STEM education can be drawn with 5D in thematic approach. It consisted of *Define, Design, Develop, Debrief, and Disseminate* for describing how pedagogical practices work by STEM learning. The details in each step may be different in research report, but the most steps can be run STEM education in their work.

Define: teachers employ situations or simulations through various kinds of technology

and communications into classroom. They can show students to have thinking critically via Youtube, clip VDO, simulations through some applications, case study, articles reading in critically, newspaper in science contents. Teachers are initially set a question to engage students make a links between prior knowledge and new experiences (Akerson *et.al.*, 2018; Andrianiet *et.al.*, 2018). The heart of this process focused on questioning, stimulating student use higher-ordered thinking. Then, teachers guide or take students to have freely discussion. Students employ science communications through many tolls and methods such as speaking, writing, searching, discussing, google, brainstorming, reading, and so on based on nature of classroom and supporting materials. Then teachers give them with assignment by situations and regulations to create innovation for solving problem (Saggi, 2018).

Design: teachers take their significant role in terms of a facilitator. Students have to employ their learning competency, learning styles, necessary learning skills, and multiple intelligences to create innovations to solve the problems. The creative problem-solving is vital tools to let students design, but they have to learn new things by broad materials and a variety of learning resources (Kelley & Knowles, 2016; Bell *et.al.*, 2018; Capraro *et.al.*, 2018). In ASEAN report, engineering process is employed more than science process because of most school science claims engineering process as a STEM education motivator. Science process in curriculum is defined in both contents and process skills, students start their design with distinctions of holistic view among science, technology, engineering, and mathematics. Students can create new technology through engineering process (National Research Council, 2013).

Develop: teachers allow students to develop their innovation to solve the problem,

but students have to had evidences, explanation, and related disciplines to describe how their innovation works. Students develop not only products to solve the problem, but they can improve themselves in the process of learning, they will employ necessary learning skills as well as they can learn through collaborative learning (Bell *et.al.*, 2018). However, they should not use trial and error in early, but write their thinking into paper is the best way to generate ideas, communications are promptly used, technical skills and theoretical skills are enhanced by themselves (Kelley & Knowles, 2016; Linet *et.al.*, 2019).

Debrief: teachers are stimulator to all students of how to discuss and conclude their findings, making effective communication based on 4 disciplines support. Students can make PowerPoint, Clip VDO, or other interesting presentations. However, students have to develop communications skills because ASEAN students may be different in terms of acting. They are so shy to speak aloud of what they are thinking and doing. When they perceived and learned STEM education, they can talk about what they do by themselves more than lesson recitation. The methods of presentations need to be improved because they are familiar with internet technology or mobile applications. Traditional technology helps them to learn new things and easy to understand about innovation or creative technology. They have to learn tools and methods for communications in different contexts.

Disseminate: teachers can motivate students to develop innovation and bring this new into community. Just let students do with others by giving service learning to public. They must learn how to make effective communication, response to society with science communication in simply presentations. Students can develop their ability to communicate with community and how to imply STEM education for their daily life.

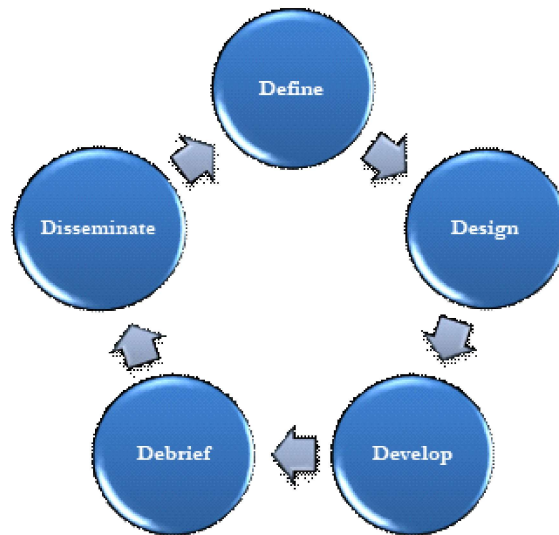


Figure 1. Process of STEM Education

Figure 1 showed that STEM education is a process to engage students meet nature of 4 basic disciplines. Teachers are particularly influential to STEM education success in the classroom. However, teachers have to professional practices in terms of technological, pedagogical and content knowledge (TPCK). It seems to be more difficult for classroom management, but interdisciplinary STEM learning needs teachers play in their classroom (Lee *et.al.*, 2015; Erduran&Ince, 2018). In the past, ASEAN students learn each subject independently and recitation is emphasized. STEM education will be success by teachers invite TPCK into classroom as well as creative classroom is opened (Kohet.*al.*, 2015).

The fruitful of STEM education and TPCK help integration approach by collaborating interdisciplinary in pedagogical design as well as technology infused (Pitipornatapinet.*al.*, 2018). TPCK is the notion of the teachers development and also make them as a designer to facilitate students meet STEM learning (Chai, 2019). But most report about TPCK in ASEAN countries are less reported. Widayanti et al (2019) reported potential of mobile learning application as a new TPCK approach to launch STEM learning media

for junior and senior high students in Indonesia. Teachers focused on subject matters and standard testing more than TPCK framework (McDonald, 2016; Prachagoolet.*al.*, 2016). STEM learning necessarily requires teachers to integrate appropriate technology, pedagogy, and associated content knowledge in the classroom through design. TPCK framework can illustrate the way of possible combinations of STEM knowledge as well as integration with school programs (Mishra & Koehler, 2006; Koehler & Mishra, 2009; Nitalindaet.*al.*, 2019). STEM education will be successful if teacher development recognizes TPCK in STEM classroom by design and promotes appropriate scaffolding to develop their competences (Abdurrahman et.al, 2019b).

■ CONCLUSIONS

The contributions of STEM education in ASEAN countries are less report in terms of TPCK and its relation to professional development. The most report focused on STEM learning in teachers' design by classroom activities. Scientific literacy is the interesting variable in

STEM research, it may be concerns nature of science and most teachers refer STEM education to science or mathematics subjects than those integration process. Especially, the engineering process is explained for significant factors to create thematic and creative approaches. However, teachers' development in TPCK and STEM learning management should be more investigated and promoted particularly in an effort to prepare ASEAN students to cover 21st-century competencies and skills.

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