Science, Mathematics, Engineering, and Mathematics (STEM) Education in Indonesia: a Literature Review

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Abstract. This study aims to describe: 1) the learning models used in the implementation of STEM education in Indonesia, 2) the level of education used in the implementation of STEM education in Indonesia, 3) the effect of STEM education in Indonesia on the students’ learning outcome. This is a literature review study, 27 articles were analyzed based on the research method, level of education, learning models, and learning outcome. A within-case analysis was carried out to analyze the articles in the dataset. The research result showed that: 1) STEM education in Indonesia was carried out by using the learning models: Project Based Learning (PjBL), 6E, HOTS assessment based-learning, inquiry, Think Pair Share (TPS), Problem Based Learning (PBL), android game, digital and student book based-learning, PjBL is the learning model which most widely used in the implementation of STEM education in Indonesia, 2) STEM education in Indonesia was conducted in elementary school, junior and senior high school, but very limited in university level, 3) STEM education in Indonesia was effective on the students’ learning outcome: scientific literacy, creative thinking, critical thinking, attitude, HOTS, character, achievement, problem solving, and 21st century skill.

1. Introduction

The fourth industrial revolution can affect at all aspects of human life. According to Zimmerman, 75% work in industrial revolution era 4.0 and beyond involves the ability of science, technology, engineering and mathematics, the internet of things, and lifelong learning [1]. The result of Program for International Student Assessment (PISA) 2018 in the science category, Indonesia is ranked 71, with a score of 396, well below the average OECD score of 489. While in mathematics, Indonesia is ranked 72 or seventh from the lowest with a score of 379. This result ranked Indonesia in 74 or sixth from the lowest [2]. The
Science, Technology, Engineering, and Mathematics (STEM) education can improve mathematics and science achievement, foster the attitude of students toward STEM subjects, and increase the higher level thinking skill. The STEM education also can develop the 21st century skills. Morze et al. stated the benefits of STEM education include: integrated training in "topics", not subjects, using the scientific and technical knowledge in real life, develop the critical thinking skills and problem solving, improving self-confidence, active communication and team work, developing an interest in technical disciplines, creative and innovative approaches to projects, the bridge between education and careers, prepare the children for technological innovation in their lives.

Fan & Yu argued that the STEM education was not only an important issue in American educational, many countries are also focus on their curriculum reform. Currently, STEM education has carried out in Finland, America and Australia (since 10 years ago), following Vietnam, China, Malaysia, and Philippines. The studies on STEM have been conducted in many abroad and there were positive impacts of them. A systematic literature review on teachers' perceptions of STEM education conducted by [12]. Meanwhile [13] has conducted a systematic review on Instructional Practices of Integrated STEM Education in Secondary Education. A review of the contribution of STEM education has also conducted [14]. This study aims to review the implementation of STEM education particularly in Indonesia. Specifically, the objective of the study are to describe: 1) the learning models used in the implementation of STEM education in Indonesia, 2) the level of education used in the implementation of STEM education in Indonesia, 3) the effect of STEM education in Indonesia on the students' learning outcome.

2. Method
This study is a literature review study. According to literature review is “a making critical and systematic references to documents which contain ideas, research designs, data and details of information gathering methods related to a research topic” (p.44). For the current study, a literature review was done by using the databases: Education Resources Information Center (ERIC), EBSCO and google scholar search engine. The screening of articles was done by criteria: 1) the article was searched using keywords: STEM education, effect, Indonesia, 2) the article was published in 2015-2020, 3) all the articles had to be peer-reviewed journal articles or conference papers 4) the article examined the effect of STEM education on the learning outcome in Indonesia. In this study, a within-case analysis was carried out to analyze the articles in the dataset. The article was analyzed separately and then summarized in a table or diagram.

3. Results and Discussion
In this research, to review the implementation of STEM education in Indonesia, 27 articles were analyzed based on the research design, level of education, learning models, and learning outcome. Based on the research design, the result review show that quantitative research design is the most widely used in the implementation of STEM education in Indonesia. The more detail of the research design are listed in Table 1.

| No | Research Design | The Number of Article |
|----|-----------------|-----------------------|
| 1  | Quantitative    | 13                    |
| 2  | Qualitative     | 2                     |
| 3  | Mix Method      | 1                     |
| 4  | R & D           | 6                     |
| 5  | Action Research | 1                     |
| 6  | Literature Review| 4                    |
| **Total** |                | **27**               |
Quantitative research design in this result study involves experiment, survey, and descriptive quantitative, meanwhile descriptive and narrative descriptive qualitative were used in qualitative research design. In the Research and Development (R&D), teaching material, digital book, student book, and HOTS assessment-based STEM were developed. Literature review was used in reviewing the STEM education to fulfil the 21st century demand, and the STEM PjBL on science learning, while meta-analysis was used to analyse the effect of STEM education on student attitude at secondary school.

Figure 1 show that 39.13% of the research on STEM education were conducted at Junior High School [17]–[25], and Senior High School [26]–[32]. There were only 18.18% STEM studies at elementary school [33]–[35], and 4.55% at university level [36], [37]. It can be seen that in Indonesia, there is a limited study on STEM education in university level. This result is not supported by [38] that argued the STEM learning experience is not only needed in early years school, but also in higher education. In line with [38], Herschbach stated that the target population of STEM education are primary to college students [39].

![Figure 1. STEM Implementation](image)

**Figure 1. STEM Implementation**

To answer the question: “which learning models are used in implementation of STEM education in Indonesia?”, the articles were reviewed on the learning models.

![Figure 2. Learning Models in STEM Education](image)

**Figure 2. Learning Models in STEM Education**
Of the 27 articles, 16 articles mentioned Project Based Learning (PjBL), 6E, HOTS assessment, inquiry, Think Pair Share (TPS), Problem Based Learning (PBL), android game, digital and student book based-learning (Figure 2). The research result show that Project Based Learning is the learning model which most widely used in the implementation of STEM education in Indonesia. STEM-PjBL can improve scientific literacy, motivation, material understanding, creative thinking ability, effectiveness, meaningful learning, and support future careers [40]. Hanif, Wijaya, & Winarno [19] argued that STEM-PjBL was an alternative teaching strategy in Junior Secondary School, the students’ creativity can be improved by STEM-PjBL.

The implementation of STEM education in Indonesia gave positive impacts on the students’ learning outcomes. Of the 27 articles, 18 articles mentioned the learning outcomes of STEM education: scientific literacy (LO-1), creative thinking (LO-2), critical thinking (LO-3), attitude (LO-4), HOTS (LO-5), character (LO-6), achievement (LO-7), problem solving (LO-8), and 21st century skill (LO-9), as listed in Table 2.

### Table 2. The Effectiveness of STEM Education on Learning Outcome

| No | Author | LO-1 | LO-2 | LO-3 | LO-4 | LO-5 | LO-6 | LO-7 | LO-8 | LO-9 |
|----|--------|------|------|------|------|------|------|------|------|------|
| 1  | Lestari & Sumarti [33] | x    | x    |      |      |      |      |      |      |      |
| 2  | Khaeroningtyas, Permanasari, & Hamidah [18] |      |      | x    |      |      |      |      |      |      |
| 3  | Rosidin, Suyatna, & Abdurrahman [26] |      |      |      | x    |      |      |      |      |      |
| 4  | Jauhariyyah, Hadi Suwono, & Ibrohim [40] |      |      |      |      | x    |      |      |      |      |
| 5  | Hakim, Sulatri, Mudrikah, & Ahmatika [17] |      |      |      |      |      | x    |      |      |      |
| 6  | Hanif, Wijaya, & Winarno [19] |      |      |      |      |      |      | x    |      |      |
| 7  | Abdurrahman, Ariyani, Achmad, & Nurulrsa [41] |      |      |      |      |      |      |      | x    |      |
| 8  | Werdiningsih, Budiyono, & Pratiwi [20] |      |      |      |      |      |      |      |      | x    |
| 9  | Yulianti, Wiyanto, Rusilowati, Nugroho, & Supardi [29] |      |      |      |      |      |      |      |      |      |
| 10 | Parno, Yuliat, & Ni’Mah [30] |      |      |      |      |      |      |      |      | x    |
| 11 | Setiawaty et al. [36] |      |      |      |      |      |      |      | x    |      |
| 12 | Qurrota & Rusilowati [22] |      |      |      |      |      |      |      |      | x    |
| 13 | Sari, Syarif Sumantri, & G Bachtiar [34] | x    |      |      |      |      |      |      |      |      |
| 14 | Yasin, Prima, & Shohihin [24] |      |      |      |      |      |      |      |      | x    |
The research results indicated that the effect of STEM education on learning outcomes are 38.10% scientific literacy, 14.29% critical thinking, 14.29% 21st century skill, 9.25% attitude, 4.76% creative thinking, 4.76% HOTS, 4.76% character, 4.76% achievement, and 4.76% problem solving. The scientific literacy, creative thinking, critical thinking, and 21st century skill were affected by STEM based-PjBL[17], [19], [25], [33], [40]. Problem solving and character were the effect of STEM education based-PBL [29], [30], while 21st century skill and achievement were the effect of STEM based-inquiry [41] and TPS [20].

This is in line with Toma & Greca [8] that concluded the integrative STEM education can develop students’ attitude toward science. Han, Rosli, Capraro, & Capraro [42] also examined the effectiveness of project-based learning integrated with STEM on students’ achievement in algebra, geometry, probability and problem solving. The research result indicated that STEM integrated with project-based learning has improved students’ scores in mathematics in general (d= 1.311), algebra (d=1.500), geometry (d=1.837), and probability (d=.487), but not in problem solving (d=.343). Meanwhile Wurdinger & Qureshi [43] in their study purposed to test the developing life skills based on Project Based Learning. The result showed that there was no significant difference in time management, collaboration, and work ethic; but there was a significant difference in responsibility, problem solving, self-direction, communication, and creativity

4. Conclusion
Based on the research result, it can be concluded that: 1) STEM education in Indonesia was carried out by using the learning models: Project Based Learning (PjBL), 6E, HOTS assessment based-learning, inquiry, Think Pair Share (TPS), Problem Based Learning (PBL), android game-based learning, digital and student book-based learning. PjBL is the learning model which most widely used in the implementation of STEM education in Indonesia 2) STEM education in Indonesia was conducted in elementary school, junior and senior high school, but very limited in university level, 3) STEM education in Indonesia was effective on the students’ learning outcome: scientific literacy, creative thinking, critical thinking, attitude, HOTS, character, achievement, problem solving, and 21st century skill. Hence, the research on STEM education integrating with other learning model in the university level is needed for the further research.

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