

# A Five-Year Trajectory of STEM Education Research in Indonesia: A Systematic Literature Review

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**Abstract.** STEM education is a learning approach developed to equip students with integrated knowledge in Science, Technology, Engineering, and Mathematics. This teaching method has many positive impacts on both students and teachers. Therefore, Indonesia, which has adopted a curriculum "Merdeka" emphasizing educational freedom, has begun to embrace this teaching method in its schools. This study proposes understanding the development of STEM research in Indonesia over the past five years, from 2018 to 2022. The systematic literature review approach was used as the methodology for this study and focused on Scopus-indexed articles. The research findings are based on the following: the number of studies over the five years has been fluctuating; the majority of articles were published in international conferences; Malaysia dominates as the collaborating country; the level of education where research implementation is dominant in high school; and the active STEM learning activities are primarily related to physics. From this study, it can be concluded that further development of STEM education research in Indonesia is possible and a high opportunity.

## INTRODUCTION

STEM education is a modern learning method developed to equip students to adapt to a technological society [1]. With this method, it is hoped that students can optimize technology in educational settings and apply it in their lives and careers. The initial goal of this method's development was to equip students with skills that can be used in their future careers [2]. From its inception until now, several countries have made STEM a mandatory method of instruction. This method is highly adaptable and is implemented from elementary school to higher education.

Based on several conducted studies, STEM education has been shown to enhance students' engagement with learning [3], [4], classroom participation [5], collaboration among students [6], interaction with teachers [7], and students' creativity in solving given problems [7], [8]. Furthermore, STEM trains students to utilize technology to assist in problem-solving [5], [9]. As for teachers, STEM learning encourages them to use available technology in the classroom and stimulates creative thinking [10]. The positive outcomes of these research findings establish STEM education as a method that positively impacts both students and teachers. These positive impacts can also be realized when implemented in the Indonesian education system.

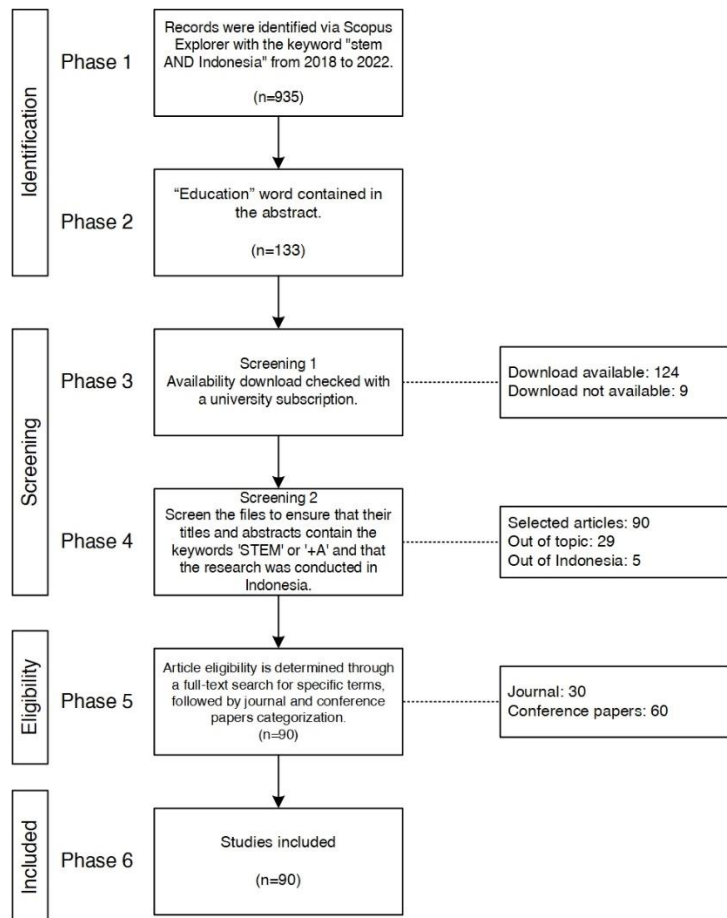
In Indonesia, the educational journey experiences changes in curriculum and teaching methods with each change in policymaker. Teaching methods that have been comprehensively implemented include case studies, problem-based learning, project-based learning, and industry-oriented learning [11], [12]. All these methods have positive outcomes for students. However, with the development of technology and the complexity of skills, these

methods are considered less conducive to students. Therefore, a method or learning strategy is needed that encourages students to use multiple skills in one learning activity.

This need has led several education researchers in Indonesia to attempt to implement STEM education. Some researchers have produced outputs in scholarly articles related to STEM education. However, when observed in the actual classroom teaching activities, the implementation of STEM education is still limited or not visible. Therefore, this research aims to identify the developments in STEM education in Indonesia over the past five years through a systematic literature review of studies published from 2018 to 2022.

## METHODOLOGY

This research is a Systematic Literature Review (SLR) that adopts the Prisma methodology. **Figure 1** illustrates the research procedure.



**Figure 1.** The Systematic Literature Review Process Adopted from the Prisma Model [13]

Phase 1: Recorded the search results of articles from the Scopus search engine using the keywords "STEM" AND "Indonesia." This study focuses on articles published in full years from 2018 to 2022. (Recorded n=935 articles)

Phase 2: Identified further by examining the presence of the word "Education" in the abstract. (Recorded n=133)

Phase 3: Screening in the first phase by checking the availability of downloads subscribed by universities. (n=124)

Phase 4: Screening in the second phase by checking for the keywords "STEM" or "+A" in the title and abstract and research conducted within Indonesia or in collaboration with other countries.

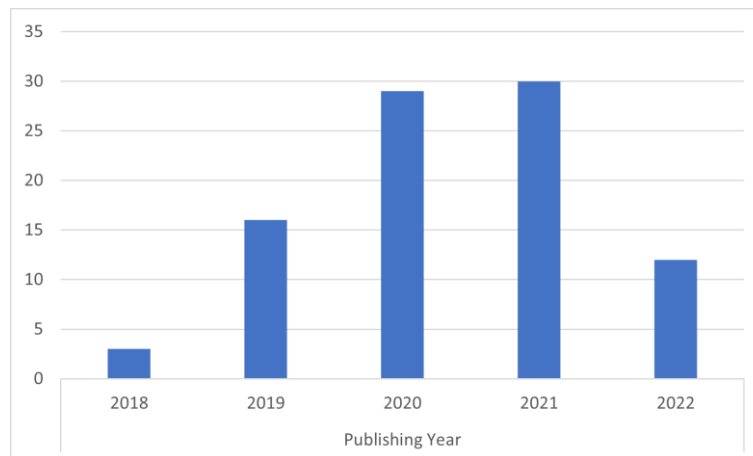
Phase 5: Checked the eligibility of selected articles by scanning each file for the presence of the keywords STEM/+A, Education, and Conducting in Indonesia. We then categorized them into two groups: journal articles and conference papers.

Phase 6: Analyzed the 90 selected articles to achieve the research objectives.

## RESULT AND DISCUSSION

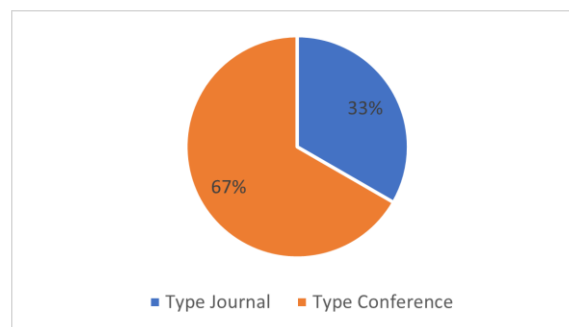
The development of research related to STEM education globally has increased [14]. The rise in the number of studies on this topic is attributed to the positive impact that leads to increased student activity, high engagement in learning, and improved knowledge and technology implementation [3]–[8]. Several previous studies have demonstrated that STEM education can enhance various student factors to a greater extent.

After conducting this research, it is evident that the development of research in the field of STEM education in Indonesia has been fluctuating. This is evident from **Figure 2**, which reveals an increase from 2018 to 2020, followed by a constant trend in 2021 and a decline in 2022. This trend can be unfavorable, especially compared to the global research output in STEM, which surpasses it by a significant margin. As a developing country, Indonesia can be gauged by the quantity of its research contributions in this area.



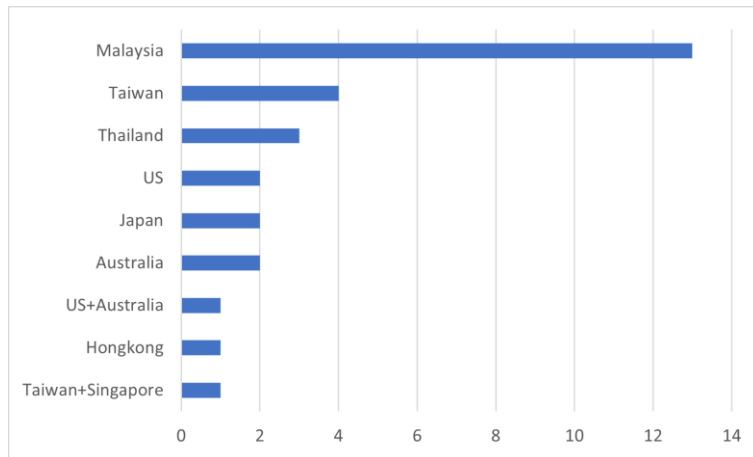
**Figure 2.** Years of published.

In addition to the quantity of research, the quality is a crucial indicator for assessing a country's progress. The quality of articles can be broadly categorized into two groups: journal publications and conference papers. Based on **Figure 3**, it is revealed that research related to STEM in Indonesia is more often published in conference papers. The ratio is 33% international journals and 67% conference proceedings. Less than half of the articles are published in international journals, indicating that the level of STEM research in Indonesia lags behind other countries. In other words, research in STEM-related fields in Indonesia still has room for development and improvement.



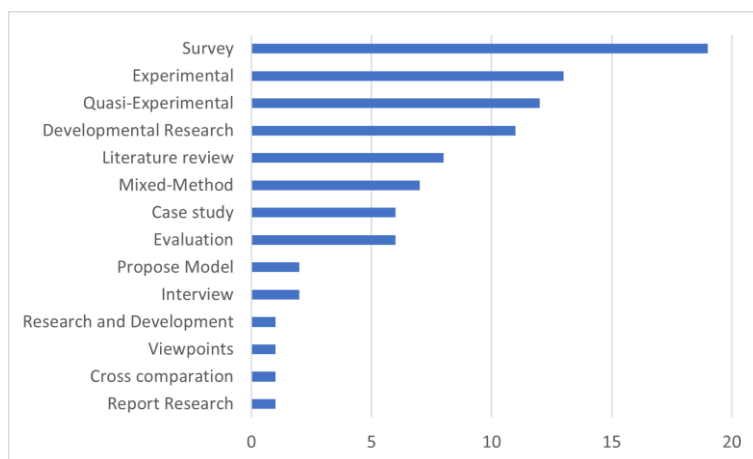
**Figure 3.** Articles Categories

When we look at the origins of STEM education, this concept was developed by advanced countries, such as the United States, to equip students with skills before entering the workforce [2], [15]. Subsequently, many developed nations have adopted STEM into their curricula, from elementary school to higher education. Furthermore, when examining the results of this research, it becomes evident that Malaysia has the most elevated collaboration in STEM research with Indonesian researchers. Additionally, **Figure 4** reveals that collaborations with other developed countries, such as the United States, Taiwan, Japan, Singapore, and Australia, are significantly lower than with Malaysia. When considering research focused on STEM, these developed nations have high journal publication rates, indicating superior implementation and development of STEM education compared to developing countries. Therefore, research collaborations with developed nations such as the United States, Japan, and Taiwan must be enhanced.



**Figure 4.** A variety of Collaborator countries

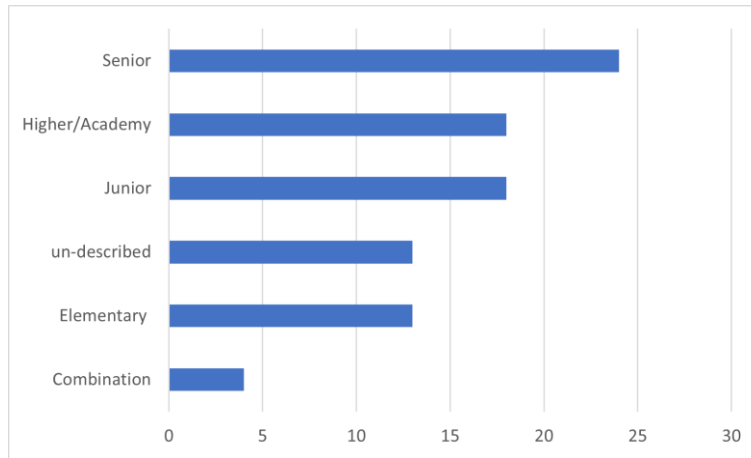
From another perspective, the quality of education research can be assessed by examining the research methodology. **Figure 5** demonstrates that STEM research in Indonesia exhibits various methods. The most frequently used research approach in STEM research in Indonesia is the survey method, employed to gain insights into respondents' perceptions regarding STEM. This suggests that STEM research in Indonesia is primarily at a general stage, focusing on understanding the perceptions of students or teachers regarding STEM instructional models. Other research, such as investigating the implementation and the impact of STEM education, can be observed using the Quasi-Experimental research method. However, most of these studies experimental and developmental research methodologies still revolve around developing teaching aids to support STEM education.



**Figure 5.** Research Methodologies approach

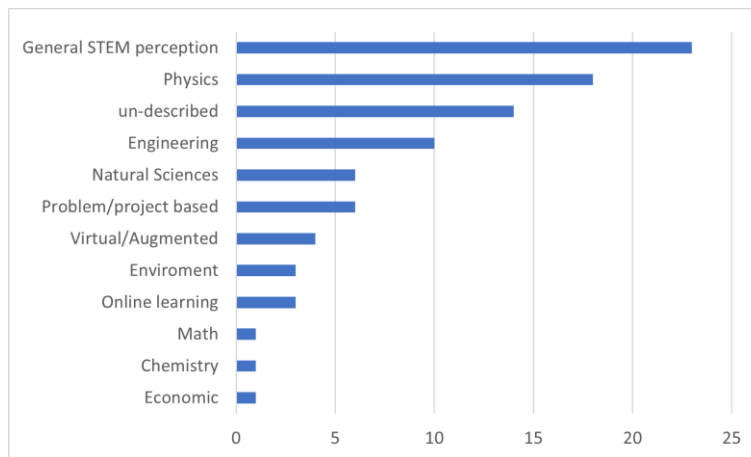
Furthermore, **Figure 6** illustrates that the distribution of STEM research in Indonesia is predominantly concentrated at the high and higher education levels. According to several STEM journals, it would be more effective if STEM education were implemented starting from primary and junior high school levels [16]. The findings of this research suggest that further development focusing on early skill development has not been

optimally explored. Therefore, there is a need to encourage STEM research that emphasizes the development of teaching materials or student skills at the elementary level. This is reinforced by research results indicating that early age is more effective for receiving information. At the elementary level, exposure to practical technology applications is still lacking.



**Figure 6.** Education level of subject research

Meanwhile, **Figure 7** reveals the diversity of topics and courses chosen in STEM research in Indonesia. Since STEM research in Indonesia primarily utilizes surveys, the highest position is occupied by general perceptions related to STEM education. STEM learning activities follow this in physics, engineering, and natural sciences. However, STEM education can be applied to all courses at all levels. The challenge lies in integrating technology into teaching that has traditionally not involved technology, requiring teachers to be creative in designing STEM activities in the classroom. Additionally, the results of this research show that the selected subject courses for study already involve technological elements. Thus, there is a challenge in developing and implementing STEM in non-technical classes.



**Figure 7.** Subject courses

Based on the research findings and discussions previously presented, it can be concluded that the development of STEM education research in Indonesia still lags behind other countries, especially when compared to more advanced nations. Data from Scopus indicates that the quality of STEM education research can and should be improved. This positions STEM education as both an opportunity and a challenge for researchers, with the implementation starting at the elementary school level. This aligns with the findings of several researchers who have argued that STEM is effective when implemented at the elementary level [17]–[20]. Therefore, STEM education in Indonesia can still be further developed to enhance the quality of education from elementary school to higher education [21]–[23].

## CONCLUSION

The Systematic Literature Review research focuses on developing STEM education research in Indonesia and has identified several shortcomings in the existing studies. This highlights that the concept of STEM learning has not been fully implemented in Indonesia, from elementary schools to higher education. This issue can be seen as a significant opportunity for researching and developing factors supporting STEM education.

*As a future suggestion*, the upcoming adoption of STEM education into curricula marks an exciting and highly potential era. This scope can be further developed through high-quality research.

## SUPPLEMENTARY FILE

A *supplementary file* containing the list of 90 selected articles can be accessed at [https://drive.google.com/drive/folders/1bSKrdJWyrM42ILBIM3nyKTOX7imKe\\_cb?usp=sharing](https://drive.google.com/drive/folders/1bSKrdJWyrM42ILBIM3nyKTOX7imKe_cb?usp=sharing)

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