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Map of the Development of STEM Learning Research in Elementary Schools in Indonesia

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Abstract

This study aims to map the development of STEM learning research in elementary schools in Indonesia based on scientific publications indexed in the Scopus database. Data were searched using search strings that combined the terms STEM, elementary school, and the Indonesian context. Data analysis was conducted using descriptive qualitative methods, including annual publication trends, document types, and subject field distribution. A total of 123 documents were obtained from 2005 to 2025. The results showed that publications on STEM learning increased significantly after 2019, declined during the COVID-19 pandemic, and increased again in recent years. Journal articles dominated the document types, while the most studied fields included social sciences, physics and astronomy, mathematics, and computer science. These results indicate that STEM studies in elementary schools continue to develop and involve various disciplines. The findings of this study provide an overview of the direction of STEM research development in Indonesia and identify potential for further studies that can use a more diverse database, so that future research mapping can be carried out more comprehensively. This study is expected to serve as a basis for curriculum development, education policy, and further research on the implementation of STEM learning in Indonesia.

Keyword: *STEM; Development; Learning; Elementary School*

I. INTRODUCTION

STEM (*Science, Technology, Engineering, Mathematics*) education has become a major agenda in 21st-century education due to its potential in developing critical thinking, problem-solving, and work readiness competencies for a knowledge-based economy. The concept of STEM, which was popularized in the early 21st century and reinforced in educational literature, emphasizes cross-disciplinary integration and project/problem-based learning to connect academic concepts with real-world contexts (Bybee, 2013) . At the elementary school level, the introduction of STEM learning is considered important because early childhood is a critical period for fostering scientific curiosity, experimental skills, and a solid foundation in mathematics—all of which are prerequisites for sustained interest and success in STEM studies at the next level (Li et al., 2020) .

Over the past two decades, scientific production on STEM education has increased globally. Various international bibliometric studies have documented a surge in publications since the late 2010s, especially after 2019, partly driven by developments in educational technology, national policies related to literacy and 21st-century skills, and a post-pandemic shift in learning paradigms (Abdi et al., 2024 ; Sokolova et al., 2025) . Bibliometric analysis in the STEM field of education shows an upward trend in the number of publications, diversification of topics (e.g., STEAM, *computational thinking,* AI in STEM), and the dominance of certain countries in production and citations (Abdi et al., 2024 ; Thanh et al., 2025) . Studies focusing on the elementary school level also indicate an increase in research attention since 2019, with several studies identifying key themes such as curriculum integration, teacher competency development, technology utilization, and project-based intervention design for early childhood (Thanh et al., 2025) .

Conditions at the national level show a similar pattern but with their own characteristics. A number of bibliometric studies examining the development of STEM research in Indonesia have found that despite an increase in publications, the volume and continuity of research is still relatively limited compared to countries with stronger research

ecosystems; Indonesian publications tend to be concentrated in regional conferences and journals, and are often directed towards implementative studies and the development of teaching materials (Kertati et al., 2024) . Indonesia's bibliometric analysis also reveals periods of fluctuation—for example, a surge in research activity at the start of the pandemic on several topics, followed by a decline in *output* on certain sub-themes—which indicates the need for further study to map out the long-term direction. In other words, there is methodological and empirical scope for conducting a more focused development map in the context of Indonesian elementary schools, taking into account year-to-year dynamics, *subject areas,* publication types, and thematic content of research.

More specifically, although there have been global bibliometric studies and several national studies, comprehensive maps of the development of STEM learning research, particularly at the elementary school level in Indonesia, are still relatively rare. Existing studies are often large in scale (such as covering all levels of education or across countries) or focused on specific aspects, so they do not provide an integrated picture of how research at the elementary school level is developing internationally and nationally. The importance of studies that specifically examine the elementary level becomes clearer given the policy implications—such as curriculum, elementary school teacher training, and resource allocation—which are greatly influenced by empirical evidence regarding the effectiveness of STEM learning models for elementary school children.

Based on this background, this article aims to map the development of STEM learning research in elementary schools in Indonesia using data from Scopus—covering aspects such as the number of annual publications, distribution of document types, and subject areas. This mapping is expected to provide a comprehensive overview of scientific trends, conceptual and methodological gaps, and urgent research directions to strengthen the implementation of quality STEM learning at the elementary school level in Indonesia.

II. RESEARCH METHOD

This study uses document analysis based on scientific publications using the Scopus database as the main source. This approach was chosen because Scopus is a reputable database that provides comprehensive publication metadata and has been widely used to map research developments in various fields of education (Aria & Cuccurullo, 2017 ; Donthu et al., 2021) . Data retrieval was conducted on November 21, 2025, using a comprehensive search string:

(TITLE-ABS-KEY("STEM" OR "STEM education" OR "STEM learning" OR "integrated science" OR "integrated learning")) AND (TITLE-ABS-KEY("elementary school" OR "primary school" OR "sekolah dasar" OR "SD")) AND (TITLE-ABS-KEY("Indonesia")).

The string was designed to capture variations in terms related to STEM education at the elementary school level in the Indonesian context, covering titles, abstracts, and keywords to enable broader document retrieval (Zupic & Čater, 2015) . The data obtained was then analyzed using a qualitative descriptive approach, focusing on: (1) publication trends per year to observe the dynamics of STEM research development in Indonesian elementary schools; (2) the distribution of document types (journal articles, conference proceedings, *book chapters,* and others) to identify the dominant medium of scientific dissemination; and (3) the distribution *of subject areas* to understand the disciplines that contribute most to STEM research at the elementary school level. The qualitative descriptive approach was chosen because it is capable of providing an in-depth interpretation of the direction of research development and research gaps that can be explored further (Xiao & Watson, 2017) . With this method, the study can provide a comprehensive picture of the map of STEM publication development in Indonesian elementary schools over the last two decades.

III. RESULTS AND DISCUSSION

A search of the Scopus database using comprehensive search strings related to STEM, elementary schools, and the Indonesian context yielded 123 documents since 2005. This number indicates that research on the implementation and development of STEM learning in Indonesian elementary schools has progressed over the past two decades.

Publication Trends from Year to Year

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The publication trend shows slow growth in the 2005–2015 period, followed by steady growth in 2016–2018, and a surge in 2019 (Figure 1). The increase in publications on STEM learning at the elementary school level in Indonesia since 2019 indicates that this issue is gaining attention from researchers, teachers, and policymakers. This increase is in line with government policies that encourage science literacy and technological innovation through the Merdeka Belajar (Freedom of Learning) program and an emphasis on strengthening 21st-century competencies (Kemdikbud, 2020). The surge in publications after 2019 can also be linked to increased access to STEM training for teachers through digital *platforms* and collaborative projects across universities. However, the decline in publications in 2022 indicates the impact of the COVID-19 pandemic on research activities, with many elementary schools experiencing restrictions on face-to-face learning, making it difficult to conduct implementative studies. After that, however, the trend increased again until 2025, showing that interest in STEM at the elementary school level is not only temporary but has developed into a sustainable research trend.

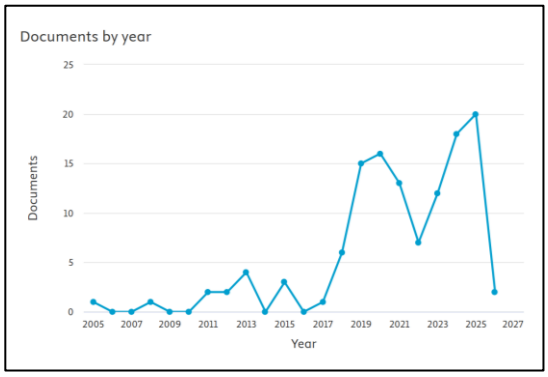


Figure 1. Development of research on STEM in Elementary Schools in Indonesia

These findings are consistent with global bibliometric research, for example, Abdi et al. (2024) , which found a surge in international STEM publications since 2018 in line with the increasing importance of 21st-century skills, and Kertati et al. (2024) noting that STEM research *output* in Southeast Asia nearly doubled during the 2019–2023 period. Specifically at the primary school level, Thanh et al. (2025) report that 34% of global STEM research has focused on *primary education,* signaling a significant shift toward the primary level as it is considered most strategic for building science and technology literacy from an early age.

Distribution of Document Types

The results obtained from the Scopus database based on document type distribution are shown in Figure 2. In terms of document type, journal articles show dominance (52.8%), indicating that STEM in basic education tends to be studied thoroughly in the form of empirical research or theoretical studies published in journals. The relatively large percentage of *conference papers* (39%) indicates that STEM is still *an emerging topic*, with many innovations first introduced through conference forums. This indicates that the STEM research ecosystem in Indonesia is still in the expansion phase and oriented towards initial findings leading to more established journal publications.

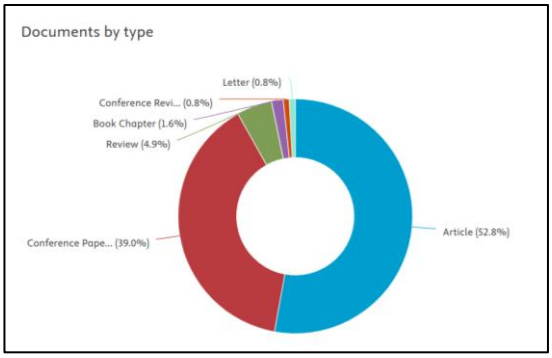


Figure 2. Distribution of Types of STEM Research Documents in Elementary Schools in Indonesia

This distribution model is similar to international trends, which find that more than 40% of STEM publications in developing countries are published through conference proceedings due to the nature of research that is development-based (*design-based learning*), limited experiments ( ), and rapidly changing pedagogical innovations following implementation in schools (Abdi et al., 2024) .

***Subject Area* Distribution**

Figure 3 shows the results of the analyzed documents covering various fields of science, with the following details: Social Sciences 30.3%; Physics and Astronomy 20.2%; Mathematics 9.6%; Computer Science 8.6%; and other fields that appear in small percentages.

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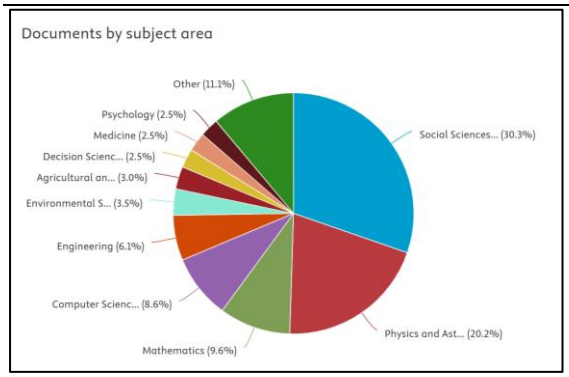


Figure 3. Distribution of STEM Research *Subject Areas* in Elementary Schools in Indonesia

The dominance of social sciences indicates that the STEM approach at the elementary school level in Indonesia focuses more on aspects of education, learning, curriculum, and pedagogy. This finding is in line with the characteristics of STEM research in elementary schools, which emphasizes the integration of science, technology, and mathematics concepts in the learning process rather than the development of the technical aspects of STEM itself.

Meanwhile, the proportion of physics and astronomy (20.2%) and mathematics (9.6%) shows that some research is still content-specific, especially in strengthening basic science concepts. This finding is in line with global reports showing that STEM research at the primary education level tends to be stronger in pedagogical aspects than in the integration of technology or complex scientific experiments (Thanh et al., 2025) . The low proportion of research in the domain of computer science (8.6%) indicates that the application of basic computing, *coding,* or STEM-based digital technology in Indonesian elementary schools is still not a major focus, even though computational skills are an important competency in various global curricula.

Critical Interpretation and Implications for Future Research

Despite the increase in publications, there are several important research gaps to note:

1. There is a lack of studies evaluating the long-term implementation of STEM. Many studies are exploratory or prototype-based. Longitudinal studies on the real impact of STEM on children's science literacy, creativity, and problem-solving skills are still limited.
2. There is still a lack of research integrating STEM with the local Indonesian context. For example: ethnoscience, local culture, or local environmental issues. Such studies have the potential to strengthen the relevance of STEM to students' real lives.
3. There is not much research that uses a *mixed-methods* approach in depth. In fact, the effectiveness of STEM implementation will be more comprehensive if it is measured with quantitative data (e.g., learning outcomes) and explored in depth through interviews or classroom observations.
4. The use of digital technology in STEM learning in elementary schools has been little researched. In fact, the integration *of Augmented Reality/Virtual Reality*, scientific simulations, and block-based *coding* is very relevant for elementary school children. Indonesia still lags behind in this integrative research.
5. There is a lack of research on teacher competence in delivering STEM learning. Many studies focus on students, but the readiness of teachers—which is the most decisive factor—has not been systematically explored.

Overall, the analysis shows that STEM research at the elementary school level in Indonesia has developed rapidly over the past decade, but there is still ample room for more in-depth, measurable, and contextual studies.

When compared to global STEM bibliometrics, several gaps are evident. The study " , for example, shows that globally, STEM publications have increased rapidly since 2015, with a major focus on digital technology-based STEM, cross-disciplinary curriculum integration, , and the development of authentic assessment tools. However, patterns in Indonesia show that research focus is more dominated by simple project-based learning, science-mathematics integration, and learning module development, rather than technological innovation or computational pedagogy. Similarly, Kertati et al., (2024) found that *global research trends* place STEM as a holistic approach based on *the engineering design process,* whereas in the Indonesian context, this engineering design approach is still rarely implemented at the elementary school level.

Future research opportunities appear to be wide open. *First*, the lack of research in the field *of computer science education* in elementary schools indicates that computational literacy still needs to be developed using approaches that are appropriate for elementary school-aged children. *Second*, there is a need for more STEM research based on the local Indonesian context, such as the use of culture, the environment, and local wisdom as contexts for inquiry-based learning. *Third,* there are enormous opportunities for integrating STEM with *emerging* technologies such as *augmented reality, IoT,* simple *microcontrollers*, and AI, given the global push towards smart technology-based education. *Fourth,* longitudinal research examining the long-term impact of STEM learning in elementary schools has not been seen in existing publications—even though this is crucial for assessing the effectiveness of the STEM approach on students' science literacy and 21st-century readiness. Thus, the results of this study not only provide a roadmap for development but also highlight the needs and new areas of research that Indonesian researchers can develop to keep pace with global trends.

Overall, Scopus publication patterns show that STEM learning research in Indonesian elementary schools is in a growth phase. The nature of publications, which still dominate the fields of pedagogy and social sciences, opens up vast opportunities for more in-depth empirical research on aspects of *engineering* design*,* digital technology in STEM, the development of discipline-integrated curricula, and the implementation of STEM that is responsive to the Indonesian social context. Thus, this study not only maps the current state of research but also provides a strategic direction for the future development of STEM education in Indonesia.

IV. CONCLUSION

The results of this study indicate that the development of STEM learning research in Indonesian elementary schools shows a dynamic that continues to increase, especially after 2019, which marks the acceleration phase of STEM adoption in the context of basic education. These findings confirm that STEM has become an important focus in the development of learning quality and science literacy in Indonesia, as reflected in the diversity of document types, fields of study, and increased consistency of publications in various journals and scientific conferences. However, it is important to note that this study relies entirely on data obtained from the Scopus database, so that patterns, trends, and the proportion of researcher contributions may differ if analyzed using other databases such as Web of Science, Dimensions, or Google Scholar. Therefore, further research is recommended to utilize more than one database in order to obtain a more comprehensive picture, while also expanding the analysis to include aspects of author collaboration, research theme mapping, and citation impact to enrich the understanding of STEM research development in elementary schools at both the national and global levels.

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