

Article

A bibliometric analysis of Indonesian stem education research (2019–2023): Trends, contributors, and future directions

Indra Kertati¹, Danu Eko Agustinova², S. Sukini³, Winci Firdaus⁴, Anri Naldi⁵, Robbi Rahim^{6,*}¹ Universitas 17 Agustus 1945 Semarang, Semarang 50133, Indonesia² Universitas Negeri Yogyakarta, Yogyakarta 55281, Indonesia³ Universitas Widya Dharma Klaten, Klaten 57421, Indonesia⁴ Badan Riset dan Inovasi Nasional, Cibinong 12190, Indonesia⁵ Prodi Pendidikan Agama Islam, Fakultas Agama Islam, Universitas Medan Area, Medan 20216, Indonesia⁶ Sekolah Tinggi Ilmu Manajemen Sukma, Medan 10560, Indonesia* Corresponding author: Robbi Rahim, usurobbi85@zoho.com

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Abstract: Science, technology, engineering, and mathematics (STEM) education is a global priority, but effective implementation faces challenges. This bibliometric study analyzed the results of Indonesian STEM education research to elucidate publication and contributor patterns. The Scopus database was searched for Indonesian STEM education publications from 2019–2023 and produced 52 documents from 23 sources. The analysis found a negative average growth rate of -5.43% , with a peak of 14 releases in 2020, possibly related to the COVID-19 pandemic. Although the output was relatively limited, the diversity of sources suggests wide-ranging interest. The leading authors were identified based on their productivity and impact on citation, with Wahono. emerging as the most influential worldwide. Universitas Pendidikan Indonesia was an institutional leader. The Journal of Physics Conference series dominated the contributions and emphasized the role of conference proceedings. Examination of the citations and text frequencies revealed key themes that include technology, engineering, pedagogy, and skills of the 21st century. Several widely cited works ensured international visibility. In general, this bibliometric analysis quantitatively mapped the landscape of Indonesian STEM education research, finding a decline in performance but a strong foundation of committed institutions and authors. The sustainability of production and impact requires targeted policies based on insight into existing strengths, productive scholars, and influential publications. The results provide an empirical basis for practices and policies for the effective development of STEM education in Indonesian schools.

Keywords: bibliometric analysis, Covid-19, education, STEM, STEM education

1. Introduction

The evolution of science, technology, engineering and mathematics (STEM) education is critical in shaping global educational paradigms, particularly in the context of Indonesia (Mustapa, 2023; Ningsih et al., 2018; Zhan et al., 2022), a country with a diverse and rapidly evolving educational landscape. With the increasing need for a skilled workforce in STEM fields and the growing interest in STEM education worldwide, understanding how different regions, including Indonesia, integrate and develop STEM education is crucial. The global application of STEM education underscores a universal shift towards interdisciplinary and applied learning approaches (Freeman et al., 2019; Sunarti et al., 2023; Suriyabutr and Williams, 2021). Integrated STEM curricula aim to cultivate critical thinking, problem solving, creativity, and other competencies required for innovation, technological advancement,

and national competitiveness. However, STEM integration faces systemic implementation challenges, including teacher readiness, alignment of assessment, and contextualization to local needs (Teo and Ke, 2014). These issues underscore the need for evidence-based insights to guide effective STEM education policies and teaching practices.

In Indonesia, STEM education represents a key strategy for developing skills to support economic growth amid demographic shifts and technological disruptions (Arlinwibowo et al., 2021). Recent government initiatives have aimed to expand STEM throughout primary and secondary schooling to prepare future-ready graduates. However, studies note inconsistencies in STEM integration across Indonesia (Suwarma and Kumano, 2019), pointing to gaps between policy aspirations and on-the-ground realities. There remains limited empirical information on how STEM education research in Indonesia has evolved amid changing policies and global trends (Farwati et al., 2021; Imaduddin et al., 2021; Sujarwanto et al., 2021).

Despite the global momentum surrounding STEM education, Indonesia's unique educational context presents specific challenges and opportunities that warrant closer examination. As a developing nation with diverse cultural and socioeconomic landscapes, Indonesia's STEM education initiatives face the dual task of aligning with international standards while addressing local needs. These include disparities in resource availability, variations in teacher readiness, and the uneven implementation of policies across different region. The purpose of this research is to explore these complexities and provide a clearer picture of how STEM education is evolving within Indonesia's specific educational framework. By delving into the current challenges—such as inconsistent curriculum implementation and the limited availability of STEM-trained educators—this study aims to offer insights that can guide more effective policy development and teaching practices in Indonesia. In doing so, it seeks to contribute to the broader conversation on how global STEM trends can be contextualized to fit national priorities and realities.

Bibliometric analysis offers a quantitative and evidence-based perspective on the research landscape (Ahmad et al., 2023; Samala et al., 2023; Watrianthos et al., 2023). By statistically analyzing publication and citation patterns, bibliometrics reveals key contributors, influential works, research priorities, and knowledge flows. This technique has been applied to map research trends in STEM education in various national contexts. However, no study has bibliometrically analyzed the literature on STEM education in Indonesia. This study aims to address this gap by conducting a systematic bibliometric analysis of STEM education research output in Indonesia over the past five years. Using the Scopus database, we retrieved Indonesian publications on STEM education from 2019–2023 to examine publication volume trends, prolific contributors, frequently cited works, and thematic characteristics. By quantitatively delineating the contours of Indonesia's STEM education knowledge base, findings can highlight strengths, gaps, and opportunities to enhance research productivity and impact. The bibliometric results provide an evidence base to inform policies and practices that successfully integrate STEM in Indonesian schooling to develop creative problem solvers prepared for 21st century challenges.

2. Method

The scientific literature is measured, tracked, and analyzed using bibliometric analysis, a quantitative method (Donohue, 1972; Lazarides et al., 2023). Since Pritchard originally coined the term, it has been widely used to aid quantitative analysis. This method identifies the author's publications, the most prestigious journals, the methodology, and the results. The method of choice and suitability for examining and evaluating large amounts of scientific data is bibliometric analysis (Lawani, 1981; Van Raan, 2003). It helps define the boundaries of a field and allows us to dive into its complicated evolutionary history. Among other things, scientists use bibliometric analysis to examine the intellectual framework of a field and to identify new and evolving patterns in papers and journals (Greener, 2022). Research components and cooperation patterns in the current area. We use the Scopus database (Burnham, 2006; Negahdary et al., 2018; Singh et al., 2021), which is widely used for bibliometric studies and represents a more comprehensive reference database. We started our process by searching for the keywords "STEM education" and "Indonesia" in the title, abstract, and keywords in the Scopus database. We limited our search to journal articles and proceedings. The search results returned 52 documents from 23 sources from 2019 to December 2023, with an annual growth rate of -5.43 percent. A total of 159 authors contributed and recorded an average of 6.23 citations per document.

Bibliometric analysis techniques were used for performance mapping and scientific analysis (Watrianthos et al., 2022; Watrianthos and Yuhefizar, 2023; Watrianthos et al., 2022). Performance analysis tools such as annual scientific production maps and the entire scientific literature produced by institutions were used to understand the production of research articles related to STEM applications in Indonesia. To achieve this, the number of articles published by journals and the number of citations received by the articles are used to identify leading journals, most cited documents, and leading scholars in STEM-related research in Indonesia. Furthermore, this study aims to identify the thematic background and development of STEM-related research in Indonesia and recommend possible research areas for the future. Bibliometric analysis was performed using Biblioshiny (Aria and Cuccurullo, 2017), a configurable web interface package for the R programming language (Radha and Arumugam, 2021).

3. Result and discussion

The bibliometric analysis of the SCOPUS publications on STEM education in Indonesia from 2019 to 2023 provided several insightful results. The 5-year time frame allowed for an examination of publication trends over this most recent period. In particular, tracking the volume of annual publications revealed a downward trend with an average annual growth rate of -5.43%. This negative development indicates a worrying decline in research attention and output related to STEM education in Indonesia in recent years. Further examination of the potential factors driving this downward trend, whether related to the availability of funding, changing academic priorities, or general education policy, represents an area for future research. The 52 documents analyzed come from a variety of 23 different sources, including academic

journals, conference proceedings, and books. This suggests a broad interest across multiple academic platforms and publishers. A closer analysis of the sources that contribute the most frequently could shed light on particularly influential publications and academic communities that shape the discourse on this topic in Indonesia.

Although the total number of 52 documents is relatively limited, it indicates a small but substantial body of Indonesian-specific research on STEM education. A detailed examination of each publication provides an opportunity to illuminate key themes, methodological approaches, and insights that engage researchers in the field. The synthesis of these findings provides a comprehensive understanding of the focus and knowledge generated related to the challenges and strategies of STEM education in the Indonesian context. The declining publication history is a concern, while the diversity of sources and the richness of study results require further synthesis and discussion.

3.1. Publication trends

The analysis of annual scientific production on STEM education in Indonesia shows interesting trends and fluctuations in research output from 2019 to 2023. The volume of publications peaked in 2020 with 14 published articles. This culmination of research activity calls for further examination of potentially catalyzing events or conditions in 2020, be it a response to global events such as the COVID-19 pandemic or STEM-focused policy changes by the Indonesian government. After this peak, production remained constant at 10 articles per year in 2019, 2021 and 2022, suggesting continued research interest. **Figure 1** illustrates the trends in the number of articles published each year, highlighting the peak in 2020 and the subsequent changes in research output over the years.

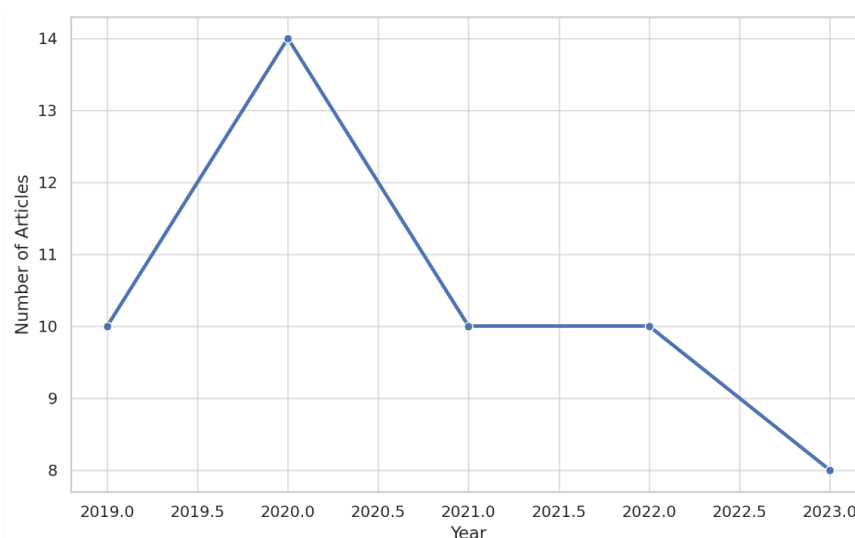


Figure 1. Annual scientific production in STEM education in Indonesia from 2019 to 2023.

However, there was a decline to just eight releases in 2023, consistent with the overall negative annual growth rate of -5.43% over the five-year period. Several factors may explain this dynamic in research productivity. The peak in 2020 suggests an increase in attention to STEM education issues, perhaps triggered by the need to

rapidly transform educational approaches during the COVID-19 pandemic. Furthermore, fluctuations in the availability of research funding or changes in government policies and priorities related to STEM education may incentivize or discourage research activity. The decline in 2023 could also indicate a change in focus within the academic community or a saturation of research on long-standing topics. More research is needed to determine the dominant forces that influence this fluid performance trajectory.

The bibliometric analysis shows both consistency and fluctuations in the productivity of STEM education research in Indonesia from 2019 to 2023. The temporary increase in publications in 2020, followed by a downward trend, suggests that research interest is focused on the current events, funding conditions, and political landscapes that have responded. Monitoring these dynamics can inform efforts to promote impactful, policy-relevant research on future challenges and solutions in STEM education. In terms of research output, Permanasari A emerges as the most prolific author with 4 publications in the period 2019–2023. However, the author's influence goes beyond the publication quantity, as shown by the corresponding total citation count of 31 for Permanasari A, Firman H and Nugroho OF despite different publication numbers. This shows the variability between productivity and real research impact. The most influential authors with the highest total citations are Chang (67 citations) and Wahono (67 citations), each with 3 published works. Their high citation counts, which exceed those of more common publishers, such as Permanasari A, demonstrate the resonance and importance of their contributions to the field. The leading h-indices belong to Chang and Wahono, suggesting their success in generating impactful publications over time.

The bibliometric analysis of institutional productivity reveals key nodes that drive research and knowledge creation on STEM education in Indonesia. Universitas Pendidikan Indonesia is the main donor with a total of 24 publications in the period 2019–2023. With this extensive service, it positions itself as a hub for research activities and expertise on issues related to STEM education. Public universities also play a central role, as shown by the 12 and 8 articles published by Universitas Negeri Semarang and Universitas Negeri Yogyakarta, respectively. Their contributions demonstrate the commitment of public institutions to advance understanding of STEM teaching and learning. Furthermore, the list of most relevant affiliations shows diversity, since leading universities from different Indonesian regions are represented. This suggests a widespread interest in research on STEM education in different geographic areas and types of public and private institutions.

The bibliometric analysis of the main sources of STEM education in Indonesia reveals key journals that drive the dissemination of research results, as well as interesting trends in publication production over time. The *Journal of Physics: The conference series* proves to be the dominant source with 20 articles in the period 2019–2023. The output shows a notable upward trend, increasing from just 6 articles in 2019 to 20 articles in 2022 and 2023. This increase suggests that conference proceedings, particularly those published in the *Journal of Physics: Conference series* are becoming important channels for exchange of STEM education, and have become research in Indonesia.

Meanwhile, AIP Conference Proceedings are experiencing steady volume growth, gradually increasing from one article in 2019 to six articles in 2023. Its lasting contribution underscores the central importance of conference publications in conveying information about STEM education. Beyond these conference-oriented journals, the analysis also introduces various journals active in this field. The Eurasia Journal of Mathematics, Science and Technology Education will be published for the first time in 2023 with two articles, perhaps indicating increasing attention to the regional Eurasia context. Other journals show gradual and stable contributions over time, such as the International Journal of Evaluation and Research in Education and the Journal for the Education of Gifted Young Scientists.

3.2. Document analysis

Examining the world’s most cited STEM education publications from Indonesia provides important insights into the works and authors that have significant international influence. The article with the highest total number of citations is Wahono’s article published in Sustainability in 2019, which recorded a total of 42 citations over a five-year period. With a normalized citation count of 3.21, this article has had an outstanding impact on research. The prominent citation underscores the resonance of Wahono’s scholarship with global audiences. This cements Wahono as the most internationally influential author in this data set. Additional frequently cited works provide additional perspectives on influential publications and contributors. Chai CS’s 2020 contribution on sustainability was cited a total of 30 times, indicating that this journal is an effective channel for disseminating impactful Indonesian research. Meanwhile, Nugroho OF’s 29-cited article in J Pendidikan IPA Indonesia highlights the ability of national journals to produce globally recognized research, while Suratno Suratno’s 22-cited article in the Journal of Turkish Science Education suggests that joint publications increase international reach can increase.

Drilling down to citation rates per year and normalized citation counts illustrates the comparative influence over time. The editorials are cited on average 4–7 times per year and are retained long after publication. Their normalized numbers of 1.5–3.3 citations per 5-year window significantly exceed most works. In general, these bibliometric data isolate both the specific publications and the productive scholars that drive the international visibility of Indonesian STEM education research. The work of Wahono and his collaborators has received worldwide acclaim, particularly when published in renowned journals, see **Table 1** for most cited article.

Table 1. Top ten most cited article.

Author	TC	Finding
Wahono, 2019, Sustainability (Wahono and Chang, 2019)	42	This study aims to foster sustainable development in STEM education, contributing to advanced research and future research directions in this field.
Chai CS, 2020, Sustainability (Chai et al., 2020)	30	This study contributes to understanding how future teachers are being prepared to effectively integrate STEM disciplines in their teaching practices.
Nugroho OF, 2019, J Pendidikan IPA Indonesia (Nugroho et al., 2021)	29	The study underscores the importance of increasing awareness and support for STEM education at both government and teacher levels in Indonesia.
Suratno Suratno, 2020, J Turk Sci Educ (Wahono et al., 2020)	22	This study suggests that science teachers hone problem-solving skills with the application of STEM education.

Table 1. (Continued).

Author	TC	Finding
Ardianti S, 2020, <i>Univers J Edu Res</i> (Ardianti et al., 2020)	21	The study found that blended learning with a STEM approach significantly improved students' critical thinking skills compared to traditional learning methods.
Parno P, 2020, <i>J Pendidikan IPA Indonesia</i> (Parno et al., 2020)	21	The study concluded that the operational implementation of PBL-STEM and PBL had a significantly positive impact on students' scientific literacy.
Hafni RN, 2020, <i>J Phys Conf Series</i> (Hafni et al., 2020)	19	The paper discusses the role of STEM education in equipping students with critical thinking skills essential for navigating the challenges of Industry 4.0.
Suwarma IR, 2019, <i>J Phys Conf Series</i> (Suwarma and Kumano, 2019)	13	The study found that the 2013 national curriculum was more conducive to integrating STEM education compared to the KTSP curriculum
Parmin P, 2020, <i>J Educ Gifted Young Sci</i> (Parmin et al., 2020)	12	The study recommends the promotion of STEM education in Indonesia's national curriculum, particularly in science subjects.
Abdurrahman A, 2019, <i>J Phys Conf Series</i> (Abdurrahman et al., 2019)	12	The findings indicate that teachers recognize the importance of STEM in education and are keen to participate in overcoming challenges associated with 21st-century learning.

The investigation of word frequencies (keyword plus) in the STEM educational literature from Indonesia highlights important topics that attract academic attention. The most common term is 'technology', appearing 29 times, indicating a strong focus on technical dimensions. In this context, "engineering" appears 19 times, underlining the central importance of this discipline. 'STEM' and its subfields now appear 19 times, confirming the research focus on the integration of science, technology, engineering, and mathematics. Beyond disciplinary foci, keywords in education also play an important role, including 'students' (15 occurrences), 'teaching' (4), 'curricula' (8) and 'education' (2). This lexical meaning demonstrates an applied interest in translating STEM subjects into educational contexts. Methodological language also emerges, with terms such as 'surveys', 'literature reviews', and 'research methods' pointing to preferred approaches to inquiry.

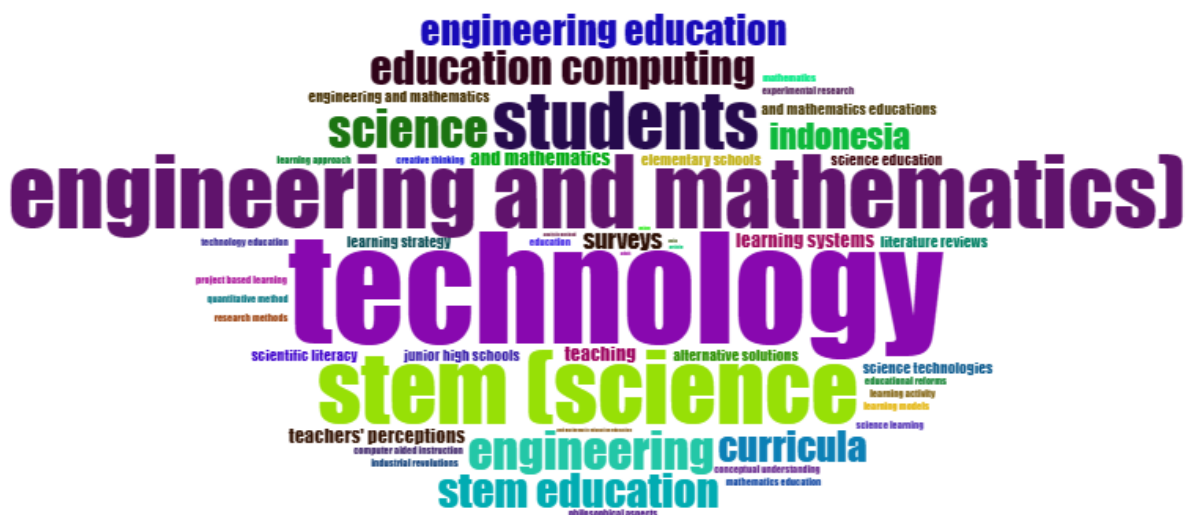
**Figure 2.** Word cloud based on keyword plus.

Figure 2 shows the repetition of Indonesia (seven times), which locates the research geographically and suggests the localization of international STEM trends. More sporadic but meaningful words like "Industry 4.0", "sustainability", and '21st century skills' may signal emerging concerns. In general, frequent word analysis

delineates the prevailing themes and suggests hierarchies of research attention. The technology and engineering orientation is based on the MINT (Mathematics, Informatics, Natural Sciences, and Technics) focus, while pedagogical dictionaries refer to teaching and learning applications. Tracing text patterns provides a high-level cartography of the knowledge landscape. The most influential concepts, as indicated by replications, require more in-depth investigation to understand their scientific significance and policy significance in the Indonesian STEM education environment.

4. Conclusion

This bibliometric analysis of STEM education research in Indonesia from 2019 to 2023 provides diverse insights into publication patterns, contributions, impacts, and thematic focus. Tracking the volume of publications over time shows a worrying downward trend, with an average annual decline of 5.43%. Despite an increase of 14 items in the abnormal pandemic year of 2020, production shows a declining trend, dropping to only 8 items by 2023. Further research is needed to clarify the factors that drive this decline and may influence policies to revitalize STEM education research production. By examining contributor patterns, the key producers and disseminators that shape Indonesia's knowledge base for STEM education are identified. Prolific authors include Permanasari A., Chang C-Y, and Wahono, the latter also emerging as the world's most influential scientist in terms of total citations. The University of Indonesia and the Bandung Institute of Technology are institutional leaders and point to critical junctures of research activity and expertise. In terms of specific document implications, bibliometric techniques identify Wahono's widely cited 2019 sustainability article as an Indonesian research breakthrough that resonates globally. Technology and engineering now dominate the thematic focus, and these keywords appear frequently in the literature. This alignment likely reflects both global STEM trends and Indonesia's development priorities. Synthesizing these quantitative insights creates a complex portrait of Indonesia's STEM education research landscape, which requires targeted actions to increase production and impact. Sustaining funding and commitment even under uncertain conditions is crucial, as is learning from productive scholars and institutions to nurture future generations of researchers to meet the challenges of STEM education in Indonesia.

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