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Exploring Global Patterns and Research Frontiers of STEM in Early Childhood: A Bibliometric Analysis

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Abstract: This study aims to explore global patterns, trends, and research frontiers related to STEM (Science, Technology, Engineering, and Mathematics) education in early childhood through a bibliometric analysis. A total of 154 research articles published between 2020 and 2025 were retrieved from the Scopus database. The data were analyzed using VOSviewer and Biblioshiny to identify publication trends, leading countries, institutions, authors, journals, and thematic clusters in this field. The findings reveal a significant increase in research interest during the past five years, indicating the growing importance of early STEM education in fostering foundational scientific literacy and problem-solving skills among young children. The United States, China, and Australia were identified as the most productive countries, while key research themes include inquiry-based learning, STEM integration, teacher professional development, and gender equity in STEM. Emerging frontiers highlight the integration of digital technologies and play-based approaches to enhance early STEM learning experiences. This study contributes to a comprehensive understanding of the global landscape of early childhood STEM research and provides insights for future research directions and policy development in early education.

Keywords: Bibliometric Analysis, Early Childhood, Global Patterns, Research Trends, STEM Education

A. Introduction

STEM education (Science, Technology, Engineering, and Mathematics) in early childhood has gained global attention over the past decade. This form of education is believed to play a strategic role in building the foundations of scientific literacy, critical thinking, creativity, and problem-solving skills from an early age (Damjanovic & Branson, 2025; Erol et al., 2025; Ho, 2025; L. Wang & Mihai, 2025; Zhou & Yang, 2025). Children who are introduced to STEM concepts in contextual and interactive ways tend to demonstrate higher learning readiness and sustained interest in science and technology at subsequent educational levels (Bierman et al., 2025; Kewalramani et al., 2025; Liang et al., 2025). Therefore, strengthening STEM education in early childhood has become an essential component of the educational agenda in many

countries.

Nevertheless, studies on the implementation, learning approaches, and policies related to STEM at the early childhood level are still developing dynamically and have not yet been systematically mapped. Most previous research has primarily focused on STEM education at the elementary and secondary school levels, while exploration during the early stages of child development remains limited. Moreover, variations in social, cultural, and educational policy contexts across countries also influence the direction and focus of research in this field (Alvidrez et al., 2024; Erol & Ivrendi, 2025; Kotaman & İnceoğlu, 2025; Monteira, 2025; Veziroglu-Celik et al., 2025; S. Wang, 2024). These circumstances highlight the need for a bibliometric analysis that can provide a comprehensive overview of global research patterns on STEM in early childhood education.

Published studies on STEM in early childhood education exhibit considerable variation in implementation contexts, pedagogical approaches, and thematic focuses. However, to date, there has been a limited number of studies that systematically map how this research area has evolved, identify the key contributors in the field, and analyze both the dominant and emerging themes. As a result, researchers and policymakers still lack a comprehensive understanding of the global research landscape related to STEM in early childhood education (Abanoz & Yabaş, 2023; Burton et al., 2022; Fleer, 2021; Gerde et al., 2023; Hachey et al., 2022; Kanaki & Kalogiannakis, 2022; Stephenson et al., 2022; Ward et al., 2022). Through a bibliometric analysis approach, this study is significant as it provides a quantitative scientific mapping of publication patterns, international and institutional collaboration networks, and thematic structures of existing research. This analysis not only illustrates the growth and distribution of studies but also reveals the research frontiers emerging areas with strong potential for future development.

Practically, the results of this study are valuable for researchers, educators, and policymakers in formulating new directions for the development of STEM education at the early childhood level based on empirical evidence (evidence-based policy). Academically, this research makes a significant contribution to enriching the international literature by providing a conceptual foundation and scientific mapping that can be used to identify research gaps and strengthen cross-country collaboration in the field of STEM education for early childhood.

The contribution of this study lies in providing a comprehensive overview of the global research landscape on STEM in early childhood, identifying major centers of scientific productivity worldwide, and mapping emerging themes such as digital technology integration, play-based learning, teacher professional development, and gender equality in STEM. These findings are expected to serve as an important reference for researchers, educational practitioners, and policymakers in formulating

strategies and directions for the development of more effective and sustainable STEM research and learning practices in the future.

B. Methods

This study employed a systematic scientific mapping approach that comprised five main stages: research design, bibliometric data collection, analysis, visualization, and interpretation. Bibliometric analysis refers to the examination of bibliographic information from scientific publications using quantitative and statistical techniques (Fleer, 2020; Garner et al., 2020; Huang et al., 2020; MacDonald et al., 2020; McGuire et al., 2020; Ndijuye & Tandika, 2020; Ogegbo & Aina, 2020). In this context, the study seeks to analyse publication characteristics and identify research trends related to stem in early childhood educations through bibliometric methods. The vast number of published works in this field presents difficulties for researchers attempting to identify consistent trends and research directions. Therefore, a bibliometric analysis is essential to map and interpret the evolution of studies on stem in early childhood educations. This research adopts a quantitative meta-analysis design aimed at identifying bibliometric data on stem in early childhood education studies indexed in the Scopus database.

The data collection phase involved retrieving and filtering bibliographic records from the Scopus database, following the procedures used in previous studies on stem in early childhood education. Scopus was chosen because its data coverage is approximately 70% broader than other indexing sources. The scope of the dataset was restricted to publications from 2020 to 2025, representing the most recent five-year period. Although citation patterns often extend to the last decade, the five-year range was selected to ensure a focus on contemporary developments and to enrich the dataset with recent research outputs.

The subsequent stage involved data analysis using specific software tools. While Scopus provides built-in analytical and visualization features—such as annual publication counts, source journals, influential authors, and productive institutions—these are insufficient for an in-depth bibliometric examination. Therefore, additional software tools were employed to conduct more detailed analyses and visualizations. This study utilized VOSviewer to process and visualize bibliographic data in RIS format. VOSviewer was selected due to its flexibility and user-friendly interface, which allows researchers to adjust visualization outputs according to analytical needs. Furthermore, compared to R-based applications, VOSviewer offers a more accessible way to explore research novelty through its *Network Visualization*, *Overlay Visualization*, and *Density Visualization* features.

C. Results and Discussion

1. General Information and Growth Trends

The Scopus database used in this paper spans from 2020 to 2025 (the last 6 years) because, generally, citations in articles must be published within the last ten years. However, the authors increased the number of years to 6 to facilitate analysis. Furthermore, there are numerous articles published on stem in early childhood educations over the past 6 years, sufficient for analysis. Figure 1 shows general information from 152 articles from 2020–2025, as follows. In Figure 1, you can see general information from 152 articles from 2020-2025.

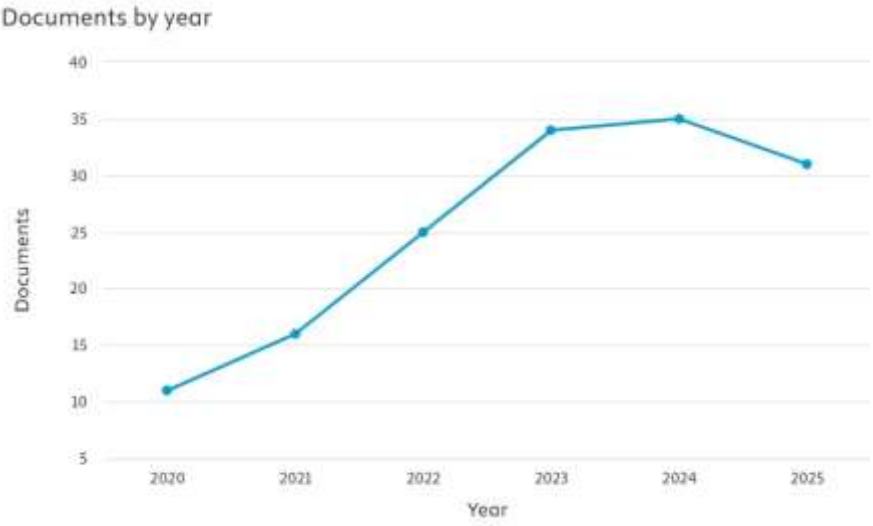

Figure 1: General Information and Growth Trends of Articles Publication of Articles Per Year

The annual growth of articles can also be seen in Figure 1. Based on the results of journals indexed by Scopus, the publication of published articles fluctuates over the past six years. In 2020, 11 articles (7,24%) were published. This number then dropped sharply in 2021 to 16 articles (10,53%), the lowest point during this period. Thereafter, a significant increase occurred in 2022 with 25 articles (34,21%), 34 articles (22,37%), and reaching a peak of 35 articles (23,03%) in 2024. However, the trend declined again in 2025 (31 articles/20,39%). In general, publication trends indicate that research interest in stem in early childhood educations increased rapidly until 2023, then experienced a moderate decline in the following two years. This pattern indicates that, despite fluctuations, the topic of stem in early childhood educations remained a consistent focus for international researchers during the 2020–2025 period. The data indicates that stem in early childhood education research has been a popular topic among stem in early childhood education researchers despite fluctuations in interest over the

years, and it should be further developed through continued research and publication.

2. Contribution by Journals

There are 69 journals contributed to publishing papers related to stem in early childhood education. Figure 1 shows the distribution of the top 5 journals that publish the most articles.

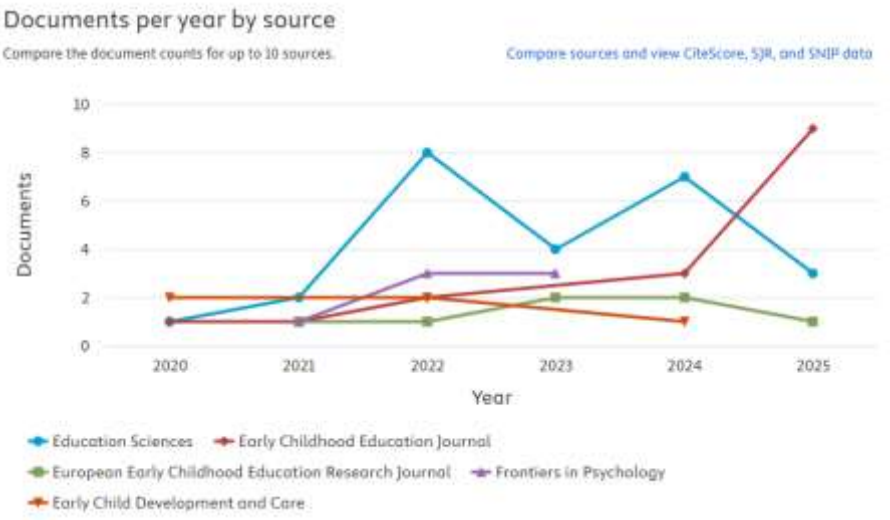

Figure 2: Contribution by Journals to Articles Distribution of Articles Based on Scopus-Indexed Journal Sources

In Figure 2, journal sources indexed by Scopus publish themes related to stem in early childhood education. The highest number of publications was published in educational sciences, with 25 articles published. The top five journal sources can also be a reference for publishing papers related to this theme. The five journals are Early Childhood Education Journal (16 articles), European Early Childhood Education Research Journal (7 articles), Frontiers in Psychology (7 articles), and Early Child Development and Care (5 articles). Although there are many other journal sources, these five journals have the most significant number of articles published compared to other journals.

Table 1. Top Five Journals

Source Title	Cite Score	Highest percentile	SJR	Publisher	The number
Education Sciences	5.5	(84%) Q1	0.730	Multidisciplinary Digital Publishing Institute (MDPI)	25
Early Childhood Education Journal	6.2	(87%) Q1	1.179	Springer	16
European Early Childhood Education Research Journal	4.0	(75%) Q2	0.673	Taylor & Francis	7
Frontiers in Psychology	6.3	(83%) Q2	0.872	Frontiers Media SA	7
Early Child Development and Care	3.5	(71%) Q2	0.551	Taylor & Francis	5

Table 1 shows the top five journals publishing the most research on stem in early childhood educations, based on bibliometric analysis. These journals generally fall within the upper quartiles (Q1 – Q2) of the Scopus database, indicating high scientific quality and influence. Education Sciences ranks first with a Cite Score of 5.5 and 25 related articles, followed by Early Childhood Education Journal (Cite Score 6.2) and the European Early Childhood Education Research Journal (Cite Score 4.0). Furthermore, Frontiers in Psychology Cite Score of 6.3 (Q2) with a citation rate of 83%, followed by Early Child Development and Care with a Cite Score of 3.5 (Q2). These results indicate that the topic of stem in early childhood educations is highly sought after and published in highly reputable journals in psychology and education, reflecting the relevance and significant contribution of stem in early childhood educations research to the development of global knowledge.

3. Contributions by Authors

There were 154 authors from various countries. Figure 3 shows the distribution of the top 10 authors who have published the most papers and cites in the field of stem in early childhood education.

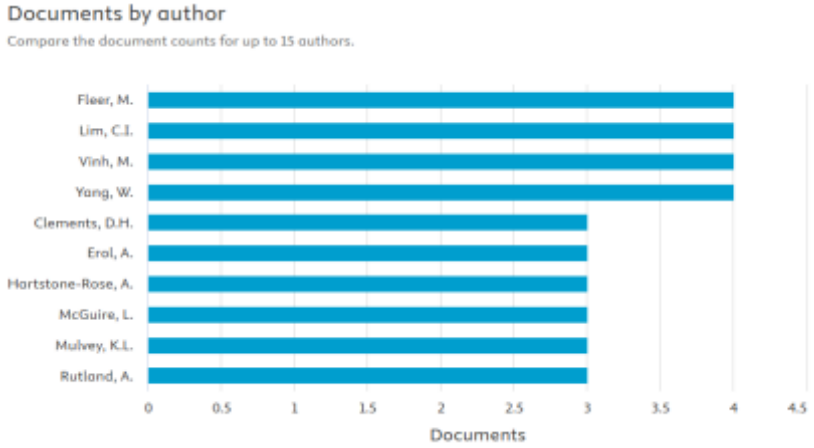

Figure 3. Contributions by Authors to Articles Distribution of Articles Based on The Author

Based on Figure 3, the most influential author related to stem in early childhood education is Marilyn Fleer from Monash University, Melbourne, Australia. This means that the authors are productive people and can be a reference in stem in early childhood education research. The focus of Prayogi S.'s study is a stem in early childhood education.

4. Distribution by Subject Area

There were 11 subjects about stem in early childhood education. Figure 4 shows the distribution of the top 5 subject area who have published the most papers and cites in the field of stem in early childhood education.

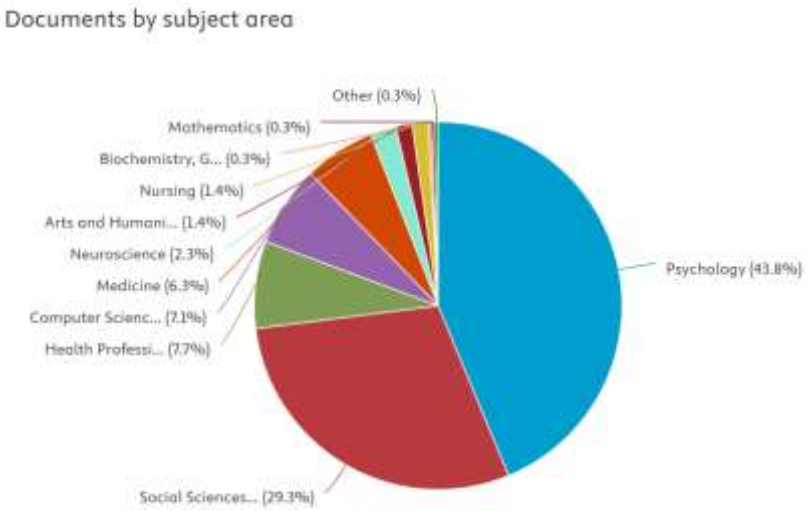

Figure 4. Distribution of Articles about Subject Area

Figure 4 shows that research on stem in early childhood education is distributed across various scientific fields. Some of these include psychology (43,8%), Social Sciences (29,3%), Health Professions (7.7%), Computer Science (7.1%), medicine (6.3%), Neuroscience (2,3%), Arts and Humanities (1.4%), Nursing (1.4%), Biochemistry, Genetics and Molecular Biology (0.3%), mathematics (0.3%) and other fields (0.3%). This distribution indicates that stem in early childhood education is a multidisciplinary concept that is not only relevant to psychology but also extends to education, technology, management, and neuroscience.

5. Contributions by Institutions

One hundred sixty universities from various countries were obtained. Figure 5 shows the distribution of the top 10 universities that publish the most papers in the stem in early childhood education.

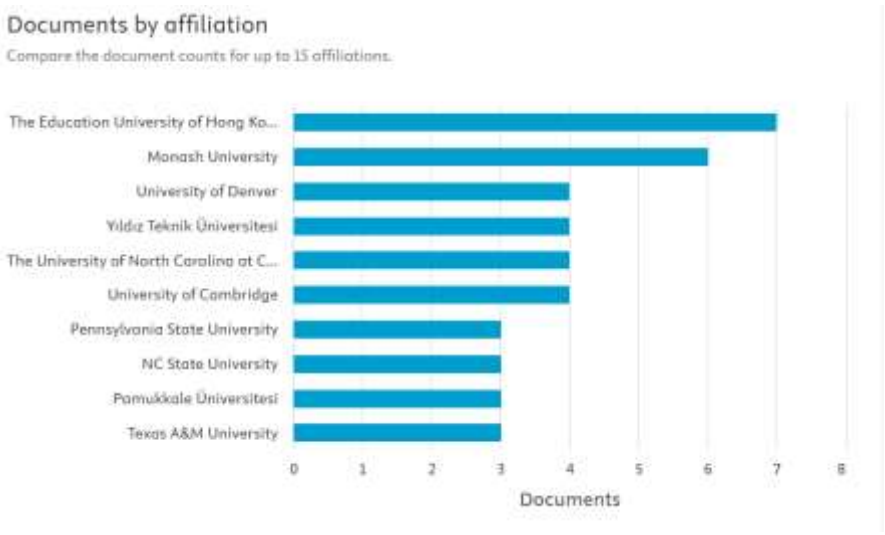

Figure 5. Distribution of Articles Per the University

Figure 5 shows the university that contributed to publishing articles related to the stem in early childhood education. The top ten campuses are The Education University of Hong Kong, Monash University, University of Denver, Yıldız Teknik Üniversitesi, The University of North Carolina at Chapel Hill, University of Cambridge, Pennsylvania State University, NC State University, Pamukkale Üniversitesi, and Texas A&M University. These ten campuses can be a reference for authors who study stem in early childhood education.

6. Distribution by Country

Fifty countries contributed to the publication of this article. Figure 6 shows the distribution of the top 10 countries that publish the most papers in the stem in early childhood education research.

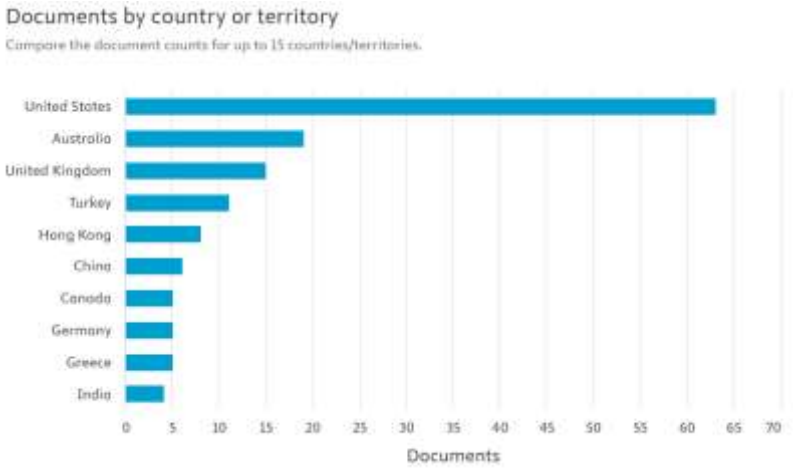

Figure 6. Distribution by Country to Articles Distribution of Articles per Country

Based on Figure 6, the country that contributed the most articles published on stem in early childhood educations was United states with 63 articles, followed by Australia, with 19 articles. Eight of the top 10 authors were, respectively, United Kingdom 15 articles, Turkey 11 articles, Hong Kong 8 articles, China 6 articles, Canada 5 articles, Germany 5 articles, Greece 5 articles, and finally, India 4 articles. Thus, stem in early childhood educations is more dominant and productive in United States, especially at The University of North Carolina at Chapel Hill. Therefore, authors from United States have conducted extensive research on the differences in students' stem in early childhood educations.

D. Conclusions

This study reveals that research on STEM in early childhood education continues to gain significant attention and is projected to remain a growing trend through 2025. The majority of the published articles are indexed in the Scopus database, predominantly within quartile one to quartile three journals, indicating a strong scholarly interest and quality in this area. Consequently, the findings of this study can serve as a valuable reference for future researchers who intend to explore STEM education in early childhood based on the current research trends identified herein.

Using bibliometric analysis of publications retrieved from the Scopus database, this research examined studies on STEM in early childhood education published over the past six years. The analysis identified 154 publications within this period, although the citation rate of these articles remains relatively low. This suggests that the increase in publication volume has not yet been matched by a corresponding rise in research influence or citation impact. Among the sources, *Educational Studies in Learning* emerged as the leading journal contributing the largest number of publications in this field. Marilyn Fleer from Monash University, Melbourne, Australia was identified as the most influential author, particularly for his contributions to reflective STEM approaches in early mathematics education. Furthermore, **United States** was found to be the most productive country in terms of research output and collaboration, recording the highest number of multi-country publications compared to other nations.

The findings reveal that research in this area is characterized by high academic standards, as numerous articles are published in top-tier journals indexed in Scopus. Building on these results, upcoming studies in the field of STEM education for young children are expected to explore developing areas such as geometry learning, the use of gestures in instruction, computational thinking, and the formation of early mathematical understanding. Nevertheless, future investigations could also be expanded to include higher education contexts, particularly among undergraduate learners, offering valuable opportunities for further inquiry.

This study provides an extensive overview of emerging directions for future research in STEM education among young learners, emphasizing the importance of further exploration into abstraction and conceptual development within early STEM learning environments. In addition, the findings reveal that existing research on early childhood STEM remains relatively narrow and underdeveloped, thereby presenting considerable potential for further scholarly inquiry. It should also be acknowledged that the current analysis was based exclusively on data from the Scopus database encompassing publications from the last six years. Consequently, subsequent research could be strengthened by incorporating other data sources, such as the Web of Science or Scopus Plus, to achieve a more comprehensive representation of the global research landscape in this domain.

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