

# RESEARCHING STEAM IN EARLY CHILDHOOD EDUCATION BETWEEN 2013-2023: A BIBLIOMETRIC ANALYSIS OF SCOPUS DATABASE

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## Abstract

*This study investigates global research trends on STEAM in early childhood education from 2013 to 2023. The bibliometric analysis method was utilized to analyze a dataset of 129 documents extracted from the Scopus database. The results reveal a growing interest in this field, with a notable increase in the number of publications from 2019 to 2023 compared to 2013-2018. The USA leads in both the number of publications and citations. "Early Childhood Education Journal" is the most prominent, while "Sullivan A" and "Bers MU" gain the most significant impact on this research topic. This review study identifies four main thematic clusters: (1) core aspects of STEAM in early childhood education, (2) gender equality in STEAM education, (3) technology and engineering education, and (4) applying this approach to early childhood education. Research trends indicate a growing interest in topics such as computer literacy, creativity, and children's learning processes in STEAM education. The authors propose several recommendations to guide future research in this area.*

**Keywords:** *Bibliometric, early childhood education, review, Scopus, STEAM.*

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# NGHIÊN CỨU VỀ GIÁO DỤC STEAM CHO TRẺ MẦM NON GIAI ĐOẠN 2013-2023: PHÂN TÍCH TRẮC LƯỢNG THƯ MỤC TỪ DỮ LIỆU SCOPUS

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## Lịch sử bài báo

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## Tóm tắt:

Nghiên cứu này khám phá xu hướng nghiên cứu về giáo dục STEAM cho trẻ mầm non trên thế giới trong thập niên 2013-2023. Phương pháp phân tích trắc lượng thư mục được sử dụng để phân tích bộ dữ liệu 129 tài liệu được trích xuất từ cơ sở dữ liệu Scopus. Kết quả cho thấy sự quan tâm ngày càng tăng trong lĩnh vực này, với sự gia tăng đáng chú ý về số lượng ấn phẩm từ 2019-2023 so với 2013-2018. Hoa Kỳ là quốc gia dẫn đầu về số lượng ấn phẩm và trích dẫn, "Early Childhood Education Journal" là tạp chí nổi bật nhất, trong khi Sullivan A và Bers MU đã có những ảnh hưởng lớn nhất về chủ đề nghiên cứu này. Nghiên cứu xác định bốn nhóm chủ đề chính: (1) các khía cạnh cốt lõi trong giáo dục STEAM cho trẻ mầm non, (2) bình đẳng giới trong giáo dục STEAM, (3) giáo dục công nghệ và kỹ thuật, và (4) kết hợp giáo dục khoa học, công nghệ, kỹ thuật, nghệ thuật và toán học trong bối cảnh giáo dục mầm non. Xu hướng nghiên cứu cho thấy sự quan tâm ngày càng tăng đối với các chủ đề tư duy tính toán, sáng tạo và quá trình học tập của trẻ em trong giáo dục STEAM. Một số khuyến nghị đã được tác giả đề xuất nhằm định hướng nghiên cứu về chủ đề này trong tương lai.

**Từ khóa:** *Giáo dục mầm non, Scopus, STEAM, trắc lượng thư mục, tổng quan.*

## 1. Introduction

STEAM refers to the integration of science, technology, engineering, arts, and mathematics in connection with STEM (Kang, 2019; Marín-Marín et al., 2021). STEAM education is an integrated approach encompassing the STEM fields, closely tied to real-world applications. It is emerging as a significant trend in global education and commences as early as young children (Aktürk & Demircan, 2017; DeJarnette, 2018; Ng et al., 2022). Recent studies have indicated that STEAM education fosters the engaging participation of young children, providing an interesting avenue for enhancing their attitudes toward the learning process. It contributes to the improvement of creativity, participation, problem-solving skills, teamwork, and communication abilities in this age group (Bayles et al., 2021; Mengmeng et al., 2019; Tee, 2022). However, researchers have also highlighted issues related to STEAM education at the early childhood education level. Early childhood teachers often exhibit lower confidence than their counterparts in primary education when implementing this approach, as they receive less specialized training in the fields. Consequently, they tend to undervalue their abilities and demonstrate a tendency toward negative attitudes regarding STEAM activities or projects (Jamil et al., 2018; Monkeviciene et al., 2020). For instance, they often allocate limited instructional time to the specific content of STEAM for young children (DeJarnette, 2018).

Although there have been numerous literature reviews on this topic (Johnston et al., 2022; Ng et al., 2022; Rodrigues-Silva & Alsina, 2023; Wahyuningsih et al., 2020), there is still a lack of research exploring the complex structure of studies and collaboration within this domain. To address this limitation, a recent bibliometric study by Su and Yang (2023) analyzed the relevant literature using the Web of Science database. However, the authors searched solely through the "keywords" field of articles, utilizing only the terms "STEM or STEAM." Restricting the search field and overlooking keyword groups related to various aspects of STEAM might lead to the omission of crucial studies.

To address the constraints mentioned earlier, this study utilizes a quantitative bibliometric analysis approach to examine scientific literature on STEAM

in early childhood education (ECE) within the Scopus database spanning from 2013 to 2023. The selection of Scopus, a large and reputable database, is expected to provide a comprehensive overview of trends, prominent authors, journals, and countries in early STEAM education. Through data analysis, the study not only aims to provide a comprehensive view of research on early STEAM education but also suggests potential avenues for further advancement in this area. To its end, this study raises three research questions as follows:

- (1) What are the global research trends on STEAM in ECE over the 2013-2023 decade?
- (2) Which countries, publication sources, authors, and studies are leading in this field?
- (3) What are primary themes on STEAM in ECE during the decade?

## 2. Methodology

The current study employs the bibliometric analysis method, a quantitative systematic research approach introduced by Pritchard (1969). This method has been proven to be a powerful tool for measuring and assessing the impact of scientific publications. With its flexibility and high precision, bibliometric analysis has found extensive use across a multitude of research disciplines, particularly in educational science research (Bui et al., 2023; Ho et al., 2020). The utilization of bibliometric analysis in the current study will assist the researchers in obtaining accurate data to address the research questions. Additionally, it will help identify significant research trends on STEAM in ECE.

### 2.1. Data collection

The authors extracted the dataset from the Scopus database on December 21, 2023. Scopus is a reputable and widely-used data source in the social sciences, holding a larger volume of information compared to other databases such as Web of Science or Dimensions (Chadegani et al., 2013; Harzing & Alakangas, 2016). Selecting Scopus enables the study to access a more extensive dataset for analysis, ensuring the representativeness of the data. To search for information on Scopus, the researchers utilized keywords that are key terms related to the research topic, such as STEAM ("scienc\*" AND "technolog\*" AND "engine\*" AND "art\*" AND

"math\*") OR ("STEAM")) (Marín-Marín et al., 2021) and early childhood education ("early childhood" OR "young child\*" OR "early years" OR "preschool" OR "preschool" OR "kindergarten" OR "pre-k\*" OR "infant education" OR "nursery school" OR "pre-primary" OR "pre-elementary") (Su & Yang, 2023), and combined them with Boolean operators to create a search query. The query was used to search across title, keywords, and abstract fields to avoid missing relevant studies. The search technique is visualized in Table 1 below:

**Table 1. Search technique**

No	Search queries	Results
1	TS-AB-KEY ("scienc*" AND "technolog*" AND "engine*" AND "art*" AND "math*") OR ("STEAM")	204.826
2	TS-AB-KEY ("early childhood" OR "young child*" OR "early years" OR "preschool" OR "preschool" OR "kindergarten" OR "pre-k*" OR "infant education" OR "nursery school" OR "pre-primary" OR "pre-elementary")	1.218.275
3	1 AND 2	412

As in Table 1, the keywords applied during the search process are referenced to fields such as title, abstract, and document keywords. By combining keyword strings 1 and 2, a total of 412 records are displayed. After narrowing down the data to the field of social sciences and specific document types such as articles, conference papers, and book chapters, 135 records were selected and downloaded to the authors' computer in Excel format. Subsequently, the data were manually synchronized by cross-referencing information from titles, abstracts, and even the entire text to ensure the relevance of the research content. Inappropriate documents were reviewed and removed from the dataset. Finally, supplementary information from external sources afforded the data synchronization process more comprehensive. After all, only 129 documents were valid for analysis.

**2.2. Data analysis**

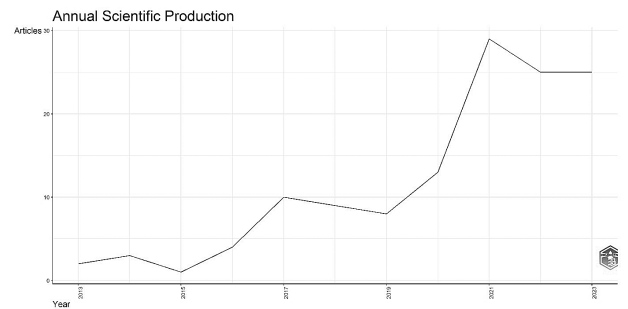
To address the research inquiries, this study utilized analytical methodologies, encompassing descriptive statistics and co-occurrence keyword network analysis. Descriptive statistics facilitated the quantification of yearly publication counts, as well as the number of publications and citations

from individual countries and journals. Additionally, these statistics enabled the determination of pertinent indices. Co-occurrence keyword network analysis aimed to identify key research content and trends. The authors utilized VOS Viewer software and R software with the Biblioshiny application package for real-time data analysis. The extraction, selection, and analysis of tables and figures were set in order to address the research questions.

**3. Results and discussion**

**3.1. Research trends on STEAM in early childhood education**

The results of analyzing the number of publications on STEAM in ECE from 2013-2023 from the dataset of 129 articles are visualized in Figure 1 below:



**Figure 1. Publication on STEAM in ECE over the 2013-2023 decade**

The figure shows an increasing trend over the decade, particularly evident in two phases:

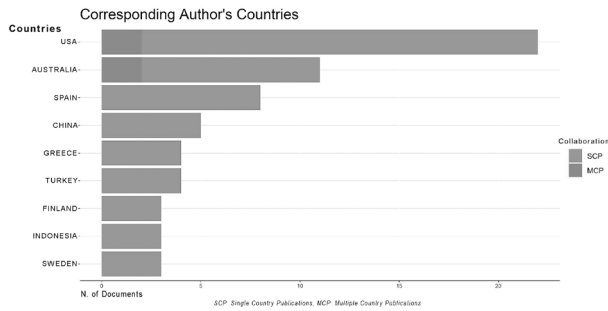
**2013-2018:** This period reflects a time when the topic of STEAM in ECE received relatively less attention. Over the five years, there were 29 publications, accounting for less than a quarter of the total publications over the ten years. The annual publication count ranged from 2 to 10, peaking in 2017.

**2019-2023:** In this phase, research on STEAM in ECE experienced a significant surge, starting with eight publications in 2019, increasing to 12 in 2020, and reaching 29 in 2021. In 2022-2023, there was a slight decrease, maintaining 25 publications for both years. During this 5-year period, the total number of publications reached 100, nearly 3.5 times higher than the 2013-2018 phase.

**3.2. Most impactful countries, journals, authors, and articles**

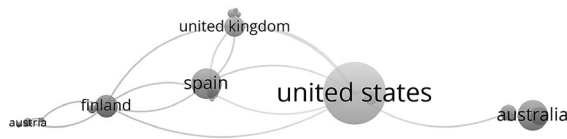
A total of 40 countries are listed in this dataset. The publication counts of leading countries based

on corresponding authors is presented in Figure 2. The publication count was based on corresponding authors to ensure accuracy, as many researchers have authors from the same country listed together, and the number of authors for each article varies. Additionally, determining the number of articles based on corresponding authors makes it easy to identify the percentage of articles from each country within the total dataset.



**Figure 2. Top nine productive countries according to corresponding authors**

Figure 2 depicts the top nine productive countries, including the USA, Australia, Spain, China, Greece, Turkey, Finland, Indonesia, and Sweden. Among them, the USA leads with 24 publications, accounting for nearly one-fifth of the total. Following are Australia,

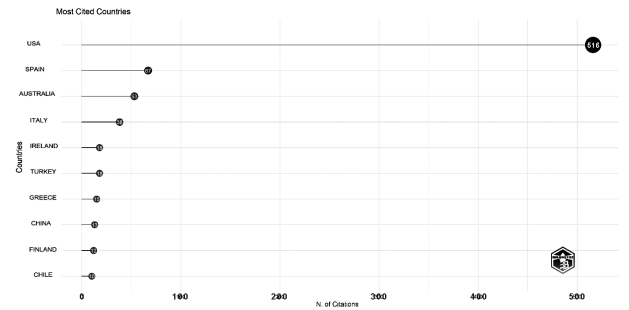


**Figure 4a. Collaboration network by countries**

Figure 4a indicates six groups of countries collaborating on research and publishing on STEAM in ECE, represented by six different colors. Among them, the USA is the country with the highest level of collaboration with the number of articles, links, and total link strength of 38-7-9, followed by Spain (13-5-5), Australia (13-2-2), Finland (8-7-7), and UK (7-7-8).

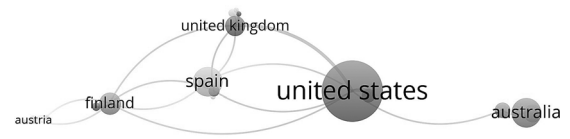
Figure 4b shows that the USA and the UK have the most substantial research and publications on

Spain, and China, with 11, 8, and 5 publications, respectively. Other countries like Greece and Turkey have four publications each, while Finland, Indonesia, and Sweden all have three publications.



**Figure 3. Top ten most cited countries**

Figure 3 below visualizes the countries receiving the most citations on STEAM in ECE. It can be observed that the USA has the most significant impact, with a total of 516 citations, more than eight times higher than the second-ranked country, Spain. The USA also has the highest average citations per article at 23.5. Following are Spain, Australia, Italy, Ireland, Turkey, Greece, China, Finland, and Chile, all with total citations ranging from 10 to 67. Chile and Finland are the last in the top ten countries, with citations of 10 and 12, respectively.



**Figure 4b. Overlay visualization of collaboration by countries**

STEAM in ECE. In contrast, Austria and Vietnam are emerging countries in this field, with publications emerging since the year 2022.

Table 2 provides details regarding the primary sources exerting the most substantial influence on publications related to STEAM in ECE between 2013 and 2023. The h-index, total number of citations, the number of publications during the period, and the year of the first publication on this topic are described to illustrate the influence of each Journal.

**Table 2. Top five influential publication sources**

Rank	Publication sources	Type	H-index	Total citations	Number of publications	Year of first publication
1	Early Childhood Education Journal	Journal	4	135	4	2018
2	Embedding STEAM in Early Childhood Education and Care	Book	3	20	11	2021
3	International Journal of Technology and Design Education	Journal	2	101	2	2018
4	European Early Childhood Education Research Journal	Journal	2	78	2	2015
5	Cultural Studies of Science Education	Journal	2	33	2	2018

It can be observed that the leading publication sources are "Early Childhood Education Journal" and "Embedding STEAM in Early Childhood Education and Care." While "Early Childhood Education Journal" leads in the H index (h-index = 4) and total citations (135), the book "Embedding STEAM in Early

Childhood Education and Care" has the highest number of publications at 11 with the second-highest H index (h-index = 3). The other journals contribute from 2 to 5 publications with total citations ranging from 33 to 101, and all have an h-index of 2, indicating that at least two articles have been cited at least two times.

**Table 3. Top four influencing authors**

Rank	Author	H_index	Total citations	Number of publications	Year of first publications
1	Sullivan A	3	131	3	2017
2	Bers MU	2	124	2	2017
3	Macdonald A	2	39	3	2020
4	Huser C	2	39	3	2020

Table 3 provides information about the leading authors in publications on STEAM in ECE in the recent decade. It can be seen that Sullivan-A author is at the forefront with an h-index of 3, a total of 131 citations, three articles published during the timeframe spanning from 2017 to 2023, and a starting publication year of

2017. Bers-MU author has an h-index of 2 and is the second-most prolific author with 124 articles, starting publications in 2017 as well. Additionally, other authors such as Clements DH, Danaia L, and Huser C all have an h-index of 2, contributing significantly with a notable number of articles and citations.

**Table 4. Top five most impactful documents**

Rank	Authors, Year, Journal, (quality ranking)	DOI	Total citations	Citations per year	Normalize citation ratio
1	Sullivan & Bers, 2018, Int J Technol Des Educ (Q1)	10.1007/s10798-017-9397-0	95	13.57	2.96
2	Sung et al., 2017, Tech Knowl Learn (Q1)	10.1007/s10758-017-9328-x	82	10.25	5.16
3	Bagiati et al., 2015, Eur Early Child Educ Res J (Q1)	10.1080/1350293X.2014.991099	75	7.5	1
4	Thuneberg et al., 2018, Think Skills Creat (Q1)	10.1016/j.tsc.2018.07.003	67	9.57	2.09
5	Jamil et al., 2018, Early Child Educ J (Q1)	10.1007/s10643-017-0875-5	51	7.29	1.59

Table 4 presents the top 5 articles with the most impact in publications on STEAM in ECE during the 2013-2023 decade. Each article's impact was gauged through metrics such as the number of citations, average citations per year, and normalized citation ratio. The normalized citation ratio is the number of citations of an article compared to the average citations of articles in the same field and publication year, helping assess the particular influence of a research work compared to others in the same field.

The article (Sullivan & Bers, 2018) has the highest impact, with a total of 95 citations, the highest average citations per year (13.57), and a normalized citation ratio of 2.96. The article centers on the design and evaluation of the Playmaker program, an early childhood education initiative aimed at instructing children in robotics and programming. The results indicate that children successfully grasp programming concepts, but teachers face challenges in connecting with the school community through robots (Sullivan & Bers, 2018). It is worth noting that this article was also listed by Su and Yang (2023) as the fourth most impactful article in STEM education for preschoolers.

The second-highest total citations (82) go to the article "Introducing Computational Thinking to Young Learners: Practicing Computational Perspectives Through Embodiment in Mathematics Education" (Sung et al., 2017), published in the *Journal Tech Knowledge Learn* (Q1). This article also has an impressive average citation per year (10.25) and a normalized citation ratio of 5.16, indicating a significant impact compared to other articles in the same field and publication year. The research focuses on utilizing robots to support mathematics education for preschoolers (Sung et al., 2017).

The remaining articles in the top impactful group presented in Table 4 all have normalized citation ratios of more than 1, indicating that the impact of these articles is higher than the average of articles in the same field and publication year. The total citations for each article are all very high, ranging from 32 to 75 citations, and most of these articles are published in reputable journals and hold high rankings in the field of education.

### 3.3. Main contents of the STEAM in ECE over the 2013-2023 decade

We employed co-occurrence keyword analysis to identify crucial research subtopics within a specific research area by examining the intersection and connections between keywords. A total of 466 keywords, provided by authors and journals, were extracted from articles/chapters in the dataset.

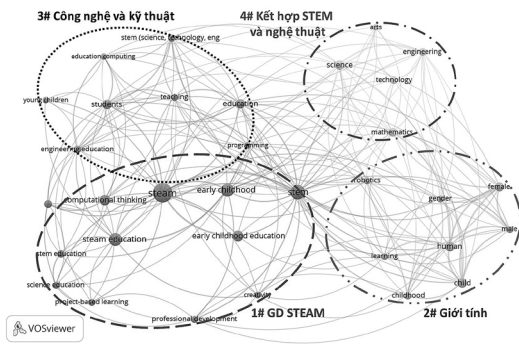
Figure 5a displays the most frequently used keywords in the dataset, with "STEAM" occurring 34 times, followed by "STEM" at 20 times, and "STEAM education" at 16 times. The keyword map reveals four distinct topic clusters that emerged from research during the specified period, represented by different color clusters:

The red cluster, which focused on fundamental issues of STEAM education, prominently featured the keyword "STEAM" and encompassed 12 keywords. With a total of 24 connections and a connection strength of 54, this cluster addressed various aspects related to STEAM in ECE, including project-based learning, computational thinking, professional development for teachers, STEM education, and creativity. Additionally, it demonstrated significant connections with the central keywords of the other clusters.

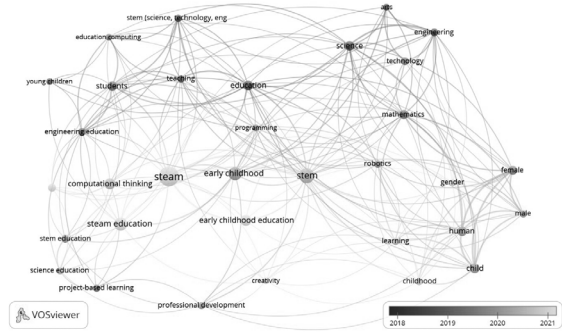
Articles/book chapters within the green cluster emphasized human aspects within STEAM education, particularly gender equality, with "Human" as the central keyword. This cluster comprised 8 keywords and had 15 connections with a connection strength of 17. Gender-related issues were linked not only to STEM education but also to professional development and creativity, with a specific emphasis on robotics.

The blue cluster, centered around the keyword "students," contained 8 keywords and exhibited 17 connections with a connection strength of 37. Research within this cluster predominantly focused on STEAM in ECE, with a notable emphasis on technical and technological education aspects.

Finally, the yellow cluster, featuring "science" as the central keyword, included 6 keywords and had 20 connections with a connection strength of 41. Studies within this cluster emphasized the integration of scientific, technological, engineering, mathematical, and artistic components, showing strong connections with keywords from clusters 2 (gender) and 3 (technology and engineering).



**Figures 5a. Co-occurrence network of 34 keywords appearing at least four times**



**Figures 5b. Overlay visualization of co-occurrence network of 34 keywords**

Figures 5a and 5b depict a network of 34 keywords appearing at least four times. While issues related to STEM education and the combination of STEM and arts garnered attention before 2018, topics such as professional development for teachers, project-based learning in STEAM education, and gender-related issues gained prominence later, around 2019 to 2020. Notably, computational thinking, creativity, and the learning process of children in STEAM education are subjects of increased interest in research from 2021 onwards.

Compared to the study by Su and Yang (2023), this research has explored more diverse and comprehensive research topic clusters related to STEAM in ECE, especially within the last decade.

**4. Conclusion and recommendations**

Based on the analysis of the research directory on STEAM in ECE, derived from a dataset comprising 129 articles in the Scopus category over the 2013-2023 decade, the following conclusions can be drawn:

The number of publications on this topic has rapidly increased over the decade, especially from 2019 onwards. This reflects growing interest and awareness of the role of STEAM education for the demographic. The USA leads in the number of publications and citations in the field of STEAM in ECE, demonstrating not only quantity but also a significant influence on the international research community. Journals such as *ECE Journal* and *Embedding STEAM in ECE* and *Care* hold the most influence, with authors Sullivan A and Bers MU having the most significant impact in terms of authorship and articles.

The research also explored key themes in research on STEAM in ECE over the decade, including (1) core aspects of STEAM in ECE, (2) gender equality in STEAM education, (3) technology and engineering education, and (4) integrating STEM in early childhood education. There was a distinct emphasis on elements such as project-based learning, computational thinking, gender equality, technology, engineering education, and science education.

Based on the research findings, the authors propose several recommendations for future research on STEAM in ECE as follows:

Firstly, this study utilized a quantitative content analysis method to explore global trends in STEAM in ECE. While this method has advantages in identifying trends and prominent research themes, it has limitations, such as dependence on the database, lack of reflection on the quality of publications, and an inability to assess the real impact of STEAM education on early childhood. Therefore, future research should integrate supplementary methods, such as content analysis, to delve deeper into the current state of research on STEAM in ECE.

Secondly, the study revealed that the USA, Australia, and Spain lead in the research and application of STEAM in ECE. However, there is a scarcity of research on STEAM in ECE in developing countries, especially in the Asian region. Hence, future research endeavors should delve into the challenges and opportunities entailed in implementing STEAM in ECE across these nations. Furthermore, it would be crucial to evaluate the cultural, values, and contextual factors that are distinct to each of these countries.



Thirdly, the research identified four main research clusters in STEAM in ECE, with one cluster focusing on human factors in STEAM education with an emphasis on gender equality. However, keyword analysis also indicates a lack of research on other human factors in STEAM education, such as cultural diversity, equal opportunity, and community engagement. Accordingly, future research should concentrate on these aspects to ensure that STEAM in ECE is a comprehensive system that reflects modern society's total values and needs.

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