Chapter 6

A Bibliometric Overview of Early Childhood Science Education[1]

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Abstract

The purpose of this study is to examine research trends in the field of science education in early childhood. In line with this purpose, 669 articles published between 2013 and 2023 in the Web of Science (WoS) database were analyzed according to year of publication, journal publication and citation counts, H-index impact, as well as publishing authors, countries, and institutions. During the review process, the R programming language and its bibliometrix package were used for data analysis and visualization of the analysis results. Based on the analysis of the obtained data, it was determined that the year with the highest number of publications between 2013 and 2023 was 2022 (116). Furthermore, when the studies related to science education in early childhood published over the last ten years were examined, it was found that studies published after 2017 constituted 75.81% of all publications. The countries with the highest number of publications were the United States (N = 210), Spain (N = 83), and Türkiye (N = 67). When the journals publishing in the WoS database were examined in terms of H-index impact, it was observed that the International Journal of Science Education ranked first (H = 15), followed by the Early Childhood Education Journal (H = 14), and the Journal of Research in Science Teaching (H = 13). Based on the analysis results, it can be stated that interest in science education during early childhood has been increasing at a significant pace. In this context, recommendations for future studies have been provided within the scope of current global trends.

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1. Introduction

The National Science Teachers Association (NSTA) states that early childhood science education constitutes a fundamental element in the lifelong progression of science learning, explaining that children's curiosity about exploring their environments and their enjoyment of this sense of discovery can be enhanced through science-related learning experiences acquired during early childhood (NSTA, 2014). Science education implemented during this period supports children's observation, inquiry, and problem-solving skills, which serve as prerequisites for their future success in STEM (science, technology, engineering, and mathematics) fields (Aronin & Floyd, 2013). Indeed, due to the rapid technological developments and scientific innovation occurring today, the necessity of preparing children for future life with competencies related to STEM fields has become a topic of global concern. It is emphasized that the nature of the future workforce will differ from the present and that, for individuals to be productive in their later lives, they must be prepared for these changes and possess competencies in STEM fields (Tytler, 2020). Within this framework of global necessity and in line with the critical importance of early childhood science education, it is observed that research in this field has been increasing at a significant pace.

Early childhood science education is regarded not only as an important factor for children's future academic achievement but also as a component that shapes their worldview and promotes various higher-order thinking skills. Indeed, in today's world, which is characterized by scientific complexities, there is an increasing emphasis on the necessity of science education to help children develop the skills and understandings they will need (Sriwarthini et al., 2023; Trundle & Saçkes, 2021). This increase is attributed to the growing interest in supporting children's engagement with natural phenomena (Larimore, 2020). In addition, the learning outcomes achieved through experiences within the scope of early childhood science education contribute to the growing interest in science education. For example, it is stated that science education implemented during this period supports children's innate curiosity and scientific inquiry skills, as it enables them to interact with their environment and the world in a critical and questioning manner (O'connor et al., 2021; Raven & Wenner, 2023). Among these learning outcomes, developments related to critical thinking skills are also considered noteworthy. Through science activities that encourage participation in scientific explorations, children are guided to ask questions, make predictions, and analyze results, thereby gaining the opportunity to examine knowledge critically (O'connor et al., 2021; Uludağ & Erkan, 2023). Moreover, the skills developed through the experiences

provided by early childhood science education are regarded as predictors of future success in STEM fields, and therefore represent a significant factor influencing children's future academic achievement (Chen et al., 2024). In addition to the positive effects of children's science-related experiences on cognitive development, these experiences also support their social-emotional development. For instance, out-of-school science learning environments such as science centers enhance children's motivation and willingness to learn (Aldemir & Kermani, 2017; Eshach & Fried, 2005; Uludağ & Erkan, 2023). In line with the increasing interest in science education during early childhood, the aim of this study is to determine the research trends in the field of preschool science education. In accordance with this aim, the research questions addressed in this study are presented below:

1. How are the studies distributed across the years?
2. What are the research trends of the journals?
3. What are the research trends of the authors?
4. What are the research trends across countries?
5. What are the research trends by subject areas?

2. Method

Bibliometric analysis (mapping) is the process of visually representing and analyzing the literature in a specific research field. This method enables researchers to better understand bibliometric indicators such as publication volume, citation counts, keywords, and international collaborations within a given area. In this study, the Bibliometrix and Biblioshiny open-source libraries (Aria & Cuccurullo, 2017), implemented in the R programming environment, were utilized to analyze data related to studies in early childhood science education. While Bibliometrix facilitates the management of scientific literature analysis and data processing, Biblioshiny allows users to perform bibliometric and visual analyses through an interactive web interface. Within this framework, a bibliometric analysis was conducted on 669 studies published in the Web of Science database in the field of early childhood science education. Accordingly, by employing performance analysis and scientific mapping techniques, the study aimed to describe research trends in the field of early childhood science education.

2.1. Data Set

The data set of the study consists of 669 articles authored by 1,505 researchers, published in the Web of Science database between 2013 and

2023. For the purpose of searching the Web of Science database, the following parameters were used: "(Preschool and science) or (Early Childhood and science) or (toddler and science) or (Preschoolers and science) or (Young Children and science) (Topic) and 2013 or 2014 or 2015 or 2016 or 2017 or 2018 or 2019 or 2020 or 2021 or 2022 or 2023 (Publication Years) and Article or Early Access or Review Article (Document Types) and Education Educational Research (Web of Science Categories) and 6.11 Education & Educational". The obtained data were organized by the researchers in the Bibliometrix library of the R programming language and prepared for analysis. Information regarding the stages of the research process is presented in Figure 1.

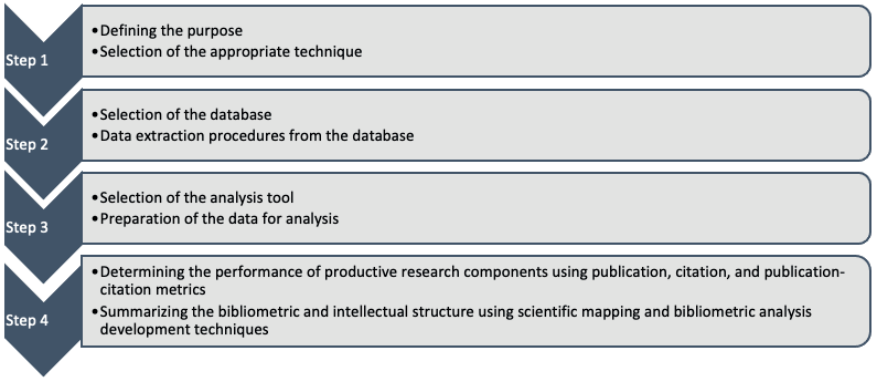

Figure 1. Bibliometric Analysis Procedure (Zupic & Čater, 2015)

3. Findings

In this section, the findings obtained from the bibliometric analysis are presented sequentially in line with the research questions. The first research question examines the distribution of studies on science education in early childhood by year. The analysis results are presented in Table 1.

Table 1. Distribution of Studies by Year

Year	Number of Article	%
2023	71	9,22
2022	116	15,06
2021	95	12,33
2020	87	11,29
2019	85	11,03
2018	67	8,7
2017	63	8,18
2016	47	6,1
2015	36	4,67
2014	59	7,66
2013	44	5,71

When Table 1 is examined, it is noteworthy that the highest number of studies on science education in early childhood over the past ten years was published in 2022 (n = 116). In addition, studies published after 2017 constitute 75.81% of all publications. The annual average citation scores are presented in Figure 2. As can be seen in Figure 2, the highest annual average number of citations occurred in 2013.

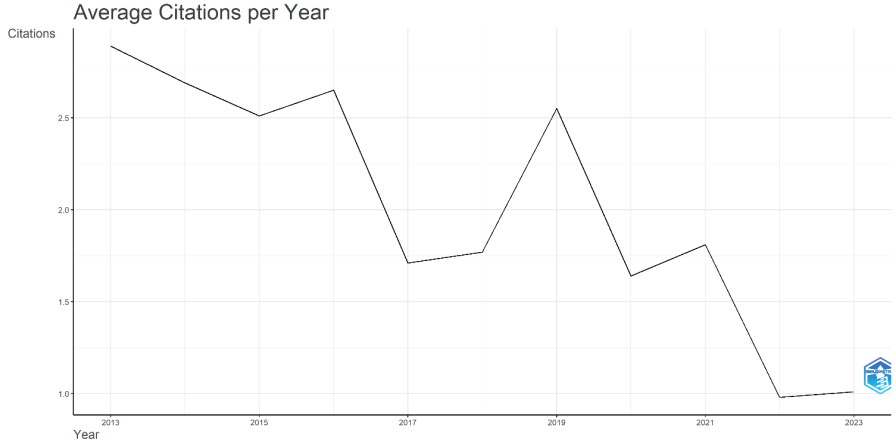

Figure 2. Average Number of Citations by Year

Within the scope of the second research question, the research trends of journals were examined. In this context, the journals indexed in the Web of

Science database were analyzed in terms of their number of publications, citation counts in the field of science education, and H-index values in order to determine their research trends in early childhood science education. Based on the findings obtained, it can be stated that the journals with the highest number of publications in the Web of Science database are, respectively, International Journal of Science Education (N = 48), Research in Science Education (N = 44), and Early Childhood Education Journal (N = 36). The findings regarding journals publishing in the field of early childhood science education in the Web of Science database are presented in Figure 3.

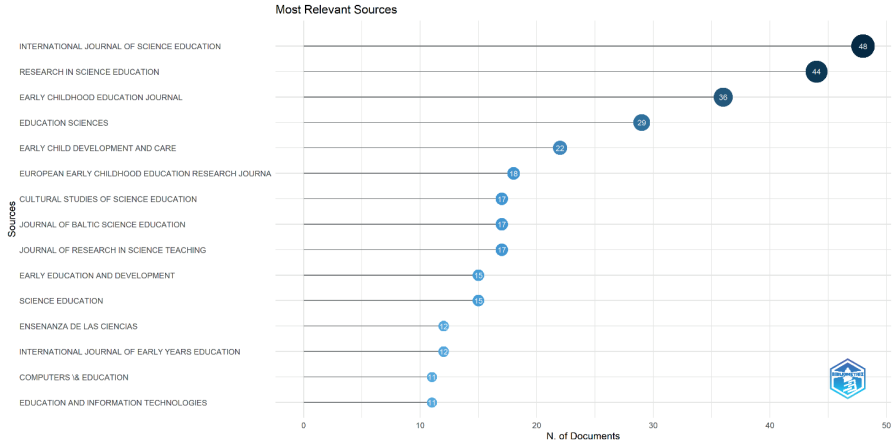

Figure 3. Journals publishing in the field of early childhood science education

One of the findings from the analysis conducted to determine the research trends of journals in the field of early childhood science education relates to the citation counts of the journals. Since citation counts form the basis of scientific productivity for journals, they can be considered an indicator that the studies are original, significant, and contribute to the relevant field. In this context, when the citation counts of journals publishing on early childhood science education in the Web of Science database are examined, it can be stated that the journal receiving the highest number of citations between 2013 and 2023 is the International Journal of Science Education (N = 1,282). The citation counts of the other journals are presented in Figure 4.

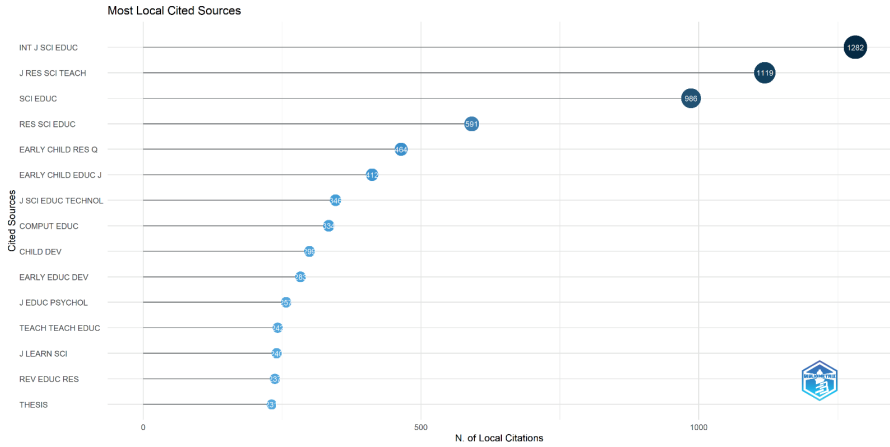

Figure 4. Citation Counts of the Most Cited Journals

When the journals in which the researchers published were examined in terms of impact factors, it was observed that the journals with the highest H-index values are the International Journal of Science Education (H = 15), Early Childhood Education Journal (H = 14), and Journal of Research in Science Teaching (H = 13). The impact factors of the journals are presented in Figure 5.

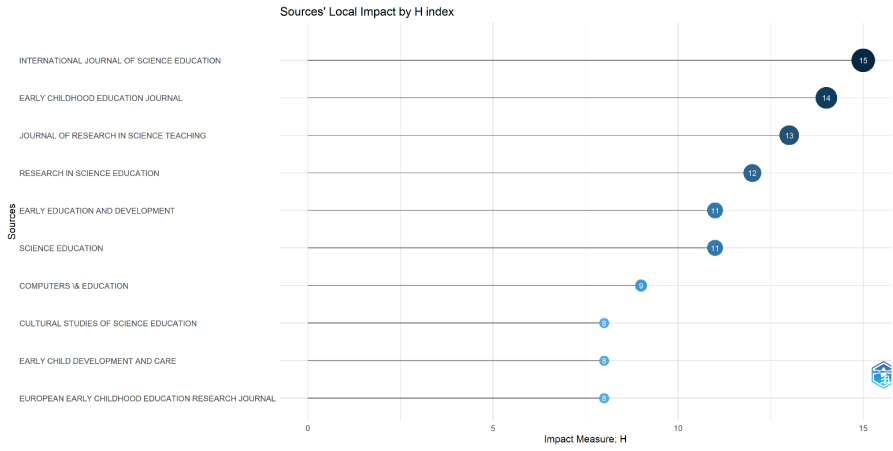

Figure 5. Impact Factors of Journals (H-Index)

One of the fundamental elements of the scientific community is the researchers and their perspectives. Determining the research trends of researchers in a given field is important for understanding the development

of that field, identifying future research topics, and understanding how scientific knowledge progresses. In this context, the third research question focuses on the research trends of authors. To examine these trends in the field of early childhood science education, the most prolific researchers publishing in the Web of Science database between 2013 and 2023 were identified, and their production trends over time, countries, impact factors, and journals of publication were analyzed. In this context, it was found that Marilyn Fleer from Monash University, Australia, is the most prolific researcher in the field of early childhood science education in the Web of Science database. The most prolific researchers and their publication counts are presented in Table 2.

Table 2. Most Prolific Researchers

Authors	**Articles**
Fleer M.	19
Bers M.	15
Dewitt J.	9
Kalogiannakis M.	9
Ravanis K.	9
Sackes M.	9
Thulin S.	9
Archer L.	8
Areljung S.	8
Fragkiadaki G.	8

The H-index is an international metric used to monitor the performance of scientists and evaluate their productivity. As a decisive criterion in determining academic achievements and assessing researchers, the H-index holds significant importance for both academics and the articles they produce. Based on searches in the Web of Science database, among researchers publishing in the field of early childhood science education, Marina Bers, with an H-index of 9 and 789 citations, and Marilyn Fleer, with an H-index of 9 and 211 citations, can be considered the most influential researchers in terms of impact in this field (WoS database). Information on the H-index, G-index, M-index, and total citation counts of the researchers is presented in Table 3.

Table 3. Researchers' Impact Factors and Citation Counts

Authors	H-index	G-index	M-index	Total Citations
Bers M.	9	14	0,818	789
Fleer M.	9	14	0,818	211
Archer L.	7	7	0,636	645
Dewitt J.	7	8	0,636	649
Ravanis K.	7	9	0,636	112
Kalogiannakis M.	6	9	0,75	140
Sackes M.	6	9	0,545	94
Fragkiadaki G.	5	7	0,556	53
Osborne J.	5	5	0,455	532
Papadakis S.	5	7	0,833	102

To determine research trends, based on the results of the Three-Factor Analysis examining the co-occurrence network of the most prolific authors' keywords and the journals in which they published, it was found that most authors used the keywords "early childhood," "science," and "early science education." The network map showing the relationships among the used keywords, authors, and published journals is presented in Figure 6.

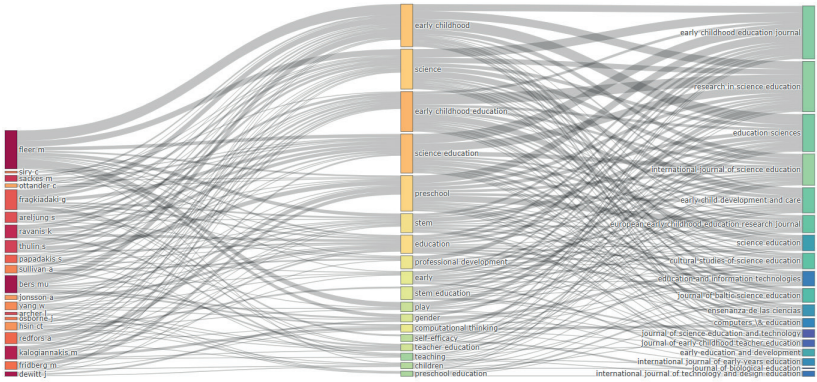

Figure 6. Author–Keyword–Journal Network

Within the scope of the fourth research question, which was developed to determine researchers' research trends in the field of early childhood science education, the global distribution of researchers was examined. Determining

this distribution is expected to provide data on scientific contributions, global trend identification, international collaboration, and similar aspects for experts working in the field.

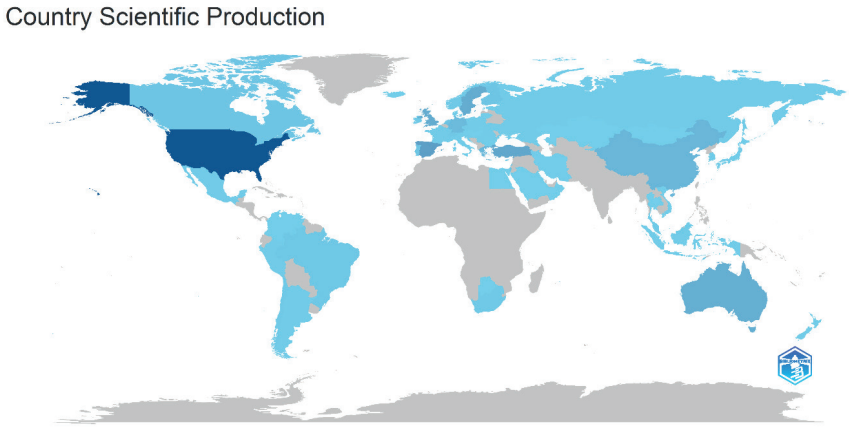

Figure 7. Distribution Map of Publications by Country

Based on the obtained findings, it can be stated that, on a global scale, the authors publishing on early childhood science education in the Web of Science database contributed most to the literature from the United States (N = 210), Spain (N = 83), and Türkiye (N = 67). The publication counts by country are presented in Table 4.

Table 4. Publication Counts by Country

Country	Articles	SCP	MCP	SCP %	MCP %
USA	210	195	15	92.8	7.1
Spain	83	78	5	93.9	6
Turkey	67	57	10	85	14.9
United Kingdom	60	47	13	78.3	21.6
Sweden	58	55	3	94.8	5.1
Australia	49	44	5	89.75	10.25
Greece	32	27	5	84.3	15.6
China	31	18	13	58	41.9
Germany	25	20	5	80	20
Netherlands	12	10	2	83,3	16.6

Another finding obtained from the analysis relates to whether the authors adopt a "single-authored" or "multi-authored" approach. In this context, examining the percentage distributions shows that the countries with the highest tendency toward single-authored publications are Sweden (f = 94.8), Spain (f = 93.9), and the United States (f = 92.8). The countries with the highest tendency toward multi-authored publications are China (f = 41.9), the United Kingdom (f = 21.6), and Germany (f = 20). The percentage distributions of publication types in terms of authorship are presented in Table 4, and the corresponding visualization of the findings is provided in Figure 8.

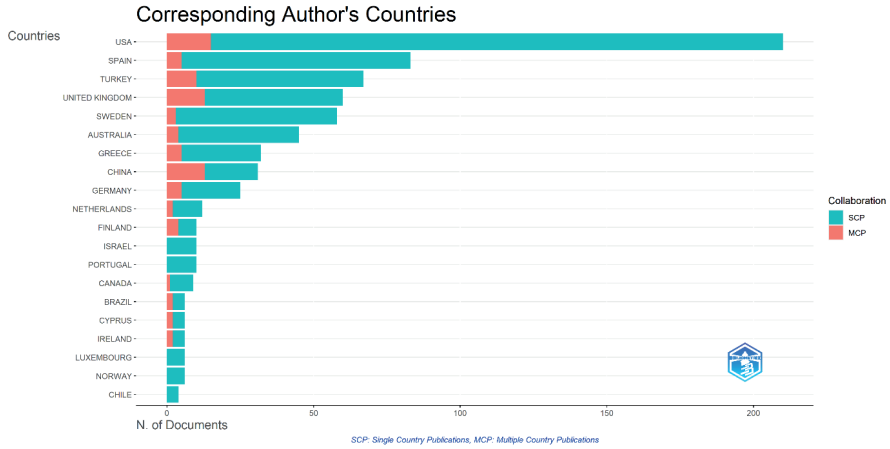

Figure 8. Publication–Authorship Type Trends by Country

When research in the field of early childhood science education is examined at the country level, it can be stated that the United States, Spain, and Türkiye lead in terms of scientific productivity and hold a significant position in the global literature. However, to evaluate countries' research trends and their impact on the literature, it is important to consider not only the number of publications but also the citation counts these publications have received. Citation counts are significant in terms of the widespread impact of studies, as they indicate how frequently a study is referenced by other researchers in the literature. In this context, an analysis of the total and average citation counts by country shows that the United States (N = 3,400), the United Kingdom (N = 1,369), and Australia (N = 509) are the countries receiving the highest number of citations. The total and average citation counts by country are presented in Table 5.

Table 5. Citation Counts by Country

Country	TC	Average Article Citations
Usa	3400	16.2
UK	1369	22.8
Australia	509	11.3
Sweden	444	7.7
Turkey	382	5.7
Spain	381	4.6
Germany	348	13.9
Greece	324	10.1
Israel	296	29.6
Netherlands	198	16.5

Although the importance of citation counts in determining countries' research trends and impact on the literature is well recognized, it is also believed that countries' institutional structures and publication productivity play a significant role in the development of research fields and their global dissemination. In this context, when universities publishing in the field of early childhood science education are examined, it can be stated that Monash University (N = 49), Tufts University (N = 39), and Penn State University (N = 37) are the most prolific institutions. The publication counts of the universities are presented in Table 6.

Table 6. Number of Publications by University

Affiliation	Country	Articles
Monash University	Australia	49
Tufts University	United States	39
Penn State University	United States	37
Kristianstad University	Sweden	26
Umea University	Sweden	23
University Crete	Greece	23
University Patras	Greece	20
Indiana University	United States	19
Aristotle University Thessaloniki	Greece	18
Linkoping University	Sweden	18

Within the scope of the fifth research question, research trends were examined according to subject areas. In this context, to determine the trends of studies on early childhood science education by subject area, the keywords used in publications indexed in the Web of Science database were analyzed using word cloud, word tree, and word network techniques. When the studies published in the Web of Science database between 2013 and 2023 are examined, it can be stated that the most frequently used keywords are "science" (f = 13), "education" (f = 6), and "students" (f = 6). The percentages and frequencies of keyword usage are presented in the word tree in Figure 9, while the word cloud of the keywords used is presented in Figure 10.

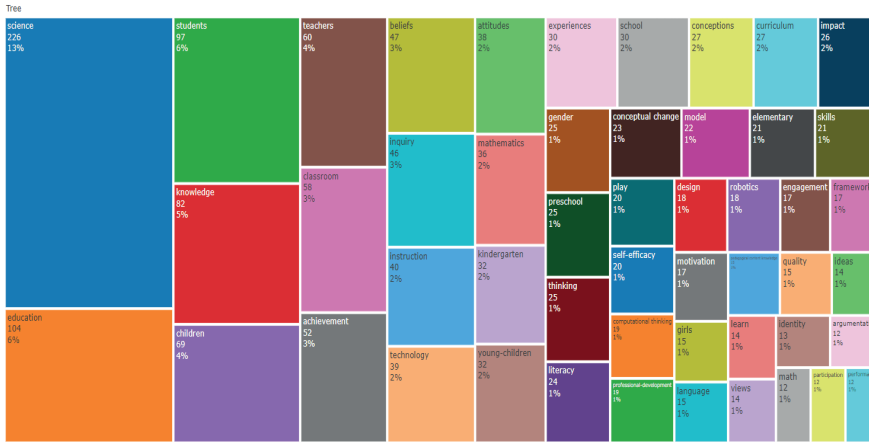

Figure 9. Keyword Tree

Figure 10. Keyword Cloud

Although the number of keywords used to determine research trends indicates the topics on which studies in early childhood science education are focused, the relationships among the keywords are important for understanding the context in which the literature is structured. For this purpose, a network analysis was conducted on the keywords used in the studies. Based on the findings from the keyword network analysis, the relationships of the prominent keywords "science," "education," and "students" with other keywords are presented in Figure 11.

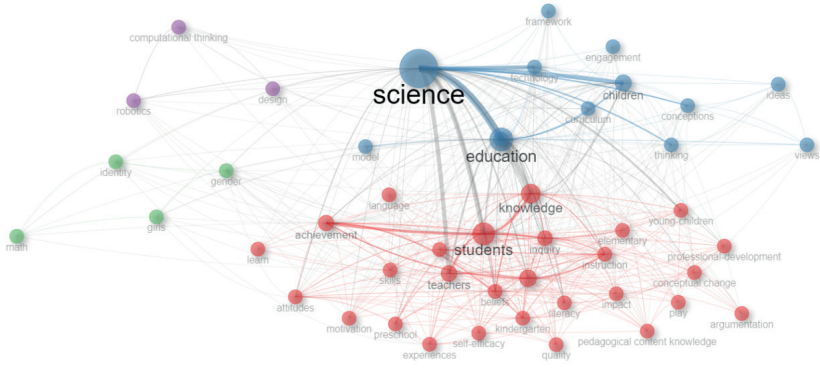

Figure 11. Keyword Network

In this context, when the research areas are examined, it can be stated that while science education is at the center, concepts such as "teacher education," "self-efficacy," "achievement," "skills," "argumentation," and "technology" also represent important topics studied within the field of early childhood science education.

4. Results

This study aimed to examine research trends in early childhood science education between 2013 and 2023. To this end, 669 studies published in the Web of Science (WoS) database were analyzed using bibliometric methods. During the review process, performance analysis and scientific mapping techniques were employed to describe the research trends addressed by the study. The analysis results indicate a global increase in studies conducted in this field. Specifically, studies published after 2017 account for 75.81% of the total publications, suggesting a growing interest in early childhood science education. In terms of journal research trends, the analysis revealed that the International Journal of Science Education, Research in Science Education, and Early Childhood Education Journal were the most prolific journals publishing studies on early childhood science education. The H-index values of these journals reflect their scientific impact within the field.

Regarding researcher trends, bibliometric analysis identified Marilyn Fleer and Marina Bers as influential scholars in early childhood science education based on their publication and citation counts and associated indices. When examining trends by country, the United States, Spain, and Turkey emerged as the leading contributors to the relevant literature. To evaluate the global impact of national research trends, total and average citation counts for each country were analyzed. According to these results, the United States, the United Kingdom, and Australia received the highest number of citations. Furthermore, to investigate the influence of institutional contributions on research trends, bibliometric analyses were conducted on university publication counts. This analysis showed that Monash University (Australia), Tufts University (USA), and Penn State University (USA) were the top-publishing institutions. These findings suggest a high level of interest in early childhood science education, particularly in the United States, and indicate substantial contributions to the literature from these countries. Analysis of research trends by topic revealed that science education remains central, with dimensions such as teacher education, self-efficacy, achievement, skills, argumentation, and technology emerging as prominent subfields.

The rapid evolution and integration of digital technologies have prompted changes in the nature of education and educational content, necessitating strategies and policies for technology integration (Timotheou et al., 2023). Moreover, the accelerated adoption of artificial intelligence (AI) is increasingly influencing educational processes and environments. For instance, the launch of ChatGPT in 2022 is recognized as having a significant impact on the field of education (Barbu & Sbughea, 2024). Globally, there is a concerted effort to integrate AI into education (Park & Kwon, 2024), which affects educational planning and curriculum design. In this context, it can be stated that research on AI in education has gained considerable momentum. Future bibliometric studies may consider AI adoption periods when constructing datasets. Comparing results from such studies with the findings of the present research could provide insights into the effects of AI on early childhood science education and emerging research directions.

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Declaration

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