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Trends Use of Technology Research for Early Childhood Education: A Bibliometric & Biblioshiny Analysis (1971-2024)

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Abstract: This study aims to analyze research trends in the use of technology in early childhood education using the Scopus Database. Employing the PRISMA method, the author identified 172 final documents, analyzed through the R Program and VOSviewer. The analysis reveals that research in this area commenced in 1971, with a fivefold increase in publications over the past 20 years. The year 2020 marked the peak with an h-index of 7 and 11 publications (6.39%). Illinois State University emerged as the leading institution with 11 articles (6.39%). The United States is the most productive country, contributing 28 articles (16.28%) and 786 citations (26.85%). Susan Edwards from Australian Catholic University is the most prolific author, achieving an h-index of 5, 253 citations (8.64%), and 5 publications (2.90%). The International Journal of Technology and Design Education is the top source, with 292 citations (9.97%) and 11 publications (6.39%). The document by Blackwell et al. (2014) received the highest citations at 210 (9.02%). The study identified 54 keywords across 7 clusters, recommending "Digital Competence," "Self-directed learning," and "Participatory design" for future research in this field.

Keywords: Bibliometric; Biblioshiny; Early Childhood; Technology

Introduction

Education is very important and is the main character in forming competent individuals (Ningsih et al., 2024; Saidov et al., 2023; Zafrullah, Bakti, et al., 2023). Education that invites active participation and involvement of each individual is able to create a dynamic and inspiring learning environment (Könings et al., 2021; Ramadhani et al., 2024; Venketsamy et al., 2021). Education is a solid foundation in nation building, because through education, the young generation is prepared to face future challenges with knowledge, skills and strong moral values. Thus, education must be made a top priority in every aspect of life, in order to create a society that is intelligent, critical and highly competitive on the global stage (Agriani, 2023; Hakim et al., 2023; Zafrullah, Fitriani, et al., 2023). One thing that is experiencing development in the field of education is schools.

Schools have an irreplaceable role in people's lives because they are not only a place to gain knowledge, but also a place to shape character and critical thinking skills in the younger generation (Sulastri, 2023; Suyanto et al., 2024; Zafrullah, Hardi, et al., 2024). With various programs and curricula that are carefully prepared, the school is able to produce intelligent and creative individuals. More than that, a conducive learning environment at school creates an atmosphere that allows students to develop optimally, both in terms of academics and personality (Wahyuni et al., 2024; Zynuddin et al., 2023). The existence of schools is not only important in providing a quality workforce, but

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also as the main foundation in forming character and morality which will have a positive impact on the progress and prosperity of the nation (Oktavianty, 2024; Zafrullah, Zetriuslita, et al., 2024). Thus, it can be said that schools are the main pillar in creating superior and competent human resources, which will ultimately contribute to development and improvement of the country's socio-economic conditions. One of the schools that is the center of attention is a school for early childhood education.

Schools for early childhood education have a very important role in forming the foundations of children's development from an early age (Clark et al., 2024; Moomaw, 2024; Zafrullah, Sultan, et al., 2024). This school makes the learning process more structured and oriented towards the developmental needs of early childhood, both in terms of cognitive, social, emotional and motor skills (Alexiadou et al., 2024; Florit et al., 2024; Kang et al., 2024). Through various methods and approaches that are appropriate to the characteristics of early childhood development, this school creates a fun and stimulating learning environment, which encourages children to actively learn and explore (Ata-Akturk et al., 2023; Bucur et al., 2023; Geletu, 2023; Mokwunye et al., 2023; Zafrullah, Suyanto, et al., 2023). Apart from that, this school also has an important role in helping children acquire social skills and the ability to interact with the surrounding environment. Thus, it can be concluded that schools for early childhood education are a very vital foundation in shaping children's potential and personality, as well as opening up opportunities for optimal growth and development at the next stage in their lives (Duncan et al., 2023; Saracho, 2023). Often schools in early childhood use various things for learning, one of which is using technology.

Technology is one aspect that has significantly changed the way we learn, interact and work in everyday life (Iivari et al., 2020; Zafrullah, Ibrahim, et al., 2024; Zafrullah et al., 2021). Technological advances have opened the door to innovation in various fields, including education (Oke et al., 2020; Waizenegger et al., 2020). In early childhood schools, technology has been widely implemented to enhance children's learning experiences (Eliasson et al., 2023; Meng et al., 2023). This is very important because it allows them to engage in learning that is more interactive, interesting and relevant to their daily lives. By using software and hardware specifically designed for early childhood education, such as interactive learning applications, educational games, and multimedia devices, technology has become a very effective means of facilitating a fun and interesting learning process for children (Ritonga et al., 2023). In addition, technology also opens up access to a variety of educational resources, including videos, images and interactive stories, which can help develop creativity, cognitive skills and problem-solving abilities in young children (Arabiat et al., 2023; Lu et al., 2023). Thus, the existence of technology for early childhood is a great opportunity to improve the quality of their education and help them reach their full potential from an early age.

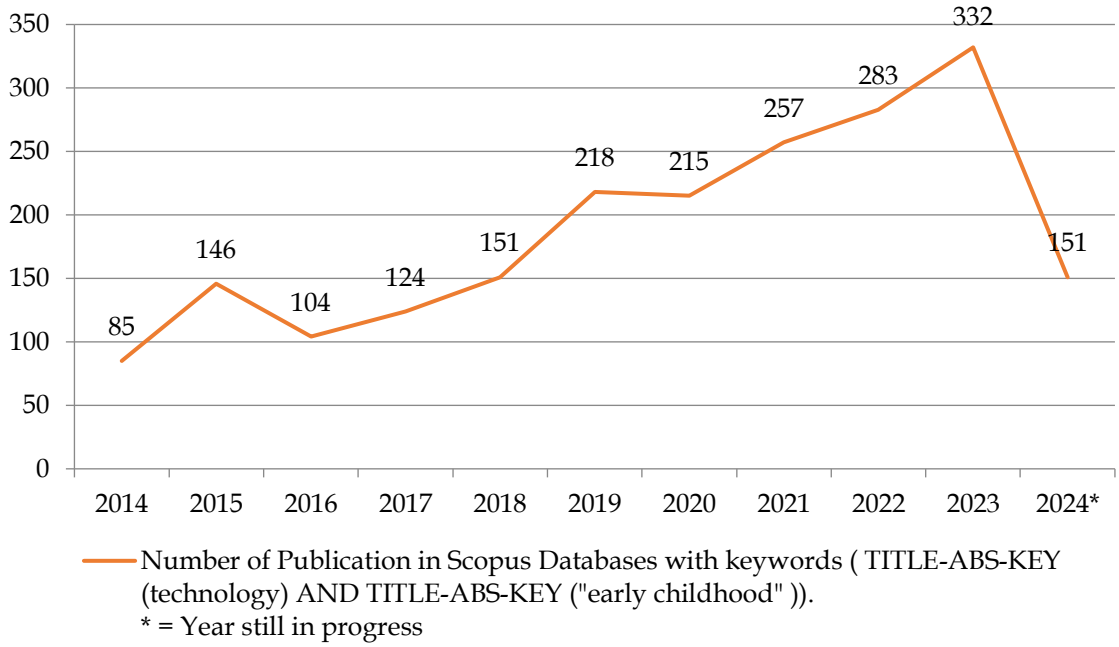

Figure 1. Number of Publications in the Last 10 Years on the Scopus Database (Source: www.scopus.com, data accessed on June 12, 2024)

Early childhood education sets the stage for lifelong learning and development, making it crucial to understand and optimize the role of technology in this foundational phase. Technology enhances engagement and interactivity in learning, which is especially important for young children who benefit from immersive and stimulating educational experiences. echnological tools can support cognitive and social development by providing diverse, interactive resources that cater to different learning styles and developmental needs. Bibliometric analysis of existing research helps identify gaps, trends, and effective practices, guiding future innovations and policies in early childhood education.

The rapid use of technology in various aspects of life has encouraged researchers to actively conduct research related to its application in the field of early childhood education. This research aims to understand in more depth how technology can be optimally used in the learning process of early childhood, as well as its impact on their overall development. From the Scopus Database in Figure 1, the graph shows the rapid development of research on technology in the field of early childhood education. Even though there was a slight decline in 2016 and 2020, overall publications experienced a very rapid increase. So this makes the author interested in carrying out bibliometric analysis which aims to see research trends and novelties in the field of technology for early childhood education.

Method

This research aims to analyze publication trends and the level of novelty contained in the field of technology in early childhood education through a bibliometric analysis approach. Bibliometric analysis is a research method that measures and analyzes information contained in published scientific works, such as journals and conferences, using statistics and computational techniques (Hinojo-Lucena et al., 2019; Kumar et al., 2023; Ülker et al., 2023; Ulwiyah, 2023; Zafrullah & Ramadhani, 2024). With this approach, researchers can identify development patterns, research trends, and relationships between concepts and research in this field (Anand et al., 2021; Zou et al., 2022). Bibliometric analysis can be expected to provide deep insight into the dynamics of research and technological developments in early childhood education. With a better understanding of publication trends and degree of novelty, educational researchers and practitioners can direct their efforts to develop new innovations that are relevant and effective in improving the overall quality of early childhood education. Before carrying out the analysis, researchers searched documents using predetermined keywords, and used the PRISMA method as a way to eliminate documents (Figure 1).

At the identification stage, researchers used the keywords listed in Figure 1 and searched the Scopus database. Researchers chose the Scopus database because of its extensive and recognized reputation for providing high-quality scientific literature and its comprehensive coverage in various scientific disciplines. From this search, 497 documents were obtained. Next, at the screening stage, researchers limited the search results to only articles that were in the topic "Social Sciences" and published in English, thus eliminating 317 documents and leaving 180 documents for the eligibility stage. At this stage, researchers carried out manual analysis of all documents by reading their respective abstracts, which resulted in the elimination of 8 additional documents and left 172 documents that survived to the included stage.

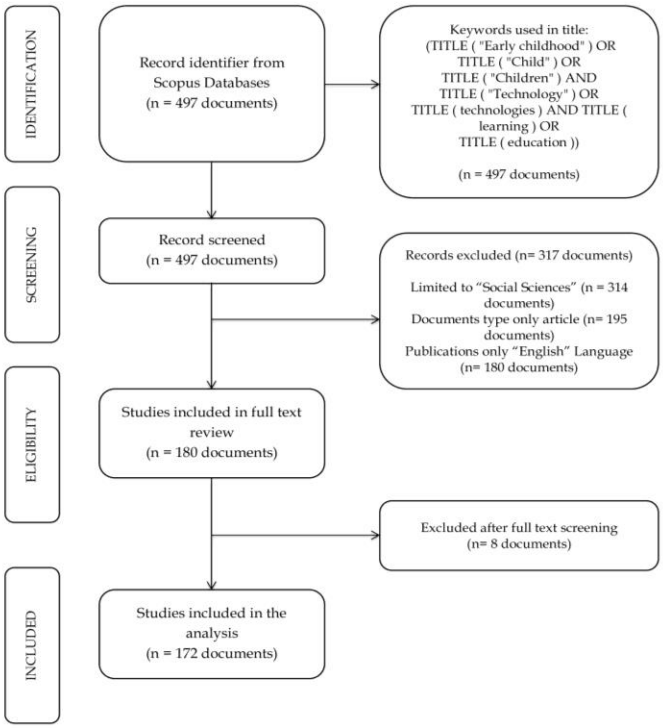

Figure 2. PRISMA Flow to Eliminate Unnecessary Documents in the Field of Technology in Early Childhood Education, Flowchart adapted by: Page et al., (2021) (Data Analysis in June 12, 2024)

After getting the final number of documents, the author continued with bibliometric analysis using Vosviewer and the R Program. The use of these two applications is due to Vosviewer's ability to intuitively visualize bibliometric networks and the R Program for in-depth statistical analysis, both of which are very helpful in identifying research trends and collaboration in the field of technology in early childhood education.

Result and Discussion

Researchers conducted several analyzes to map bibliometric results in the field of technology use in the field of early childhood education, namely by Main Information, Publications and Citations Trends, Productive Affiliation, Productive Country, Productive Author, Productive Source, Document with the Highest Citations, Group Focus on Keywords, and Keyword Novelty.

Main Information

Main Information in R Program the Biblioshiny aims to provide an overview and basic statistical summary of the bibliometric dataset being analyzed. This feature allows researchers to obtain essential initial information such as the number of documents, number of authors, number of citations, as well as distribution of publications per year. In addition, Main Information also provides data on the most frequently used sources, main affiliated institutions, and collaboration patterns between authors. In this way, researchers can quickly understand the general characteristics of the literature being studied and identify key trends and patterns in the field of technology in early childhood education.

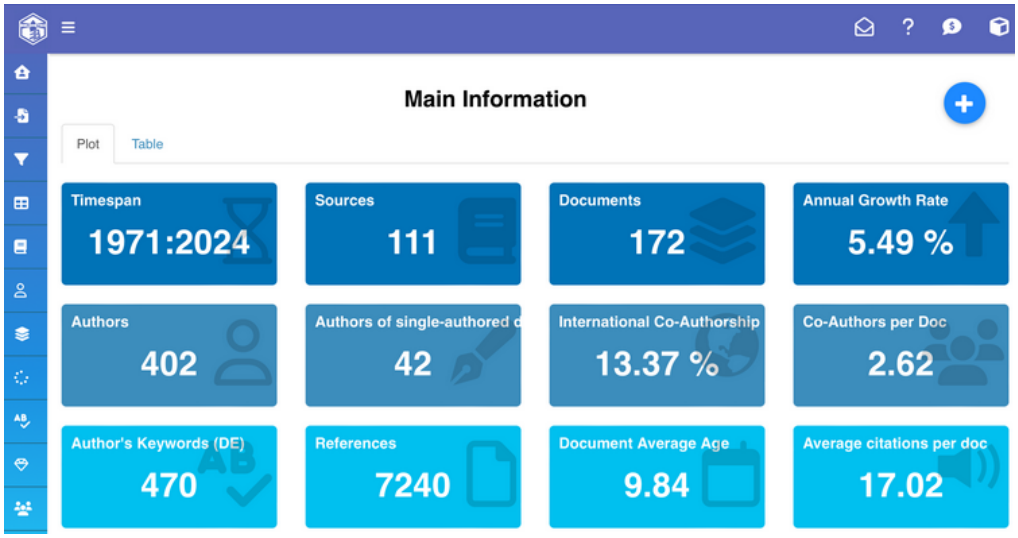

Figure 3. Main Information Regarding General Statistics on the Results of Biblioshiny Analysis of Research on the Use of Technology in Early Childhood Education

Analysis shows that research in the field of technology in early childhood education includes 111 sources consisting of journals. There were 172 documents analyzed, with an annual growth rate of 5.49%. The average age of documents is 9.84 years, with an average of 17.02 citations per document, and the total number of references used is 7240. This data shows that research in this field has a fairly high citation rate and extensive references, indicating that relevance and significant contribution to academic literature.

In terms of authors, there were 402 contributing authors, of which 42 were authors of single documents. A total of 46 documents were written by single authors, indicating a number of important individual contributions to this field. Additionally, there were an average of 2.62 authors per document, and 13.37% of documents involved international collaboration, indicating significant global collaboration and diversity in technology-related research in early childhood education.

Publications and Citations Trends

Publication trends and citation trends are analyzed to understand the development, influence and distribution patterns of research in the field of technology in early childhood education.

This research started from 1971 to 2024. In the first 23 years, the number of publications was only 27(15.69%) publications. However, from 2005 to 2024 or the last 20 years, the number of publications increased rapidly to 145(84.30%) publications or an increase of 5 times. This is due to increasing awareness of the importance of technology in early childhood education, the rapid development of information and communication technology, as well as greater policy support and investment in the education sector. In addition, international collaboration and knowledge exchange through conferences and scientific publications contributed to a significant increase in the amount of research during that period.

Analysis of publication data shows that there were several blank years without publications, especially in the periods 1972-1978 and 1980-1988. After this period,

the number of publications began to increase gradually. A significant increase can be seen starting in 2022 with 13(7.55%) publications, and reaching a peak in 2023 with 23(13.37%) publications. 2024 also shows a high number with 17(9.88%) publications. This increase reflects the growing interest and attention paid to research in technology in early childhood education in recent years.

The analysis shows that the most productive years in terms of the number of publications and citations in technology research in early childhood education occurred after 2005. In particular, 2008 and 2009 were the starting points for significant spikes with 5(2.90%) and 12(6.97%) published documents. In 2008, the number of citations reached 293(10.01%) citations with an h-index of 5, indicating that several documents from that year were very influential. This surge continued in 2009 with a total of 289(9.87%) citations and an h-index of 7, indicating a significant increase in research influence. The period after 2009 shows a consistent increasing trend, with another peak occurring in 2015 where there were 6(3.48%) documents published, getting 340(11.61%) citations, and an h-index of 4. 2020 also recorded high productivity with 11(6.39%) documents and 144(4.91%) citations, as well as an h-index of 7. In addition, 2023 recorded the highest number of documents with 23(13.37%) publications, although the citations were relatively low 24(0.81%) with an h-index of 3, indicating that many new publications may not have received significant citation attention. This data shows increasing interest and recognition of the importance of technology in early childhood education, especially in the last two decades.

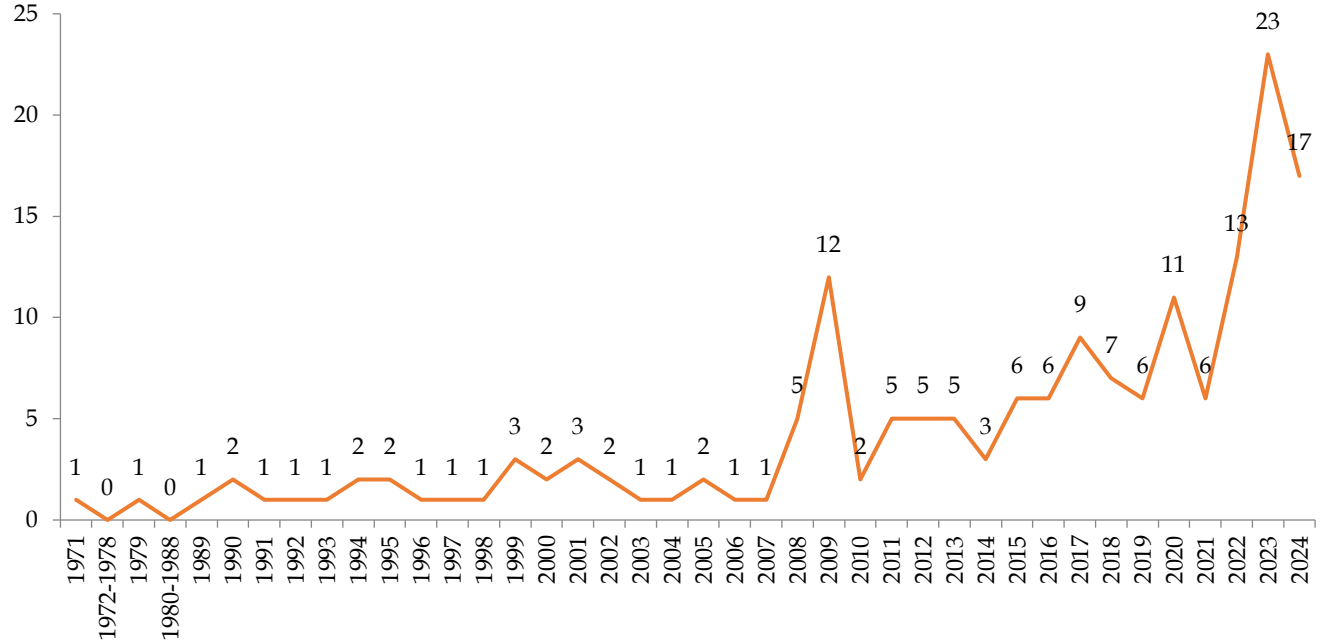

Figure 4. Publication Trends from 1971 to 2024 on Research Concerning the Use of Technology in Early Childhood Education

Table 1. Citation Trends from 1971 to 2024 in Research Regarding Trends in the Use of Technology in Early Childhood Education

Years	Total of Documents[a]	Total of Citations[a]	Number Documents of Citations[a] (%)	h-index[a]	Total Citation/Article[b]	Citable Years[b]
1971	1(0.58)	16(0.54)	1(0.75)	1	16	54
1972-1978	-	-	-	-	-	-
1979	1(0.58)	2(0.06)	1(0.75)	1	2	46
1980-1988	-	-	-	-	-	-
1989	1(0.58)	9(0.30)	1(0.75)	1	9	36
1990	2(1.16)	20(0.68)	2(1.50)	2	10	35
1991	1(0.58)	3(0.10)	1(0.75)	1	3	34
1992	1(0.58)	8(0.27)	1(0.75)	1	8	33
1993	1(0.58)	11(0.37)	1(0.75)	1	11	32

Years	Total of Documents[a]	Total of Citations[a]	Number Documents of Citations[a (%)]	h-index[a]	Total Citation/Article[b]	Citable Years[b]
1994	2(1.16)	19(0.64)	2(1.50)	2	9.5	31
1995	2(1.16)	13(0.44)	2(1.50)	2	6.5	30
1996	1(0.58)	15(0.51)	1(0.75)	1	15	29
1997	1(0.58)	4(0.13)	1(0.75)	1	4	28
1998	1(0.58)	5(0.17)	1(0.75)	1	5	27
1999	3(1.74)	54(1.84)	2(1.50)	2	18	26
2000	2(1.16)	73(2.49)	2(1.50)	2	36.5	25
2001	3(1.74)	51(1.74)	2(1.50)	2	17	24
2002	2(1.16)	6(0.20)	2(1.50)	2	3	23
2003	1(0.58)	45(1.53)	1(0.75)	1	45	22
2004	1(0.58)	38(1.29)	1(0.75)	1	38	21
2005	2(1.16)	42(1.43)	2(1.50)	2	21	20
2006	1(0.58)	25(0.85)	1(0.75)	1	25	19
2007	1(0.58)	31(1.05)	1(0.75)	1	31	18
2008	5(2.90)	293(10.01)	5(3.75)	5	58.6	17
2009	12(6.97)	289(9.87)	11(8.27)	7	24.08	16
2010	2(1.16)	161(5.50)	2(1.50)	2	80.5	15
2011	5(2.90)	152(5.19)	4(3.00)	3	30.4	14
2012	5(2.90)	48(1.63)	5(3.75)	4	9.6	13
2013	5(2.90)	37(1.26)	4(3.00)	3	7.4	12
2014	3(1.74)	312(10.65)	2(1.50)	2	104	11
2015	6(3.48)	340(11.61)	6(4.51)	4	56.67	10
2016	6(3.48)	196(6.69)	6(4.51)	4	32.67	9
2017	9(5.23)	131(4.47)	8(6.01)	7	14.56	8
2018	7(4.06)	113(3.86)	7(5.26)	5	16.14	7
2019	6(3.48)	37(1.26)	5(3.75)	5	6.17	6
2020	11(6.39)	144(4.91)	11(8.27)	7	13.09	5
2021	6(3.48)	33(1.12)	5(3.75)	3	5.5	4
2022	13(7.55)	118(4.03)	12(9.02)	5	09.08	3
2023	23(13.37)	24(0.81)	8(6.01)	3	01.04	2
2024	17(9.88)	9(0.30)	3(2.25)	1	0.53	1

a = Data Source by RIS files interpreted using Publish or Perish 8 & Microsoft Excel
b = Data Source by R Program, data accessed by June 12, 2024

The Most Productive Affiliations

The analysis by productive affiliation aims to identify the institutions most active in research in the field of early childhood education technology. This helps understand patterns of academic collaboration and determine centers of excellence and significant contributions in the field.

From the analysis of productive affiliates, Illinois State University was ranked first with the highest number of publications, namely 11(6.39%) articles. This shows that the institution is a significant research center in the field of early childhood education technology. The University of Gothenburg in Sweden and the University of Girona in Spain followed in second and third place, with 9(5.23%) and 8(4.65%) articles respectively. Macquarie University in Australia was ranked fourth with 7(4.06%) articles, followed by Ataturk University and the University of Stirling which each had 6(3.48%) articles.

Overall, institutions from Europe dominate the list of most productive affiliates, with 8 out of 15 universities originating from the continent. This shows Europe's important role in research and development of early childhood education technology. In addition, significant contributions have also come from institutions in Asia, Australia and North America, indicating that research in this field is global in nature with many centers of excellence spread across various continents. All of these affiliates contribute substantially to the literature and knowledge in early childhood education technology, reflecting widespread collaboration and innovation throughout the world.

The second graph shows several university groups involved in early childhood education technology collaborations, where each group is represented by circles of varying sizes. Universities with large circles, such as Monash University, University of Jyväskylä, and University of Koblenz-Landau, show that they have an important and significant role in this collaboration network. Each group reflected on their contribution to the field, with various universities from various countries involved, showing that this collaboration is international and involves many parties who play an active role in the development of technology for early childhood education.

Table 2. The 15 Most Productive Affiliates in Research Regarding the Use of Technology in Early Childhood Education

Affiliation	City	Country	Continent	Number of Articles
Illinois State University	Normal, Illinois	United States	North America	11(6.39)
University of Gothenburg	Gothenburg	Sweden	Europe	9(5.23)
University of Girona	Girona	Spain	Europe	8(4.65)
Macquarie University	Sydney	Australia	Australia	7(4.06)
Ataturk University	Erzurum	Turkey	Asia	6(3.48)
University of Stirling	Stirling	United Kingdom	Europe	6(3.48)
University of East Anglia	Norwich	United Kingdom	Europe	5(2.90)
University of Eastern Finland	Joensuu, Kuopio	Finland	Europe	5(2.90)
University of Nottingham	Nottingham	United Kingdom	Europe	5(2.90)
Hashemite University	Zarqa	Jordan	Asia	4(2.32)
London Metropolitan University	London	United Kingdom	Europe	4(2.32)
Monash University	Melbourne	Australia	Australia	4(2.32)
Queensland University of Technology	Brisbane	Australia	Australia	4(2.32)
Universiti Tun Hussein Onn	Batu Pahat	Malaysia	Asia	4(2.32)
University of Jyväskylä	Jyväskylä	Finland	Europe	4(2.32)

Description: Data Source by R Program, data accessed by June 12, 2024

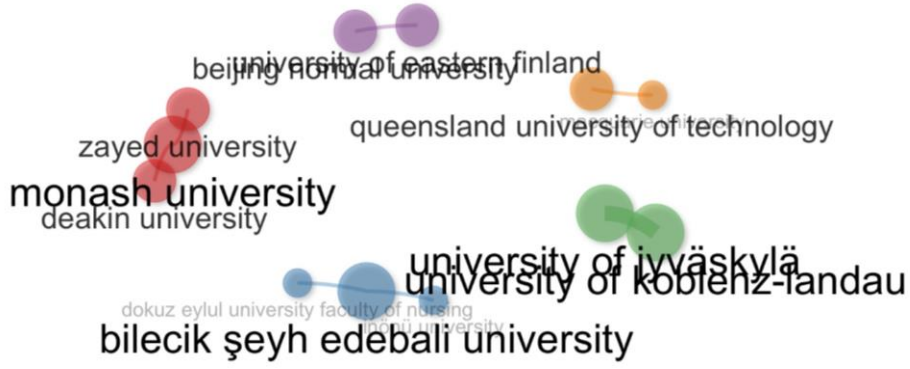

Figure 5. Collaboration Between Countries in Research Regarding the Use of Technology in Early Childhood Education. Analysis using R Program

The Most Productive Country

Collaboration between countries is analyzed with the aim of understanding international cooperation patterns and collective contributions in early childhood education technology research. The analysis shows that the United States is the most productive country in early childhood education technology research, with 28 articles accounting for 16.28% of total publications and obtaining 786 citations or 26.85% of total citations. England is in second place with 15 articles (8.72%) and 488 citations (16.67%), followed by Australia with 10 articles (5.81%) and 238 citations (8.13%). China, although producing 7 articles (4.07%), only received 17 citations (0.58%), indicating relatively lower influence compared to other countries.

Overall, continental Europe dominates research contributions with countries such as the United Kingdom, Norway, Sweden, Finland, and Greece collectively contributing a large number of articles and citations. In addition, countries from Asia such as China, Turkey, Indonesia, Jordan, Malaysia and Saudi Arabia also contributed significantly, although with a lower number of articles and citations. This diversity of contributions from across continents reflects the global nature of research in early childhood education technology, with different countries playing a role in developing knowledge and practice in this area.

Table 3. The Top 15 Productive Affiliate with the Highest Number of Articles in the Field of Technology Use in Early Childhood Education

Country	Continent	Number of Articles	%	Total Citation	%
United States	North America	28	16.28	786	26.85
United Kingdom	Europe	15	8.72	488	16.67
Australia	Australia	10	5.81	238	8.13
China	Asia	7	4.07	17	0.58
Turkey	Asia	6	3.49	80	2.73
Canada	North America	5	2.91	78	2.66
Norway	Europe	5	2.91	46	1.57
Sweden	Europe	5	2.91	43	1.47
Finland	Europe	3	1.74	75	2.56
Greece	Europe	3	1.74	52	1.78
Indonesia	Asia	3	1.74	-	-
Jordan	Asia	3	1.74	45	1.54
Malaysia	Asia	3	1.74	-	-
New Zealand	Australia	3	1.74	16	0.55
Saudi Arabia	Asia	3	1.74	13	0.44

Description: Data Source by R Program, data accessed by June 12, 2024

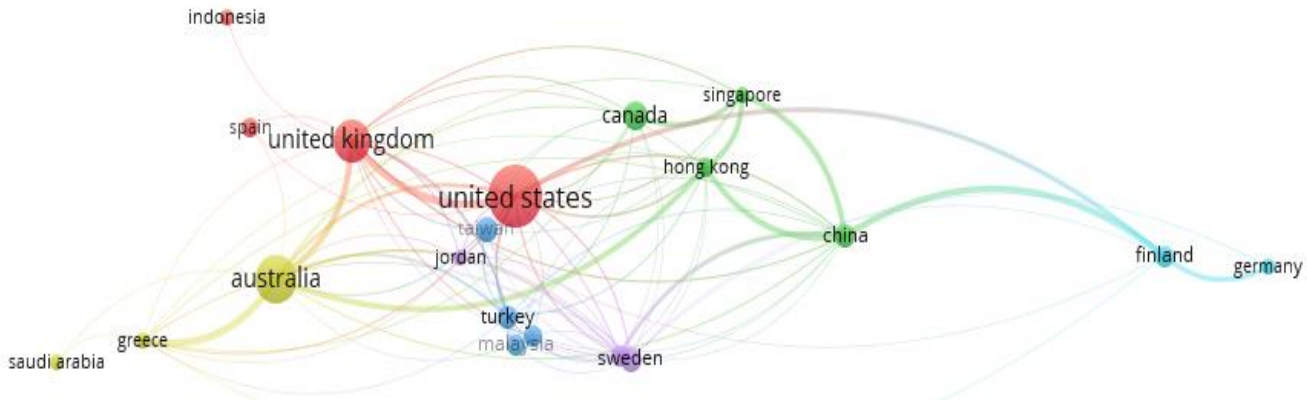

Figure 6. Collaboration Between Countries in the World (at least 2 papers) in the Field of Technology use in Early Childhood Education. Source by VOSviewer

The graph displayed shows collaborative relationships between countries in the field of technology for early childhood education, with the largest and most prominent circles being the United States, the United Kingdom, and Australia, which shows that these three countries have a high level of collaboration with many other countries in the field. the. This relationship is marked by lines connecting various countries, indicating a strong and extensive cooperation network. These graphic highlights the key roles of these three countries in leading and contributing to technological developments in early childhood education at the global level.

The Most Productive Authors

The author conducted a productive author analysis which aims to identify the most active and influential researchers in the field of early childhood education technology. By knowing who productive researchers are, the academic community can more easily access important works and build stronger collaborative networks.

Table 4. The Top 15 The Most Productive Authors in the Use of Technology in Early Childhood Education

Author Name	Affiliation	Country	h[a]	TC[b]	NP[c]
Susan Edwards	Australian Catholic University	Australia	5	253(8.64)	5(2.90)
Marilyn Fleer	Monash University	Australia	3	76(2.59)	3(1.74)
Howard P. Parette	Illinois State University	United States	3	50(1.70)	3(1.74)
Lynette Schaverien	University of Technology	Australia	3	38(1.29)	3(1.74)
Margaret Bearlin	University of Canberra	Australia	2	23(0.78)	2(1.16)
Craig Blum	Illinois State University	United States	2	20(0.68)	2(1.16)
Mark Cosgrove	University of Technology	Australia	2	20(0.68)	2(1.16)
Martina Endepohls-Ulpe	University of Koblenz-Landau	Germany	2	70(2.39)	2(1.16)
Karen Guldberg	University of Birmingham	United Kingdom	2	62(2.11)	2(1.16)
Fay Hadley	Macquarie University	Australia	2	34(1.16)	2(1.16)
Tim Hardy	University of Canberra	Australia	2	23(0.78)	2(1.16)
Ching-Ting Hsin	National Tsing Hua University	Taiwan	2	106(3.62)	2(1.16)
Annie Xinyun Hu	The Education University of Hong Kong	Hong Kong	2	13(0.44)	3(1.74)
Mihyun Kim	Yonsei University	South Korea	2	11(0.37)	2(1.16)
Mi Song Kim	University of Western Ontario	Canada	2	31(1.05)	2(1.16)

a: h-index, b: Total of Citations, c: Number of Publications
Description: Data Source by R Program, data accessed by June 12, 2024

Analysis of productive authors shows that Susan Edwards from Australian Catholic University in Australia is the most productive author with an h-index of 5, total citations of 253(8.64%), and 5(2.90%) publications. Other prominent researchers include Marilyn Fleer from Monash University, Australia, with an h-index of 3 and 76(2.59%) citations, and Howard P. Parette from Illinois State University, United States, with an h-index of 3 and 50(1.70%) citation. This shows that some researchers have a large influence in the field of early childhood education technology, both through the number of publications and their citation impact.

The country that dominates the list of productive writers is Australia, with five writers from various universities, such as Australian Catholic University, Monash University, University of Technology, and University of Canberra. The United States also has significant representation with two authors from Illinois State University. In addition, other countries such as Germany, the United Kingdom, Taiwan, Hong Kong, South Korea and Canada also contributed, showing that research in this field is global. These contributions from various countries reflect the broad international diversity and collaboration in early childhood education technology research.

Apart from analyzing by looking at the h-index, researchers also interpreted it by looking at the number of authors with the highest publications over time. Susan Edwards is the author with the most significant contribution, as can be seen from the consistent frequency of her publications from the beginning to the end of the period studied. The graph shows Edwards has several publications with high citation counts, reflecting the significant impact of his work in this field. Marilyn Fleer also made important contributions, albeit

with a more sporadic frequency of publication but still has some highly cited work.

The longest publication frequency can also be seen from authors such as Howard P. Parette and Lynette Schaverien, who have publications spread over a longer period compared to other authors. Each author in this graph contributes significantly to the development of knowledge in the field of early childhood education technology, although with varying frequency and impact. The combined contributions of these diverse authors illustrate the diversity of research and the importance of collaboration in advancing this field of study.

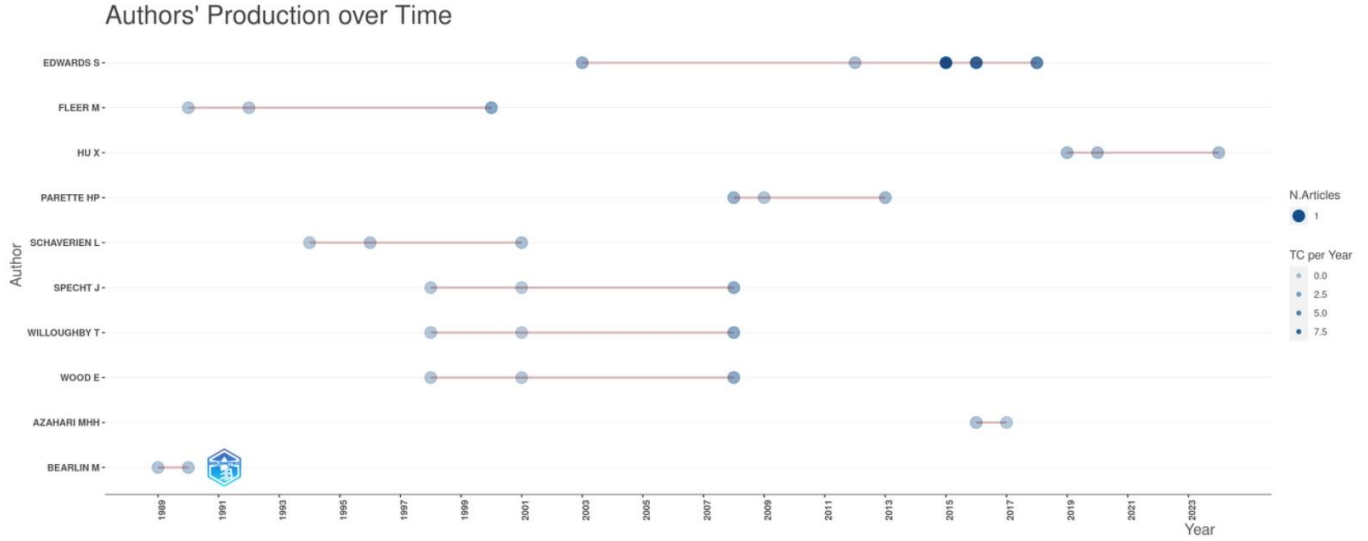

Figure 7. Author with Total Production Time in the Field of Technology Use in Early Childhood Education. Analysis With Biblioshiny

The Most Productive Source

The most productive sources are analyzed in order to identify journals, books, or other publications that have contributed the most to the field of using technology in early childhood education. This is important for understanding research trends and directing research efforts to the most influential sources.

In this analysis, the International Journal of Technology and Design Education ranked first as the most productive source, with a total of 292(9.97%) citations and 11(6.39%) publications since 1994. This source was followed by the British Journal of Educational Technology with 188(6.42%) citations and 5(2.90%) publications since 2003. Early Childhood Education Journal also stands out with 206(7.43%) citations and 7(4.06%) publications since 2008. The dominance of citations and number of publications from these journals indicates that they are a very influential source in the field of early childhood education technology.

In addition, the sources ranked at the top mostly come from journals in the Q1 category, such as Education and Information Technologies, Computers and Education, and International Journal of Child-Computer Interaction. These Q1 journals account for 11 of the 15 sources analyzed, indicating the dominance of the highest-ranking journals in research contributions in this area. Sources from countries as diverse as the United States, the United Kingdom, and the Netherlands also contributed, reflecting the geographic diversity and international collaboration in early childhood education technology research. Each journal involved makes a significant contribution to the development and dissemination of knowledge in this field, both through the number of articles published and the total citations received.

Table 6. The Top 15 Documents with the Highest Citations in the Field of Technology Use in Early Childhood Education

Source Title	SQ[a]	Publisher	Country	h[b]	TC[c]	NP[d]	FP[e]
International Journal of Technology and Design Education	Q1	Springer Netherlands	Netherlands	8	292(9.97)	11(6.39)	1994
British Journal of Educational Technology	Q1	Wiley-Blackwell Publishing Ltd	United Kingdom	5	188(6.42)	5(2.90)	2003

Source Title	SQ[a]	Publisher	Country	h[b]	TC[c]	NP[d]	FP[e]
Early Childhood Education Journal	Q1	Springer Netherlands	Netherlands	5	206(7.43)	7(4.06)	2008
Education and Information Technologies	Q1	Kluwer Academic Publishers	United States	4	67(2.28)	5(2.90)	2017
Research in Science Education	Q1	Springer Netherlands	Netherlands	4	46(1.57)	4(2.32)	1989
Australasian Journal of Early Childhood	Q2	Early Childhood Australia	Australia	3	66(2.25)	4(2.32)	2014
Computers and Education	Q1	Elsevier Ltd	United Kingdom	3	246(8.40)	3(1.74)	1993
International Journal of Child-Computer Interaction	Q1	Elsevier B.V.	Netherlands	3	50(1.70)	3(1.74)	2017
International Journal of Science Education	Q1	Taylor and Francis Ltd.	United Kingdom	3	43(1.46)	3(1.74)	1990
Educational Technology and Society	Q1	National Taiwan Normal University	Taiwan	2	106(3.62)	2(1.16)	2014
Environmental Education Research	Q1	Carfax Publishing Ltd.	United Kingdom	2	181(6.18)	2(1.16)	2011
Frontiers in Education	Q2	Frontiers Media SA	Switzerland	2	9(0.30)	2(1.16)	2022
Interactive Learning Environments	Q1	Taylor and Francis Ltd.	United Kingdom	2	35(1.19)	2(1.16)	2017
International Journal of Early Years Education	Q2	Routledge	United Kingdom	2	55(1.87)	3(1.74)	2002
International Journal of Learning	Q4	Common Ground Research Networks	United States	2	8(0.27)	3(1.74)	2009

a = Scopus Quartile with a focus on "Education", Quartile checked on June 16, 2024, b = h-index, c = Total Citations, d = Number of Publications, e = First publication on the relevant Source

Document with the Highest Citation

The documents with the highest citations were analyzed with the aim of evaluating their impact and influence in the field of early childhood education technology. Through Table 6, researchers interpret the title, number of citations, and others.

The study with the highest number of citations is research by Blackwell et al., (2014), which discusses the factors that influence the use of digital technology in early childhood education. This research had 210(9.02%) citations, indicating the high interest and relevance of the topic among academics and educational practitioners. In addition, research by Lu & Liu (2014) who developed an augmented reality-based ocean learning program for elementary school students, also showed a significant impact with 172(7.39%) citations.

Research with the highest number of citations is dominated by publications between 2008 and 2015. The focus of these studies is on the use of technology in early childhood education, covering topics such as factors influencing the use of digital technology by early childhood educators, integration of augmented technology reality to improve children's learning, to the use of technology at home by three- and four-year-olds. All of this research contributes to understanding how technology can be used to support and enhance children's learning, both in home and school settings.

Overall, these studies make important contributions to the field of early childhood education, especially in the use of technology to support the learning process. By focusing on various aspects of educational technology, from digital use in the classroom to technology-based learning at home, these studies help form a deeper understanding of the role of technology in children's education and how technology can be used effectively to improve learning outcomes.

Focus Research

The author grouped keywords in VOSviewer with the aim of identifying the main themes in the research.

In addition, this grouping also helps in understanding the relationship between various concepts and topics discussed in the literature in the field of technology use in early childhood education.

By using predetermined keywords, 54 keywords were obtained which were divided into 7 clusters on the topic of using technology in early childhood education. Next, the researchers provide the name of each cluster in Table 7.

The red cluster entitled "Educational Innovation and Participatory Design" covers a wide range of topics focused on the development and application of innovative methods to support learning and communication. These include assistive technology for individuals with autism spectrum disorders, co-design that involves students in the process of creating learning materials, and digital literacy and multimodality that enrich the learning experience (Kim et al., 2023). Additionally, this cluster also highlights the importance of professional development for educators and effective pedagogy to accommodate the needs of students with disabilities (Brunsek et al., 2020; A. Page et al., 2023).

The green cluster entitled "Digital Learning Innovation" covers a variety of topics related to the use of advanced technology to improve children's education. This includes the use of augmented reality and touchscreens to create interactive learning experiences, as well as computer-assisted instruction and computer-based communications to support classroom teaching (Budiarto et al., 2021; Spadoni et al., 2022). In addition, this cluster discusses the use of the Internet of Things to improve social interaction and language learning, as well as the role of institutions and society in supporting student learning (Semary et al., 2024). The main goal is to improve teaching methods in the classroom and facilitate better social interaction in the educational environment.

The blue cluster entitled "Digital Innovation in Early Education" illustrates the importance of digital competence, literacy and independent learning in the context of early childhood education. Focusing on STEM and the application of digital media, this research involves prospective teachers to develop new models through structural equation modeling (Jiang et al., 2024; Mukuka, 2024). The goal is to advance early education by effectively utilizing technology, increasing children's digital literacy, and supporting comprehensive STEM-based learning (Intisari et al., 2024; Xu et al., 2024).

Table 6. The Top 15 Documents with the Highest Citations in the Field of Technology Use in Early Childhood Education

Author	Title And Years	Description	TC
Courtney K. Blackwell, Alexis R. Lauricella & Ellen Wartella	Factors Influencing Digital Technology Use in Early Childhood Education (2014)	This research discusses the factors that influence the use of digital technology by early childhood educators.	210(9.02)
Su-Ju Lu & Ying-Chieh Liu	Integrating Augmented Reality Technology to Enhance Children's Learning in Marine Education (2014)	This research discusses the development of an augmented reality-based ocean learning program for elementary school students.	172(7.39)
Lydia Plowman, Joanna Mcpake & Christine Stephen	Just Picking It Up? Young Children Learning with Technology at Home (2008)	This research discusses the use of technology by children aged three and four years at home.	140(6.01)
Ching-Ting Hsin, Ming-Chaun Li & Chin-Chung Tsai	The Influence of Young Children's Use of Technology on Their Learning: A Review (2014)	This research discusses the influence of technology on children's learning through a systematic literature review.	102(4.38)
S. Hollingworth, A. Mansaray , K. Allen & A. Rose	Parents' Perspectives on Technology and Children's Learning In The Home: Social Class And The Role Of The Habitus (2011)	This research discusses the role of technology in supporting family learning and how the experiences of parents from different social class backgrounds influence the learning potential using technology at home.	98(4.21)
Jo Bird & Susan Edwards	Children Learning to Use Technologies Through Play: A Digital Play Framework (2015)	This research discusses the pedagogical understanding of the use of technology in play-based early childhood education.	93(3.99)
Feng Wang, Mable B. Kinzie, Patrick Mcguire & Edward Pan	Applying Technology to Inquiry-Based Learning n Early Childhood Education (2009)	This research discusses the use of computer technology in inquiry-based learning in early childhood education.	82(3.52)
Lydia Plowman, Christine Stephen & Joanna Mcpake	Supporting Young Children's Learning with Technology at Home and In Preschool (2008)	This research examines the use of technology by three- and four-year-old children at home and in preschool.	79(3.39)

Author	Title And Years	Description	TC
Jared Keengwe & Grace Onchwari	Technology And Early Childhood Education: A Technology Integration Professional Development Model for Practicing Teachers (2009)	This research discusses the challenges and strategies of technology integration in teaching by early childhood education teachers.	74(3.18)
Paul Kim, Talia Miranda & Claudia Olaciregui	Pocket School: Exploring Mobile Technology as A Sustainable Literacy Education Option for Underserved Indigenous Children in Latin America (2008)	This Research Examines Educational Inequalities in Latin America and The Opportunities for Mobile Learning Technology to Address These Issues.	70(3.09)
Susan Edwards	New Concepts of Play and The Problem of Technology, Digital Media and Popular-Culture Integration with Play-Based Learning in Early Childhood Education (2015)	This Research Discusses the Integration of Technology, Digital Media and Popular Culture in Early Childhood Education.	69(2.96)
Theodere Lewis	Creativity in Technology Education: Providing Children with Glimpses of Their Inventive Potential (2009)	This Research Discusses the Role of Technology Education (Design and Technology) In Fostering Creativity in The Curriculum.	68(2.92)
Elena De La Guia, Vicenre López Camacho, Luis Orizco-Barbosa, Victor M. Brea Luján, Victor M. R. Penichet & Maria Lozano Pérez	Introducing Iot and Wearable Technologies into Task-Based Language Learning for Young Children (2016)	This Research Discusses the Use of Wearable Technology and The Internet-Of-Things (Iot) In Making It Easier to Create Realistic, Task-Based Language Learning Scenarios.	64(2.75)
Marilyn Fleer	Working Technologically: Investigations Into How Young Children Design and Make During Technology Education (2000)	This Research Discusses Technology Education for Children Aged 3-8 Years in Australia.	62(2.66)
Marshall H. Raskind & Eleanor L. Higgins	Speaking to Read: The Effects of Speech Recognition Technology on the Reading and Spelling Performance of Children with Learning Disabilities (1999)	This Research Examines the Use of Speech Recognition Technology to Help Students with Learning Disabilities.	52(2.23)

Source: R Program & Google Scholar, data accessed from June 16-17, 2024

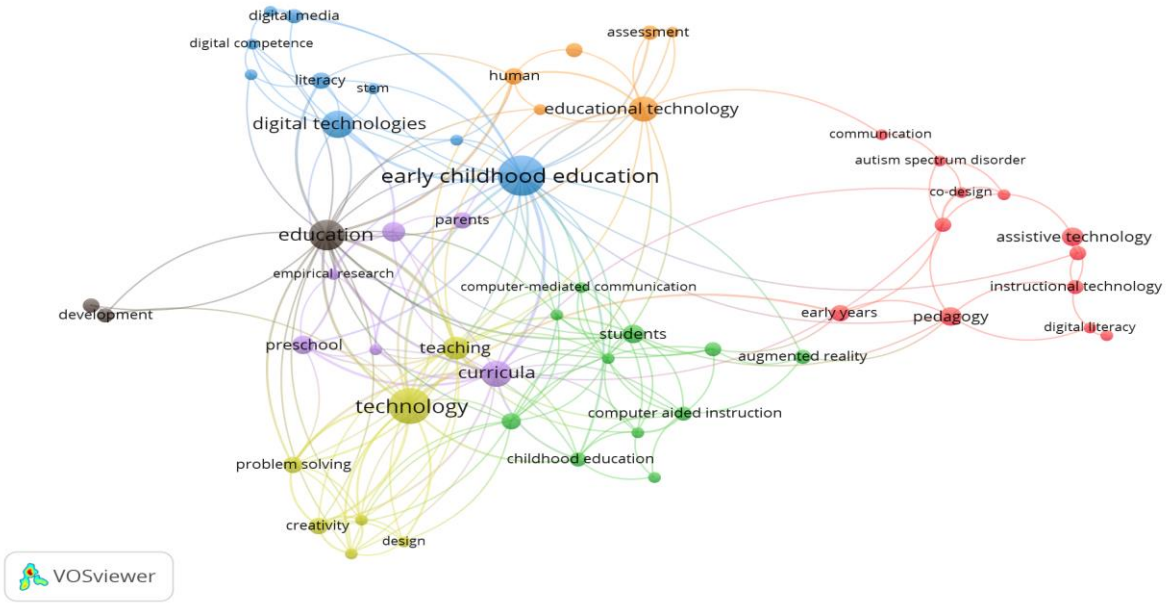

Figure 8. Keyword Group Analysis with the Network Visualization Menu (Keyword Occurance ≤ 2) in VOSviewer

The yellow cluster entitled "Innovation in Encouraging Creativity and Problem Solutions" describes an approach to designing learning that motivates students to develop their creativity in solving problems. The primary focus is on teaching that inspires innovation, utilizes technology as a tool to enhance design abilities, and stimulates students' intrinsic motivation to face challenges (Javaid et al., 2021). These methods not only aim to teach practical solutions, but also to shape the critical thinking and creative skills necessary in today's digital era.

The purple cluster entitled "Conceptual Framework for Pre-School Curriculum Development" summarizes the importance of empirical research in designing e-learning-oriented curricula for early childhood. The primary focus is on the role of parents in supporting children's learning, using a deep conceptual framework to inform evidence-based curriculum development (Sheridan et al., 2020). This research explores new ways of devising innovative approaches that enable effective and measurable improvements in pre-school learning experiences.

The cluster titled "Innovative Assessment in Special Education" illustrates the importance of technology in promoting enriched learning for individuals with hearing loss. The focus is on the use of enhanced technology to facilitate learning tailored to these specific needs, by exploring assessment methods that can be humanely adapted (Hampton et al., 2022). This approach aims to create an inclusive and supportive educational environment, where technology is used as a tool to promote equal access to learning.

The cluster entitled "Education Development through ICT" describes efforts to utilize information and communication technology (ICT) to improve the education system as a whole. The focus is on curriculum development that leverages ICT to enrich learning experiences and optimize teaching (Tahat et al., 2023). The research explores how ICT can be used to bring innovation in education, facilitate wider access to educational resources, and improve the quality of learning through technology that is well integrated in the learning process

Table 7. Seven Grouping Keywords in the Field of Technology Use in Early Childhood Education

Color Group	Cluster Name	Keywords
Red (12 items/22.22%)	Educational Innovation and Participatory Design	Assistive Technology, Autism Spectrum Disord, Co-Design, Communication, Digital Literacy, Disability, Early Years, Instructional Technology, Multimodality, Participatory Design, Pedagogy, Professional Development
Green (11 items/20.37%)	Digital Learning Innovation	Augmented Reality, Childhood Education, Computer Aided Instruction, Computer-Mediated Communication, Improving Classroom Teaching, Internet of Things, Language Learning, Social Interactions, Societes and Institution, Students, Touchscreen Technology
Blue (9 items/16.67%)	Digital Innovation in Early Education	Digital Competence, Digital Media, Digital Technologies, Early Childhood Education, Literacy, Preservice Teachers, Self-Directed Learning, STEM, Structural Equation Modelling
Yellow (7 items/12.96%)	Innovation in Encouraging Creativity and Problem Solutions	Creativity, Design, Innovation, Motivation, Problem Solving, Teaching, Technology
Purple (6 items/11.11%)	Conceptual Framework for Pre-School Curriculum Development	Conceptual Frameworks, Curricula, E-Learning, Empirical Research, Parents, Preschool
Orange (6 items/11.11%)	Innovative Assessment in Special Education	Assessment, Educational Technology, Hearing Impairment, Human, Special Education, Technology-Enchanced Learning
Black (3 items/5.55%)	Education Development through ICT	Development, Education, Information and Communication Technology

Source: VOSviewer, Data accessed June 17, 2024

Keyword Novelty

The keyword novelty analysis on VOSviewer aims to identify the latest trends and developments in early childhood education technology. With this understanding, new innovations can be designed that support the improvement of the quality of early childhood learning and development through technology.

In 2022, analysis using VOSviewer showed that the keywords "Digital Competence", "Self-directed learning", and "Participatory design" were in the yellow category, indicating that their use is rare in the literature. Nevertheless, their existence as newly emerging keywords indicates their important potential to be the focus of future research in technology development in early childhood education.

In this context, further research could delve deeper into digital competence, self-directed learning and participatory design in the development of technology applications for early childhood. This has the potential to formulate innovative approaches that can enhance children's interaction with technology in a productive manner, while developing skills relevant to the digital age. By prioritizing these keywords, research can lead to curriculum development that is responsive to children's needs in preparing them for the demands of an increasingly digitized future.

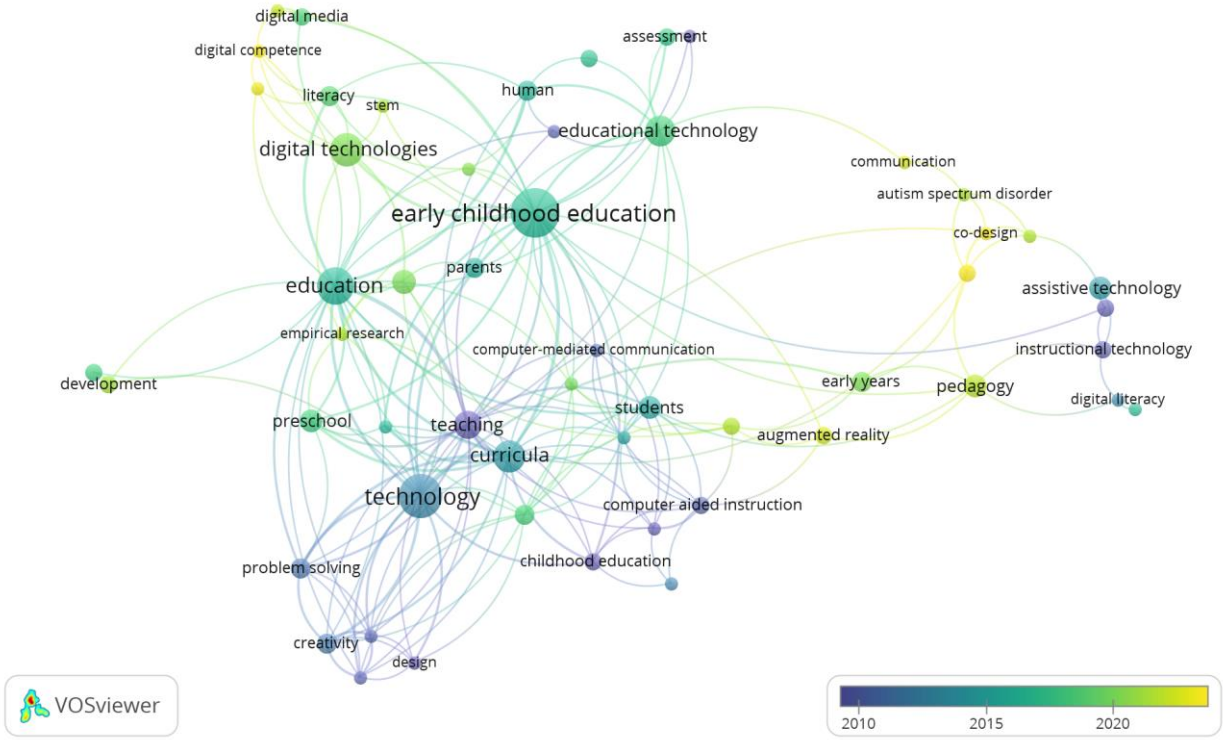

Figure 9. Keyword Novelty on Overlay Visualization Menu. Analysis with VOSviewer

Conclusion

Based on the analysis, it can be concluded that research on the use of technology in early childhood education has been ongoing from 1971 to 2024, with a fivefold increase in the number of articles in the last 20 years. The year 2020 was the most productive, with an h-index of 7 and 11 publications (6.39%). Illinois State University ranked first with the highest number of publications, totaling 11 articles (6.39%). The United States is the most productive country, contributing 28 articles (16.28%) and receiving 786 citations (26.85%). Susan Edwards from Australian Catholic University is the most productive author, with an h-index of 5, total citations of 253 (8.64%), and 5 publications (2.90%). The International Journal of Technology and Design Education is the most productive source, with 292 citations (9.97%) and 11 publications (6.39%). The article by Blackwell et al. (2014) has the highest number of citations at 210 (9.02%). There are 54 keywords distributed across 7 clusters, with "Digital Competence," "Self-directed learning," and "Participatory design" recommended for future research in this field.

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Article writing was done by A.M.R, Data collection and data analysis were done by Z.Z, R.T.A, and R.N.G, direction, guidance, review of ideas, concepts, methodology, analysis were done by R.S.

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Conflicts of Interest
The authors declare no conflict of interest.

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