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Trends in Mathematics Research in Early Childhood: Bibliometric Review

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Abstract
Early childhood education is a critical stage in individual development. At an early age, children have the ability to absorb knowledge quickly, including in mathematics. The aim of this study was to identify trends and patterns of mathematics research in early childhood using bibliometric analysis. The data was obtained from the Scopus database which has been refined with 4 stages (identification, screening, eligibility, and inclusion). The results showed that the peak of publications related to mathematics research in early childhood occurred in 2022. 2017 was the year with the most influential publications. Journal "Early Childhood Education Indexed Journal Scopus with the highest quartile score (Q1) is the most popular place for publication of previous research related to this field. The United States is the most influential country in this field because both the number of publications and the number of citations are the highest than any other country. As for three focus study related study mathematics in children age early on the Scopus database from 1988-2023 namely, 1) mathematics, human, learning and gender; 2) early childhood, professional development, and teachers; 3) mathematics learning, early childhood, curriculum, and achievement.

Keywords: Bibliometrics, early childhood, mathematics

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Introduction
Earlyhood children is terms used For refers to children who are in range age preschool, usually between 0 to 6 years (Bazaz et al., 2023; Stiani et al., 2023). In this period, childs experience rapid development in various aspects, incl physical, cognitive, social, and emotional (Ardiana, 2023; Supriani & Arifudin, 2023). Mathematics is discipline studying science number, quantity, structure, space, and relationship. Mathematics involves problem solving, logical thinking, measurement, calculation, and patterns (Mayani et al., 2022). This field has wide applications in everyday life, science, technology, and many other fields.

The relationship between early childhood and mathematics lies in the importance of providing appropriate mathematics education at this time (Dewi et al., 2023). Early childhood has a natural ability to learn and understand mathematical concepts (Alfantiya et al., 2023). They are able to develop an understanding of numbers, shapes, patterns, sizes, and other mathematical relationships through interactions with the environment and play activities. Mathematics education in early childhood helps them develop early math skills, such as counting, recognizing numbers, comparing quantities, understanding quantity relationships, and solving simple problems (Hafifah & Athar, 2023). Mathematics at this time was taught

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through a play and exploration approach, using teaching aids, games and other interactive activities (Usnah, 2023).

The introduction of mathematics at an early age has long-term benefits for children's development, this helps build a strong foundation in understanding math concepts, logical thinking, reasoning, and problem solving (Ariskasari, 2019). Children who have a good understanding of mathematics at an early age tend to be better prepared to learn more complex mathematics at school, and will also have strong cognitive skills that are useful in everyday life (Nurmaliza (Nurmaliza & Smith, 2023; Potensia, 2023). In addition, the introduction of mathematics at an early age can also improve children's critical thinking skills, communication skills, cooperative abilities, and independence. Mathematics helps develop an analytical mindset, the ability to organize information, and the ability to argue and solve problems systematically. Thus, the relationship between early childhood and mathematics involves the importance of providing mathematics education that is appropriate to the development of children at that age. Appropriate and fun approaches to teaching mathematics to young children can help them develop a strong foundation in mathematics, as well as the cognitive and social skills that are important for their future development.

Early childhood education is a critical stage in individual development. At an early age, children have the ability to absorb knowledge quickly, including in the field of mathematics (Fitria & Fadlillah, 2023). Therefore, mathematics research in early childhood is very important to understand their cognitive development. One of the reasons research in early childhood mathematics is important is to identify approaches that are effective in teaching and helping children build solid understanding of mathematics from an early age. Through this research, educators and practitioners can gain better insight into appropriate teaching strategies for early childhood.

Previous research has shown that a play approach and the use of manipulative materials are effective methods in teaching mathematics to early childhood (Anggarani et al., 2022; Nafisah et al., 2022). However, it is important to continue to conduct more in-depth research to explore more about effective teaching strategies and appropriate learning methods in early childhood contexts. In addition, research on mathematics in early childhood also helps in identifying the factors that influence the development of mathematics at this stage factors like environment learning, the role of parents, and the individual tendencies of children can impact significant to understanding and interest child in math.

In recent years, mathematics research in early childhood has experienced rapid development (Nafisah et al., 2022; Saputra et al., 2022). Through bibliometric analysis, we can see the research trends that are developing in this field, topics that are currently popular, and research collaborations that occur. In previous bibliometric studies, it has been found that mathematics research in early childhood tends to focus on topics such as cognitive development, use of technology in teaching, and evaluation of mathematics learning programs in early childhood (Asmawati, 2021). However, there are still research gaps that need to be explored further, for example, research on the effect of specific teaching approaches on certain aspects of mathematics such as numbers, measurement, and geometry.

By conducting a bibliometric analysis of early childhood mathematics research, we can gain a more complete and comprehensive picture of research trends, trending topics, and ongoing research collaborations. (Angraini & Muhammad, 2023; Muhammad, Triansyah, Fahri, & Lizein, 2023). This will assist in identifying research gaps that need to be filled and provide directions for future research in this area (Angraini et al., 2023; Maryanto et al., 2023; Muhammad, Triansyah, Fahri, & Gunawan, 2023; Muhammad & Angraini, 2023). In addition, through bibliometric analysis, it can also be known about the geographic spread of mathematics research in early childhood. Is this research mostly carried out in developed countries or is there already significant research in developing countries. This information can be helpful in seeing to what extent research in early childhood mathematics has spread globally and whether there are gaps between countries.

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However, although mathematics research in early childhood has experienced rapid progress, there are still some challenges that need to be overcome. One of them is the diversity of research methodologies used in this study. Efforts are needed to achieve consistency and uniformity in the research approach used so that research results can be compared more effectively, it is also necessary to pay attention to ethical aspects in mathematics research in early childhood. The involvement of children in research must comply with the principles of security, fairness and privacy. Protection of children's rights and the consent of parents or guardians is important in any research involving early childhood. In facing this challenge, collaboration between researchers, educators, and educational practitioners is key. Through the exchange of knowledge, experience, and ideas, we can strengthen early childhood mathematics research and advance the field as a whole.

Thus, research on mathematics in early childhood using bibliometric analysis is an important step for understanding research trends, identifying gaps, and formulating better research directions. It is hoped that through comprehensive research and strong collaboration, it can increase understanding of mathematics in early childhood, design effective teaching strategies, and encourage optimal development of mathematics in the early stages of a child's life. Research in this area aims to identify trends and patterns of early childhood mathematics research using bibliometric analysis. Analysis bibliometric involve data collection from sources relevant literature and analysis quantitative to these data (Muhammad & Juandi, 2023; Samosir et al., 2023). Method This help in identify the most influential research and the most voluminous topics studied in field This (Muhammad, 2023; Siahaan et al., 2023).

Methodology

This study uses a descriptive bibliometric analysis method, there are several steps in analyzing the results of studies related to mathematics education in earlyhood children which are collected from the database dimension. Identification, screening, eligibility and inclusion are the four required steps (Moher et al., 2009). Identification is the first step that must be done, at this stage the researcher must search or enter predetermined keywords into the database to access research results related to a particular field. At this stage the researcher entered keywords according to the research theme, namely "Early Childhood" and "mathematics learning" in the Scopus database. After being identified, the data that came out was 328 documents.

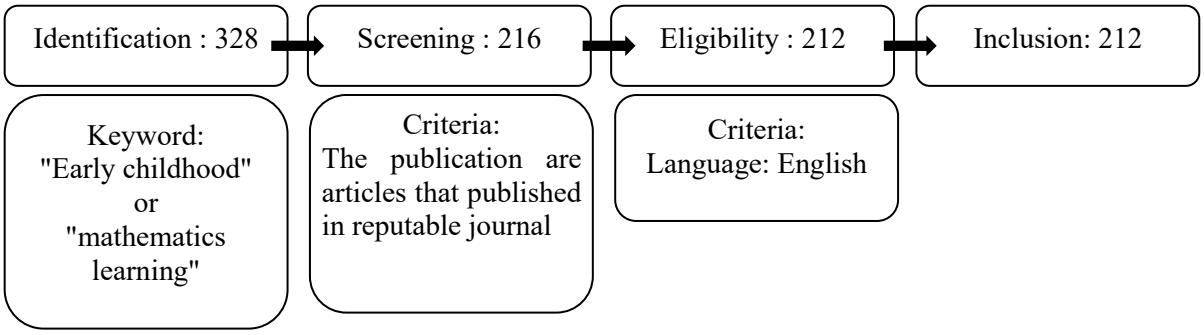

Figure 1. Stages in perfecting data

Screening is the second step that must be passed, at this stage the researcher filters out the 328 publications that have been obtained in the previous stage. In conducting screening, researchers must set criteria according to what is needed. At this stage the researcher sets the criteria, namely publication must be in the form of articles published only in reputable journals, from 328 data there are 112 articles that do not meet these criteria. This means that 112 publications that do not meet these criteria will not proceed to the next stage. the remaining 216 publications of the results of this screening stage will be continued at the next stage.

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Eligibility is the third step that must be passed, at this stage the researcher looks at whether 216 publications are feasible to be included in the final stage, for this reason the researcher must establish criteria, namely publications are written in English, meaning publications that are not in English are not continued to the next stage. Of the 216 existing publications and after conducting a feasibility study, the remaining publications were 212 publications. for more details can be seen in Figure 1.

In conducting the analysis, researchers use various applications to help calculate and display the data that has been collected. The Microsoft Exel application is used to enter data and then displays tables such as publication trends and citation trends, the Vosviewer application is used to display images of relations between countries as well as research focus related to the field under study. PoP applications researchers use in calculating trend quotes such as NCP, C/CP, h- index and others.

Result and Discussion

In displaying the results of the analysis of the inclusion results obtained, the researcher starts from publication trends then citation trends, journal distribution, relations between countries and research focus.

Publication trends and citation trends

Publication trends are displayed by grouping the number of publications by year of publication. The trend of publications from 1988 to 2023 related to mathematics research in early childhood can be seen in Figure 1.

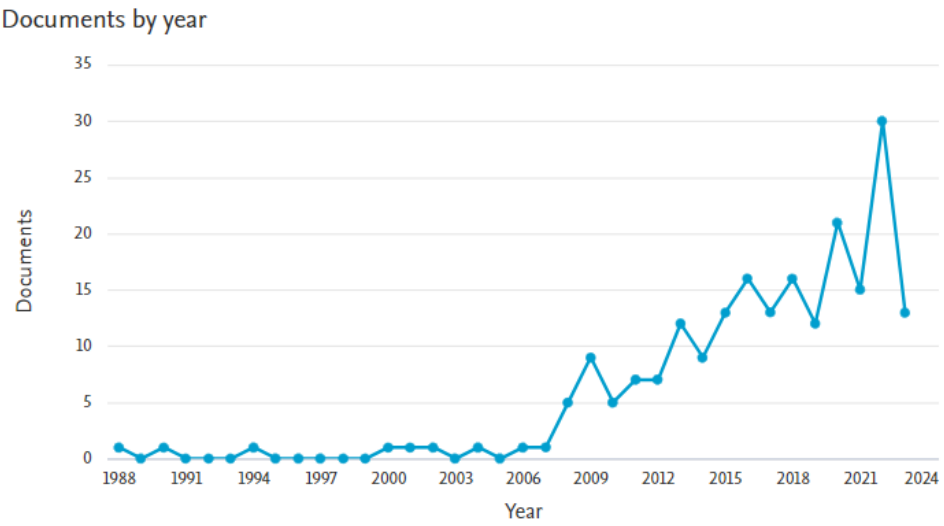

Figure 2. Publication Trends

From figure 1 above it can be seen that the year with the most publications is 2022 with 30 documents. The highest increase was in 2021 to 2022, which increased by 15 publications, but in the following year, namely 2023, the number of publications decreased to only 13 published documents, this is because 2023 is still running. Next, we will see trends in citations related to mathematics research in early childhood from 1988 to 2023.

From table 1 it can be seen that the highest NCP is in 2020, even though 2022 is the year with the highest number of publications it does not guarantee a high NCP score, this is because out of 30 publications in 2022 only 13 publications have been cited at least once. Furthermore, the trend of quotations can be seen from TC, TC is the total quotations in a certain year, the highest TC value was in 2008 with 741 quotations. But the h- index it is the one who determines whether the publication in a particular year has a strong influence on the topic raised. The h-index value is a measure for researchers in developing their articles, meaning that the h- index

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value in a particular year determines the size in a particular year which has a major impact on a particular theme. The highest h- index value was in 2017, meaning that in 2017, published articles had the greatest impact on mathematics research in early childhood. There was research in 2017 which can be seen in table 2.

Table 1. ***Citation Trends***

Year	TP	NCP	tc	H	G
2023	13	3	6	1	2
2022	30	18	29	3	3
2021	15	12	62	5	7
2020	21	20	159	8	11
2019	12	10	73	6	8
2018	16	14	114	6	10
2017	13	12	298	9	13
2016	16	14	247	8	15
2015	13	11	184	8	13
2014	9	9	423	6	9
2013	12	11	364	7	12
2012	7	7	130	5	7
2011	7	7	408	6	7
2010	5	5	84	5	5
2009	9	9	569	8	9
2008	5	5	741	5	5
2007	1	1	10	1	1
2006	1	1	9	1	1
2005	-	-	-	-	-
2004	1	-	-	-	-
2003	-	-	-	-	-
2002	1	1	6	1	1
2001	1	1	16	1	1
2000	1	1	49	1	1
1995- 1999	-	-	-	-	-
1994	1	1	5	1	1
1991- 1993	-	-	-	-	-
1990	1	1	6	1	1
1989	-	-	-	-	-
1988	1	1	7	1	1

TP: Total publications; NCP: Number Citation Papers; TC: Total Citation; H: h- index; G: g- index

Publications in 2027 that have the greatest impact on research in this field, one of the most cited articles in that year is research conducted by (Park et al., 2017) on "Early childhood teachers ' beliefs about readiness for teach science, technology, engineering, and mathematics ” which has been cited 76 times. The article was widely cited because it explains that early childhood education teachers have heterogeneous beliefs about readiness to teach STEM the importance and challenges STEM education plays in classifying these teachers. This research also shows that collaboration between teachers within schools is very important in STEM education, especially when teachers have not been trained beyond their content areas on issues related to STEM education. A limitation of the study was that the study sample was limited to white female early childhood education teachers from public schools in West Kentucky. Therefore, the results of this study may not be generalizable to other important demographic variables such as gender, ethnicity and region. In addition, the survey developed for the purposes of this research does not include a comprehensive set of indicators on teachers'

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beliefs about readiness to teach STEM. Therefore, some important aspects of the construct of interest may not be considered in this study.

Table 2. Publications in 2017

Writer	Title	Journal name	Quote
(Park et al., 2017)	Early childhood teachers' beliefs about readiness for teaching science, technology, engineering, and mathematics	Journals of Early Childhood Research	76
(Papadakis et al., 2017)	Improving Mathematics Teaching in Kindergarten with Realistic Mathematical Education	Early Childhood Education Journals	64
(Schacter & Jo, 2017)	Improving preschoolers' mathematics achievement with tablets: a randomized controlled trial	Mathematics Education Research Journals	35
(Trawick-Smith et al., 2017)	Block play and mathematics learning in preschool: The effects of building complexity, peer and teacher interactions in the block area, and replica play materials	Journals of Early Childhood Research	27
(Castro et al., 2017)	Block play and mathematics learning in preschool: The effects of building complexity, peer and teacher interactions in the block area, and replica play materials	Journals of Early Childhood Research	24

Most articles quoted between article other is research conducted by (Watts et al., 2014) about " What's Past Is Prologue: Relations Between Early Mathematics Knowledge and High School Achievement" which has been quoted 291 times. the article published in 2014 being the most quoted Because article the put forward ability math at school medium own strong relationship with various results positive in adulthood, incl achievement title bachelor, quality work and choice maintenance health. Besides that, research this also shows that ability math at age pre-school can influence achievement mathematics in adolescence. However, research This own a number of necessary limitations noticed. First, because study the is non-experimental studies, exist variable bias potential that is not observed. Although effort has done for overcome problem This with using a growth model that takes into account correlated factors with achievement mathematics, research more carry on with consider other factors like system number estimation or function executive Possible give more estimate strong and unbiased.

Second, research it also generates question about who gets the most benefit from growth ability mathematics during period the, as well is growth during another period in education The same or even more beneficial than growth during years beginning school. Required study more carry on For answer questions this. Lastly, measurement mistakes too become source potential bias, and score enhancement often criticized Because is more size noisy than estimation level. However, an increase math on level beginning school show validity strong predictor in these models.

In Figure 3 it can be seen that there are 13 publications in the journal "Early Childhood Education Journal "This is the highest number among other journals, the journal "Early Childhood Education Journal " has indexed journal rankings scopus with the highest quartile value (Q1), if we look at table 2 there is also the journal "Early Childhood Education Journal " which is the article with the second highest number of citations in 2017. The journals in Figure 2 can be used as publication destinations for further research that wants to publish articles related to this field in indexed journals scopus.

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Source	Documents
Early Childhood Education Journal	13
International Journal Of Early Years Education	10
Mathematics Education Research Journal	9
Early Education And Development	8
Zdm Mathematics Education	8
Contemporary Issues In Early Childhood	6
European Early Childhood Education Research Journal	5

Figure 3. Number of documents by journal Amount document based on Journal and Country

Country	Documents	Citations	Total link strength
united states	102	3180	1779
australia	20	110	376
spain	18	50	375
germany	11	137	474
sweden	11	95	369
turkey	10	71	299
china	8	98	556
norway	6	31	360
switzerland	5	129	348
united kingdom	4	67	321
south korea	4	5	134
hong kong	3	6	379
netherlands	3	28	235
taiwan	3	19	218
finland	3	76	213
chile	3	17	135
macao	3	15	119
new zealand	3	48	116
south africa	3	26	51
brazil	3	7	17

Figure 3. Bibliography State Couplings

In Figure 3 it is displayed with a threshold, namely only countries with a minimum of 3 documents that will be displayed. There are 20 countries that meet the threshold. In Figure 3 above, the United States is the country with the largest number of documents, namely 102 publications. The country with the most citations is also the United States with 3180 citations, meaning that at least one article published by the United States has been cited at least 31 times. The United States of America also has a high total link strength, with 1779 total link strengths. this make America union become one by one its the most influential country to study mathematics in children age early moment this.

Research focus

The focus of research related to mathematics in early childhood can be seen in Figure 4, while to see the novelty of the research can be seen in Figure 5. The images displayed with the help of the Vosviewer application with a threshold of 3, meaning that the keywords displayed have been used by at least 3 documents.

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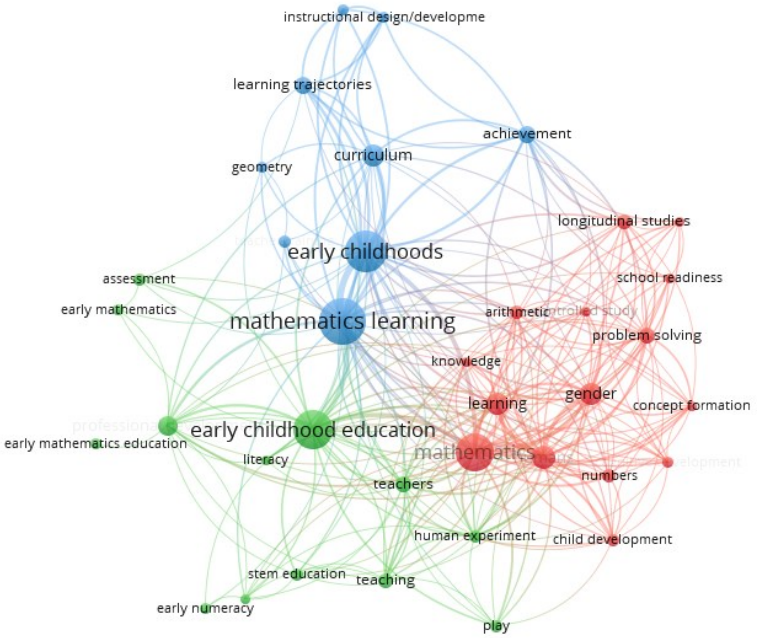

Figure 4. Research Focus

From Figure 4, it can be seen that there are three different colors, these colors are clusters that can be used to divide research focus related to this field. Keywords with red circles are the first cluster as well as the largest cluster, meaning the red cluster is the focus of the first research, followed by the second largest cluster, namely keywords that have green circles. The last cluster is also the focus of the third research, namely the blue cluster.

There are 37 keywords in Figure 4, while the focus of the first research consists of 15 items. The keywords that are the focus of research are keywords that have the largest circle among them circle other. Keyword mathematics, human, learning and gender are the keywords with the biggest circles in the red cluster. This means that these keywords are the focus of the first research. The second research focus consists of 13 items. The keywords that are the focus of research are keywords that have the largest circle among them circle other. Keyword early childhood, professional development, and teachers are the keywords with the biggest circles in the green cluster. This means that these keywords are the focus of the second research.

The third research focus consists of 9 items. The keywords that are the focus of research are keywords that have the largest circle among them circle other. Keyword mathematics learning, early childhood, curriculum, and achievement are the keywords with the biggest circles in the blue cluster. This means that these keywords are the focus of the third research. The three research focuses above can be useful for further research in setting research themes.

In Figure 5, several colors are displayed, starting from blue which indicates the keyword was used around 2014, green means the keyword was used around 2017 and yellow means the keyword has only been used in the last few years. Keywords with yellow circles are keywords that have just been used, meaning that these keywords are new themes in this field. The new themes are controlled study, stem education, teacher training, and learning environment.

In looking at the novelty of research, links between keywords can be used, meaning that keywords that do not have links with other keywords are the novelty of research in this field. Judging from figure 4, keywords mathematics learning together with early childhoods is not directly connected with 2 keywords, namely with the new controlled study theme and with the school keyword readability. This means that this is novelty and can be used for further research to help find problems that have not been studied by previous studies.

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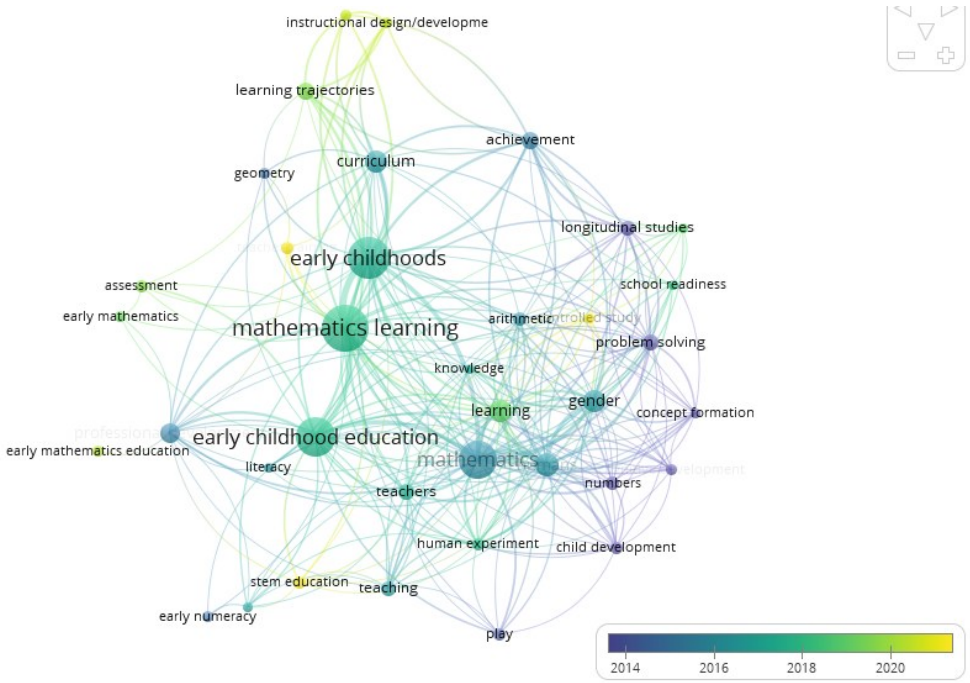

Figure 5. Novelty of research

Conclusion

From the results and discussion above, it can be concluded that the peak of publications related to mathematics research in early childhood will occur in 2022 with 30 documents. 2017 was the year with the most influential publication this year with the highest h- index value compared to other years. Journal " Early Childhood Education Journal " which has indexed scopus with the highest quartile value (Q1) is place publication most popular study earlier related field this. United States become the most influential country in the field This Because Good amount publication amount quote is the most from other countries. As for three focus study related study mathematics in children age early on the Scopus database from 1988-2023 namely, 1) mathematics, human, learning and gender; 2) early childhood, professional development, and teachers; 3) mathematics learning, early childhood, curriculum, and achievement. As for the theme new to research This namely controlled study, stem education, teacher training, and learning environment. Focus research and themes new the can made reference for researcher next in the field this. In searching for data researchers only use databases Scopus, meaning that there are still many databases other than Scopus that can be used for further research. The data was taken in June 2023, so the publication after that time was not analyzed by this study so that there might be slight differences in the results of the research

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