



Research Trend of Mathematical Literacy in Mathematics Education: A Bibliometric Analysis from 2011-2024

Vidia Amalia Adjis; Ariyadi Wijaya; Rusdiati Lagalante; Maharani Dewi Saputri

Mathematics Education Study Program, Faculty of Mathematics and Natural Sciences, Yogyakarta State University,
Indonesia

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Abstract

Mathematical literacy plays an important role in 21st century education, becoming an essential foundation to face global demands. In addition, the evaluation of mathematical literacy is also a crucial aspect in the Program for International Student Assessment (PISA) which reflects the importance of this ability in the context of global educational competition. This study aims to provide a bibliometric review of trends in the use of mathematical literacy skills in mathematics teaching research. The method in this study is bibliometric analysis, which aims to analyze and classify bibliographic materials by presenting mathematical literacy summaries of the literature in the Scopus database. The search was conducted by using the keyword "mathematical literacy" and selecting "article title" in the search menu in the Scopus database. The results showed that the highest peak of research from 2011 - 2024 was in 2023 with 22 publications related to mathematical literacy. Mathematics learning, mathematical concepts, and mathematical literacy research design are research trends related to these variables. Therefore, paying attention to mathematical concepts in mathematics learning and using effective research designs to improve students' mathematical literacy skills are important.

Keywords: *Mathematical Literacy; Mathematics Education; Bibliometric*

Introduction

Mathematical literacy plays an important role in 21st century education, becoming an essential foundation to face global demands. Mathematical literacy is also crucial because it provides awareness about the role of mathematics in the world and helps students apply mathematics in various real situations (Rizki & Priatna, 2019; Genc & Erbas, 2019). Mathematical literacy has also been launched by the National Council of Teachers of Mathematics (NCTM) which is in line with the vision of mathematics education, namely mathematical literacy (Salsabila et al., 2020). The main goal of the mathematical literacy agenda is to increase awareness of the usefulness and ability to use mathematics in various fields (Niss & Jablonka 2014; Frejd & Geiger, 2017).

The definition of mathematical literacy includes an individual's ability to understand, formulate, apply, and interpret mathematics in various contexts, as well as communicate with the language of

mathematics and connect it to the real world (Asmara et al., 2024). Meanwhile, mathematical literacy according to the Program for International Student Assessment (PISA) is an individual's capacity to reason mathematically, formulate, use, and interpret mathematics to solve problems in various real-world contexts. It includes concepts, procedures, facts and tools to describe, explain and predict phenomena. It helps individuals to know the role that mathematics plays in the world and to make reasoned judgments and decisions that are required of constructive, engaged and reflective 21st century citizens (OECD, 2023).

Powell and Anderson (2007) argue that mathematical literacy is important and necessary for every individual to maintain an informed, functional, and effective daily life. Through literacy, students will have literacy skills, then foster curiosity and build ideas that can be conveyed to other humans (Padmadewi & Artini, 2018). Mathematical literacy not only enables individuals to understand and use mathematical concepts in everyday life, but it is also a critical skill for success in various fields such as science and technology. Therefore, mathematical literacy is beneficial not only for individual citizens but also for society as a whole to foster democracy and civilization in society.

Based on the results of this review, this study aims to systematically review and analyze the existing research literature to obtain information related to research gaps. Furthermore, the results of this study are expected to contribute to further research on the steps to be taken for further research related to mathematical literacy.

Method

This study aims to identify research gaps and steps to be taken for further research on mathematical literacy in mathematics education. Bibliometric analysis was chosen because bibliometric analysis can represent the state of all research from past to present based on several perspectives (Aktoprak & Hursen, 2022; Donthu et al., 2021). Bibliometrics is a statistical examination of information and quantitative analysis of bibliographic elements of scientific publications (Mayr, et al., 2018). Based on that, researchers can use bibliometric analysis to examine the dynamics of all existing research from a broader perspective.

In the data collection for the bibliometric analysis, "literacy" and "mathematics" were keywords used to identify research related to mathematical literacy in mathematics education. Document access was done in Scopus on October 20, 2024 with the research field of social science and mathematics. Data collection for this bibliometric analysis collected 467 documents. Data collection for descriptive content analysis used the PRISMA stage, which consists of four stages: identification, screening, eligibility, and inclusion. Identification in this data collection was based on the word "mathematical literacy" and focused on article titles only. Therefore, there was no filtering in this first stage. The string used to search for (TITLE ("mathematical literacy") OR TITLE ("mathematics literacy") OR TITLE ("mathematical literacy") OR TITLE ("literacy mathematics")). At this stage, 467 documents were generated.

Furthermore, screening was carried out, namely filtering documents based on inclusion/exclusion criteria. The inclusion criteria are open access, year of publication in the range 2011-2024, research field is social science and mathematics, document type is article, language used is English, and all open access documents. This was done to ensure the novelty of the research and a sufficient number of studies so that it could be studied comprehensively. This stage resulted in 102 articles. Details can be seen in Figure 1.

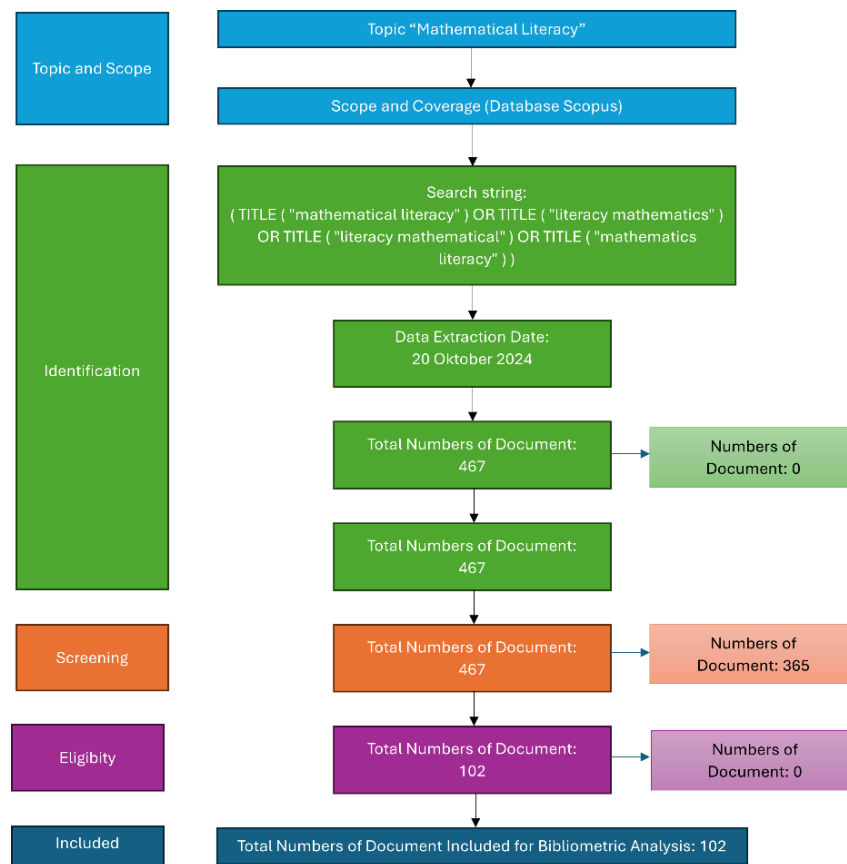


Figure 1. PRISMA

Data Analysis

Bibliometric analysis was conducted using the Bibliometrix software package in the RStudio program. To simplify the analysis, a ready-to-use, no-coding version of bibliometric software, Biblioshiny, was used. In the past, Bibliometric was a quantitative evaluation tool for publication and citation data. Today, bibliometrics is used in almost all scientific fields to evaluate the growth, maturity, leading authors, conceptual and intellectual maps, and trends of the scientific community (Aria & Cuccurullo, (2017). Furthermore, the data analysis method for descriptive content analysis was performed by collecting similar data within the framework of specific concepts and themes for further interpretation. The selected articles were grouped as a classification of publications developed by (Birgin & Peker, 2021) in the data analysis process. The grouping of articles was based on information in the article, such as the author's name, year of publication, research methods used, subjects, number of samples taken, research instruments, and data analysis techniques. Data related to article content was recapitulated using Microsoft Excel. Furthermore, after the data was recorded based on the content, the data was grouped based on predetermined criteria. Finally, prior to data interpretation, a percentage calculation related to the frequency of the data obtained was carried out.

Results

This research focuses on mathematical literacy in mathematics education. After analyzing using RStudio, the main information can be seen in Figure 2.



Figure 2. Main Information

Research on mathematical literacy in the context of mathematics education has been conducted from 1961 to 2024, with a total of 467 documents. This study analyzed research on mathematical literacy in the context of mathematics education from 2011 to 2024 from 48 journal sources. The analysis showed that there was a 20.26% increase in the number of publications each year, reflecting the high interest and relevance of this topic in the research community. In this analysis, the active participation of 246 authors was also recorded, and international collaboration dominated at a rate of 12.75%, indicating the global dimension of research on mathematical literacy in mathematics education. These findings provide an overview of the development and collaboration in the scientific literature on this topic over the period.

Trend Publication from 2011-2024

Analysis using Biblioshiny shows that the number of studies on mathematical literacy in mathematics education has increased significantly since 2014. Although in 2020 there was a downward trend, in the following year there was a rapid increase. As presented in Figure 2, the number of publications on mathematical literacy in mathematics education was the highest in 2023, with 22 documents.

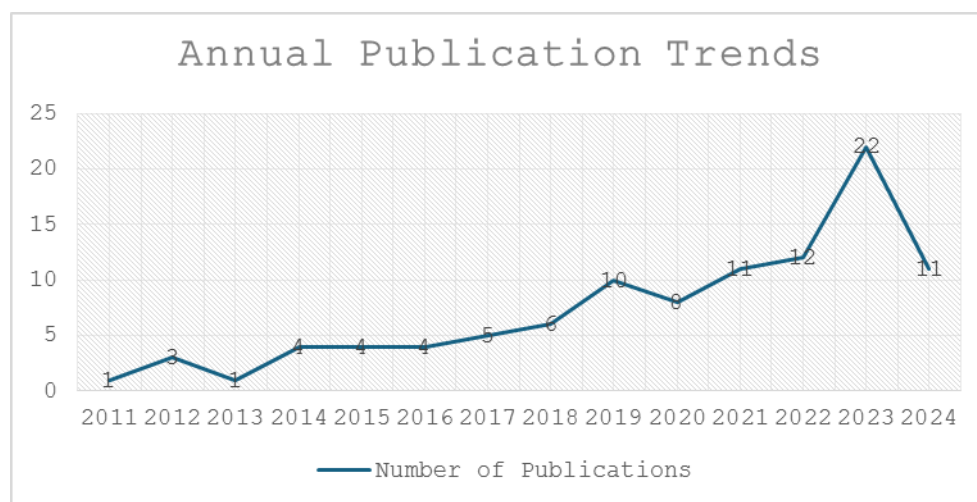


Figure 3. Publication Trends 2011 – 2024

Trend Country Publication

The distribution of publications of a country is shown in Figure 4, it can be seen that the country that published the most research related to mathematical literacy in mathematics education from 2011 to 2024 was Indonesia, with a total of 42 publications. Turkey ranked second with 17 publications.

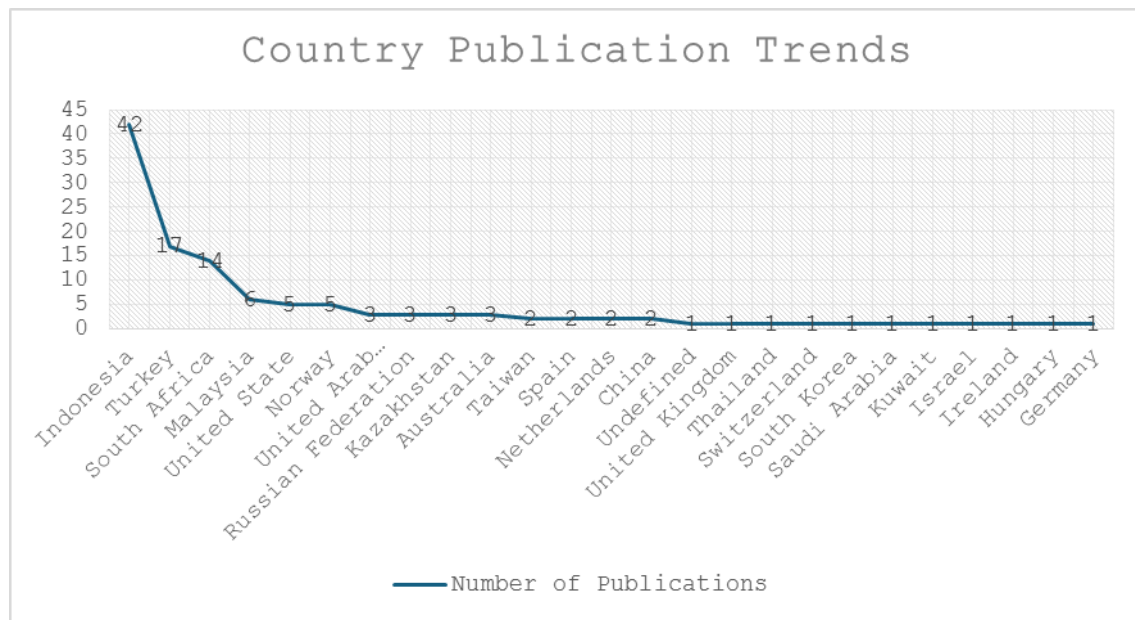


Figure 4. Trends in Country Publications 2011 - 2024

Most Cited Countries

Analysis using Biblioshiny shows that Indonesia is the country that receives the most citations for research on mathematical literacy in mathematics education. Figure 4 shows a total of 219 citations for mathematical literacy research in mathematics education obtained from 2011-2024. This number is very significant when compared to the number of citations obtained by Australia, which is 186.

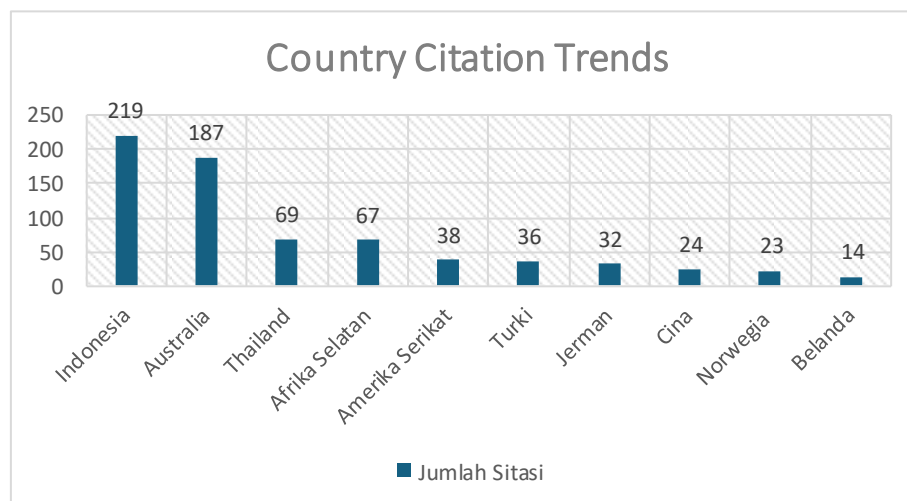


Figure 5. Countries with the most citations in 2011 – 2024

Affiliation with Highest Publication

Based on Table 1, the fifteen universities listed in the table are from several countries in the world and have similar contributions in academic research. Qiannan Normal University for Nationalities from China, Universitas Negeri Semarang, and Yogyakarta State University from Indonesia have 8 publications each, indicating significant involvement in research. Sriwijaya University from Indonesia has a total of 6 publications. Meanwhile, Sultan Agung Islamic University from Indonesia, University Of Johannesburg from South Africa, University of Kwazulu-Natal from South Africa, and Utrecht University

from the Netherlands have a total of 5 publications each. The representation of these different countries demonstrates the diversity and global contribution in the research areas covered in the articles produced by these universities.

Table 1. Affiliations with Highest Publications

Affiliate	Country	Article
Qiannan Normal University For Nationalities	China	8
Universitas Negeri Semarang	Indonesia	8
Yogyakarta State University	Indonesia	8
Sriwijaya University	Indonesia	6
Sultan Agung Islamic University	Indonesia	5
Yogyakarta State University	Indonesia	5
Sriwijaya University	Indonesia	5
University Of Johannesburg	South Africa	5
University Of Kwazulu-Natal	South Africa	5
Utrecht University	Netherlands	5
Bursa Uludag University	Turkey	4
Halu Oleo University	Indonesia	4
Universitas Negeri Malang	Indonesia	4
University of Indonesia Pendidikan	Indonesia	4
Sebelas Maret University	Indonesia	4

Most Cited Sources

Based on Table 2, the most cited source for research related to critical thinking in mathematics is the international journal Educational Studies in Mathematics. This journal is a journal that presents new ideas and research developments in the field of mathematics education. 104 citations were obtained in this journal related to critical thinking research in mathematics.

Table 2: Sources with the Highest H-index

Source	H-index	TC	NP
Journal On Mathematics Education	6	296	9
Pythagoras	5	42	5
Eğitim Ve Bilim	4	64	6
European Journal Of Educational Research	3	30	6
Infinity Journal	3	32	8
South African Journal Of Education	3	21	4
Eurasian Journal Of Educational Research	2	13	2
European Journal Of Science And Mathematics Education	2	13	2
International Journal Of Educational Methodology	2	7	2
International Journal Of Instruction	2	40	2
Journal Of Higher Education Theory And Practice	2	18	6
Pegem Eğitim Ve Öğretim Dergisi	2	6	3
Sustainability (Switzerland)	2	8	2
Zdm - Mathematics Education	2	18	3
African Journal Of Research In Mathematics, Science And Technology Education	1	3	1

Most Cited Documents Globally

The results of the bibliometric analysis showed that the document entitled "The PISA View of Mathematical Literacy in Indonesia" was the document that received the most citations from research related to mathematical literacy in mathematics education. The article written by Stacey (2011) received 149 citations. This article describes the Programme for International Student Assessment (PISA) and mathematical literacy in Indonesia and several countries, where the results of Indonesian students are compared with the average of OECD countries and several selected countries. Table 3 shows the distribution of the most cited global documents.

Table 3. Documents with the Most Citations

Article	Source	Total Citations	TC per Year
Stacey K, 2011	Journal on Mathematics Education	149	10.64
Sumirattana S, 2017	Kasetsart Journal of Social Sciences	69	8.63
Oktiningrum W, 2016	Journal on Mathematics Education	47	5.22
Gabriel F, 2018	International Journal of Research & Method in Education	38	5.43
Wijaya A, 2016	Journal on Mathematics Education	35	3.89
Dewantara Ah, 2015	Journal on Mathematics Education	34	3.40
Jürges H, 2012	Economics of Education Review	32	2.46
Umbara U, 2019	International Journal of Instruction	32	5.33
Aksu G, 2016	EGITIM VE BILIM	27	3.00
Machaba Fm, 2018	Eurasia Journal of Mathematics, Science and Technology Education	26	3.71
Hwang J, 2021	Journal on Mathematics Education	25	6.25
Pradana Ln, 2020	International Journal of Emerging Technologies in Learning	25	5.00
KoLAR H, 2015	EGITIM VE BILIM	20	2.00
Wang H-H, 2022	International Journal of STEM Education	19	6.33
Kholid Mn, 2022	Journal of Higher Education Theory and Practice	16	5.33

Co-Occurrence Network

The co-occurrence network of mathematical literacy research in mathematics education is shown in Figure 5. This data is obtained from the keywords used by the authors. Figure 5 shows the relationship between the keywords used by the authors. The co-occurrence results show that there is only one main cluster, namely mathematical literacy.

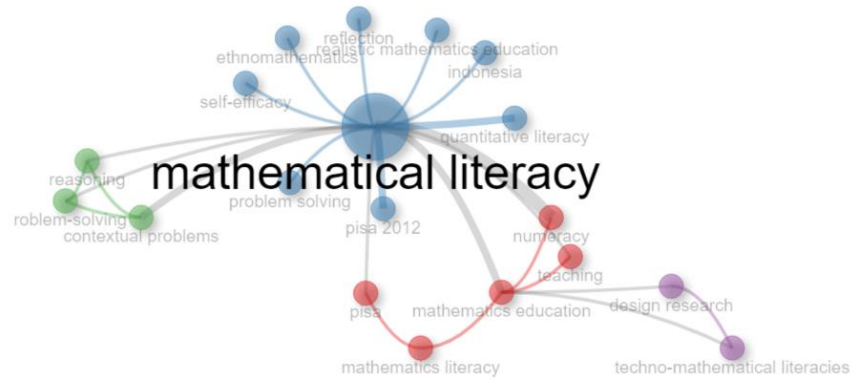


Figure 6. Co-Occurrence Network

Thematic Evolution

Furthermore, Figure 7 shows a thematic evolution map obtained through bibliometrics that illustrates the development of keywords over time in mathematical literacy research in mathematics education. The map was created by considering two stages, 2011-2021 and 2022-2024. For example, from 2011-2021, mathematical literacy is connected to mathematics education, while mathematics learning, mathematical concepts and research design are separated from the theme of mathematical literacy. However, in 2019-2022, there is a connection between literacy and mathematics learning, mathematical concepts and research design.

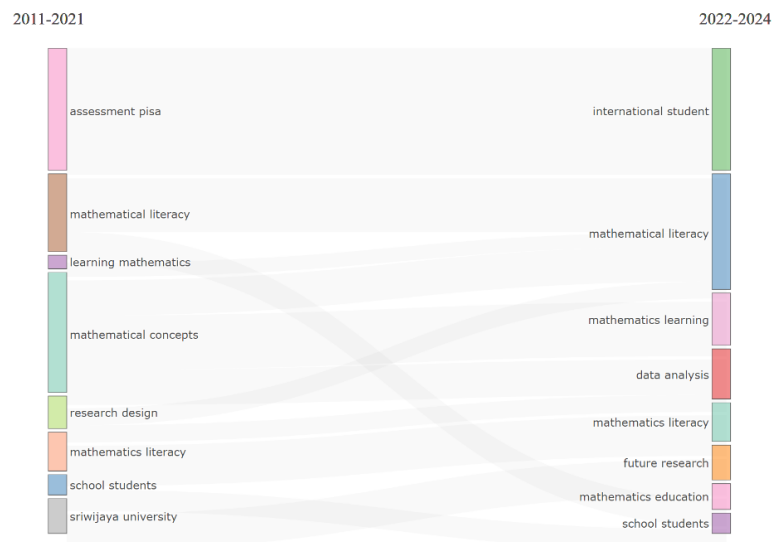


Figure 7. Thematic Evolution

Discussion

This study aims to systematically review and analyze previous research literature to identify research gaps and steps to be taken for future research on mathematical literacy in mathematics education. To achieve this goal, the researcher used bibliometric analysis to reveal the year of publication, country, and citations by source and country, as well as keywords that are often used in research on mathematical literacy in mathematics education.

Based on the bibliometric results in Figure 2, the first research that fulfills the theme search category is mathematical literacy in mathematics education was published since 1961. After that, research on mathematical literacy in mathematics education experienced an increasing trend from year to year based on the number of publications observed after 2011. In recent years from 2011 to 2024 the number of publications reached 102 documents. This shows that interest in mathematical literacy in mathematics education is increasing and growing. The bibliometric results also show that 25 countries produced research on mathematical literacy. Judging from the number of publications, Indonesia is the country with the highest number of publications from 2011 to 2024. Likewise, in terms of the number of citations, Indonesia is ranked the highest, namely 219. This is consistent with the results of Stacey's (2011) research on mathematical literacy in Indonesia. Since 2019, important steps towards the practice of mathematical literacy have been taken in Indonesia by implementing the minimum competency assessment (AKM).

Furthermore, regarding the cited documents, the document written by Stacey (2011) received 149 citations. This article describes the Programme for International Student Assessment (PISA) and mathematical literacy in Indonesia and several countries, where the results of Indonesian students are compared with the average of OECD countries and several selected countries. According to bibliometrics, the most widely used reference source for mathematics literacy research in mathematics education is the Journal on Mathematics Education. These results provide information to researchers who will look for references to support theoretical studies of mathematical literacy research. Regarding the frequency of the most frequently used keywords, it can be seen in Figure 5 that the most widely used keyword is mathematical literacy. In comparison, the keywords that were rarely used were quantitative literacy, problem solving and reasoning. Based on the linkage analysis of these common keywords, the main research areas in mathematical literacy can be identified. In addition, the keywords can be used to identify evolutionary themes. Through the analysis of these evolutionary themes, information on the development of keywords can be obtained over time in mathematical literacy research in mathematics education. Therefore, keywords are very important in determining research trends because they are informative for researchers (Kolle, 2017; Trinarningsih, et al., 2021).

Conclusion

The results of the bibliometric analysis present an overall systematization of the existing literature and contribute to identifying potential gaps in mathematical literacy research. In addition, this research provides readers with information on sources and documents that need to be studied as a basis for mathematical literacy research. The results also reveal the need for literacy research in mathematics education in many other countries. Indonesia can be used as a reference in this research. Research trends can also be used to determine themes for mathematics literacy research. A framework for mathematical literacy research, such as focus areas of study and methodology in research, has been produced in this study. The database used in this study is limited to the Scopus database, so the resulting mathematical literacy research framework is also limited. For future research, the development of the findings of this study can be done by using different keyword string searches and alternative databases. The results of this study may be useful for other researchers who will research related to mathematical literacy, namely as a guide for the research they will develop. In addition, the existence of some research gaps may motivate other researchers to fill these gaps to contribute to improving the quality of mathematical literacy.

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