

BIBLIOMETRIC REVIEW: RESEARCH ON MATHEMATICAL LITERACY ABILITY IN MATHEMATICS LEARNING (1979-2023)

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Abstract

This study aims to look at the relevant previous research landscape related to mathematical literacy in mathematics learning from 1979 to 2023 using bibliometric analysis. Data were taken from the Scopus database of 578 and refined into 112 publications. Based on the results of the bibliometric analysis, it was found that 2022 would be the year for the most published articles, namely 12 articles. The trend of citations related to mathematical literacy in learning mathematics occurred in 2015 as many as 295 citations. South African countries are countries that publish articles related to mathematical literacy in learning mathematics with 26 publications and 20 collaboration links with other countries. Of the 112 journals that have published research related to this field, 46 of them have been published in Q1 journals. The focus of research related to literacy in learning mathematics is 1) gender and students; 2) numeracy; 3) mathematics education.

Key Words: Mathematical literacy abilities, mathematical literacy.

A. Introduction

Mathematical literacy is a skill in understanding the use of mathematics in the world and how to apply it to make decisions in life (Rizki & Priatna, 2019). Mathematical Literacy is a skill that can enable each individual to successfully identify problems, make steps to complete solutions, and effectively assess the suitability of the results obtained (Pugalee, 1999). Mathematical Literacy provides an understanding of the basic characteristics of mathematical concepts, which are represented both orally and in writing (McCabe, 2002). Mathematical literacy does not discuss more detailed or in-depth knowledge related to calculus, differential equations, topology, analysis, linear algebra, abstract algebra, and other complicated mathematical formulas, but rather discusses related to a broader understanding about what mathematics can achieve (Ojose, 2011).

Holistically, the definition of mathematical literacy is a person's skill in thinking at a higher level in mathematics, for example analysis, reasoning, and communicating mathematical concepts in real life (Kramarski, 2004). Mathematical Literacy provides students with an understanding as well as a description of the position that mathematics plays in the modern world. This allows students to increase skills and confidence in thinking numerically and spatially in interpreting and critically analyzing situations in everyday life and solving problems. Mathematics literacy provides opportunities for people to contribute and participate confidently in society (Venkat & Graven, 2008). According to the assessment and analysis framework of the Program for International Student Assessment (PISA), mathematical literacy is a person's expertise in formulating, practicing, and interpreting mathematics in various contexts such as mathematical reasoning skills and using concepts, procedures and facts to describe, or predict a phenomenon or events (OECD, 2012).

Mathematical literacy includes knowledge related to mathematical content, mathematical reasoning, mastering the social impacts and uses of mathematics, mastering the characteristics and history of the development of mathematics (Wilkins, 2000). Mathematical literacy is necessary both at work and in everyday life. This is one of the keys to dealing with societal change (Ojose, 2011). An important part of math literacy is using, doing, and recognizing math in a variety of situations. In dealing with problems that require mathematical treatment, the choice of method and mathematical representation often depends on the situation in which the problem is presented. Students' mathematical literacy abilities are very important and needed so that students are able to express ideas, build mathematical concepts, reason, and communicate ideas effectively in mathematical problems, so that high mathematical literacy results will be obtained (Widdah & Faradiba, 2022).

Research related to learning mathematics is an interesting thing and has been carried out by many previous researchers such as research conducted by (Juandi, 2021) concerning Heterogeneity of problem-based learning outcomes for improving mathematical competence, which is a study of systematic literature review that analyzes the impact application of Problem Based Learning (PBL) in improving the mathematics competence of elementary, junior high and high school

students. Research conducted by (Juandi & Tamur, 2021) regarding the impact of problem-based learning toward enhancing mathematical thinking is a study of meta-analysis that analyzes the application of Problem Based Learning (PBL) in improving problem solving abilities, literacy, communication, critical thinking, and think creatively on mathematics

In addition, the themes related to mathematical literacy skills in learning mathematics is certainly an interesting research as well, because several studies that have been written reveal the many uses and benefits of mathematical literacy in learning mathematics (Supinah & Soebagyo, 2022). Research conducted by (Paloloang et al., 2020) regarding meta-analysis by looking at the effect of problem-based learning on students' mathematical literacy abilities in Indonesia for the last seven years, the results of this study show that the application of PBL has a large positive impact on students' mathematical literacy abilities compared to the application of a conventional approach. Another research was conducted by (Amelia et al., 2022) regarding meta-analysts who used 11 studies that discussed the effect of learning on students' mathematical literacy abilities. Research themes related to mathematical literacy skills in learning mathematics can also be analyzed using bibliometrics. Bibliometric analysis is a technique that allows to provide a macroscopic overview of a large amount of academic literature (van Nunen et al., 2018). Bibliometric methods can be used to assess the performance and research patterns of authors, journals, countries and institutions, and can be used to identify and measure patterns of cooperation between them (Li & Zhao, 2015).

On this basis, to reveal further research on mathematical literacy skills, researchers feel the need to conduct a bibliometric analysis related to mathematical literacy skills in learning mathematics using the *Scopus database*. The purpose of this study is to find out the trend of writing articles related to mathematical literacy skills in learning mathematics from 1979 to 2023.

1. Literature Review

To synthesize the results of previous research related to mathematical literacy in learning mathematics, several studies such as research conducted by (Widdah & Faradiba, 2022) concerning the analysis of mathematical literacy in matrix learning using mind mapping, this research discusses the ability of mathematical literacy to

use mind mapping in learning at the high school level. Likewise research conducted by (Amelia et al., 2022) regarding meta-analysis to see the effect of learning models on students' mathematical literacy abilities. In this study several models such as PJBL, Discovery Learning, Metacognitive Guidance, and Blended Learning can have a strong influence on mathematical literacy skills. from the results of previous research, no one has specifically analyzed mathematical literacy skills in learning mathematics. Then research conducted by (Karmila, 2018) related to the description of students' mathematical literacy abilities in terms of gender differences in junior high school students which shows that male students can answer questions up to the second level related to mathematical literacy abilities.

2. Research purposes

The purpose of this study is to look at the research landscape related to mathematical literacy skills in learning mathematics from 1979 to 2023. The research questions are as follows.

1. What are the citation trends related to mathematical literacy skills in learning mathematics ?
2. What is the geographical distribution of publications and work patterns the same between countries in research related to mathematical literacy skills in learning mathematics?
3. How is the distribution of journal rankings based on quartile values related to mathematical literacy skills in learning mathematics?
4. What is the focus of research related to mathematical literacy skills in learning mathematics ?

B. Method

To see the data used related to "mathematical literacy skills in learning mathematics", researchers used *the Scopus database* because of its very broad indiscipline coverage. In collecting Scopus data, there are several steps taken to improve the data that has been collected as shown in Figure 1. The first step is identification, after being identified, it is then followed by the data filtering step, carrying out feasibility and finally the inclusion step (Moher, 2009 (Moher, 2009)). The first step is the identification process, in this step the researchers entered keywords ("*mathematical literacy abilities*" OR "*mathematical literacy*") in the

Scopus database search. Researchers identified and obtained publication data of 578 articles. The second step is to carry out the screening process by screening. In this stage the researcher chooses the publication of articles in English that are published in journals. From the screening results that have been carried out, a total of 143 articles were obtained that match the criteria.

In the following step, the researchers carried out the feasibility process. At this stage, researchers did it manually to select publications that were feasible for the final stage. Researchers chose appropriate publications by observing the abstracts and titles of 143 publications by including the variable ability of mathematical literacy in learning mathematics. At this final stage the researchers obtained 112 publications that were worthy of being analyzed at a later stage. The data in this study were taken on 5 February 2023 during the inclusion stage. Publication trends related to mathematical literacy skills were carried out using descriptive analysis taken from *the Scopus database* using bibliometric analysis.

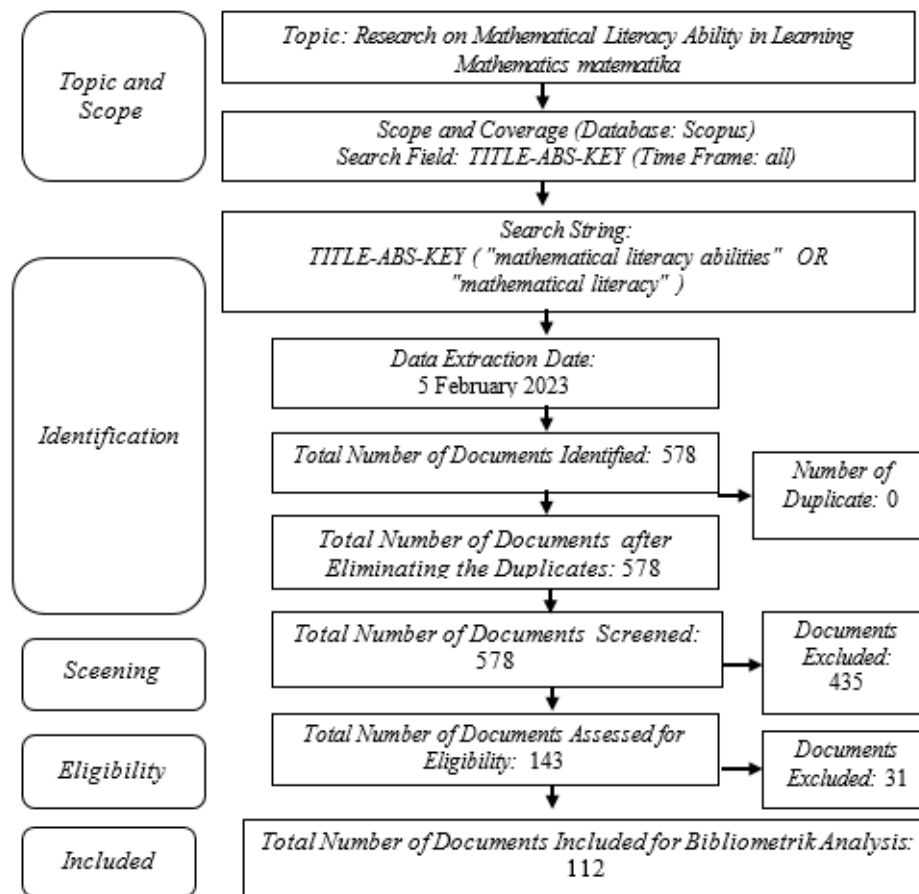


Figure 1. Data Collection Process

1. Data analysis method

Publication trends and citation trends related to mathematical literacy skills in learning mathematics are seen based on years starting from 1979 to 2023. The number of publications and the average citations each year will be calculated and displayed using the help of Microsoft Excel software. Publish or Perish (PoP) software will be used to calculate the h-index and g-index for each publication.

To summarize the geographical distribution of the data that has been collected, researchers use Microsoft Excel software. In addition, researchers use the VOSviewer application to see cooperation between countries. Researchers use Microsoft excel software to display journal rankings based on quartiles. The data that has been obtained from the Scopus database of 112 will be categorized based on (Q1), (Q2), (Q3), and (Q4). This shows that the data that has been collected from 112 of these publications has been published in the journal rankings mentioned above.

C. Result

Publications related to mathematical literacy skills in learning mathematics have gone through several stages of data collection. Through the data collection process, 112 publications from 1979 to 2023 were obtained that matched the criteria. The next stage will be a descriptive bibliometric analysis. Publication trends, citation trends, distribution of countries and journals and research focus will be discussed further.

1. Publication Trends

Publication trends related to mathematical literacy skills in mathematics learning from 1979 to 2023 are shown in Figure 2. A total of 112 publications that have been grouped by year of publication will be displayed in table form as shown in Figure 2 below:

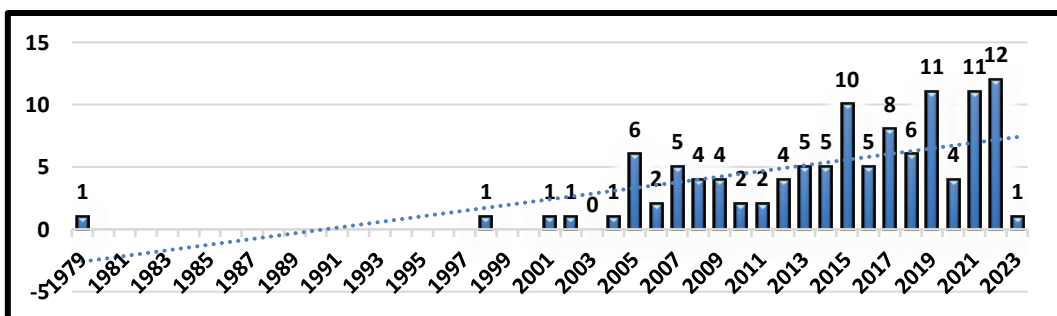


Figure 2. Number of Publications from 1979 to 2023

From the picture above it can be seen that in 2022 there have been published as many as 12 documents, articles related to literacy skills in learning mathematics were first published in 1979 in the Scopus *database* . However, from 1981 to 1997 there were no publications related to this research.

2. Trending of citation

The citation trends related to mathematical literacy skills in mathematics learning from 1979 to 2023 will be shown in table 1. A total of 112 publications that have been collected will be seen in total publications each year grouped by NCP, TC, C/P, C/ CP, h-index and g-index which will be displayed in table 1 below:

Table 1. Citation Analysis of Publications

| year | T | NCP | TC | C/P | C/CP | h | g |
|------|----|-----|-----|-------|-------|---|----|
| 2023 | 1 | - | - | - | - | - | - |
| 2022 | 12 | 5 | 7 | 0.58 | 1.4 | 2 | 2 |
| 2021 | 11 | 10 | 61 | 5.55 | 6.1 | 6 | 7 |
| 2020 | 5 | 4 | 33 | 6.6 | 8.25 | 4 | 5 |
| 2019 | 11 | 11 | 86 | 7.82 | 7.81 | 7 | 9 |
| 2018 | 6 | 6 | 73 | 12.17 | 12.16 | 5 | 6 |
| 2017 | 8 | 7 | 46 | 5.75 | 6.57 | 4 | 6 |
| 2016 | 5 | 5 | 105 | 105 | 21 | 4 | 5 |
| 2015 | 10 | 10 | 195 | 19.5 | 19.5 | 8 | 10 |
| 2014 | 5 | 5 | 12 | 2.4 | 2.4 | 2 | 3 |
| 2013 | 5 | 5 | 105 | 21 | 21 | 4 | 5 |
| 2012 | 4 | 4 | 48 | 12 | 12 | 4 | 4 |
| 2011 | 2 | 2 | 121 | 60.5 | 60.5 | 2 | 2 |
| 2010 | 2 | 2 | 66 | 33 | 33 | 2 | 2 |
| 2009 | 4 | 4 | 48 | 12 | 12 | 4 | 4 |
| 2008 | 4 | 3 | 19 | 4.75 | 6.3 | 3 | 4 |
| 2007 | 5 | 5 | 181 | 36.2 | 36.2 | 5 | 5 |
| 2006 | 2 | 1 | 62 | 31 | 62 | 1 | 2 |
| 2005 | 6 | 5 | 46 | 7.67 | 9.2 | 3 | 6 |
| 2004 | 1 | 1 | 16 | 16 | 16 | 1 | 1 |
| 2003 | - | - | - | - | - | - | - |
| 2002 | 1 | 1 | 7 | 7 | 7 | 1 | 1 |
| 2001 | 1 | 1 | 56 | 56 | 56 | 1 | 1 |
| 2000 | - | - | - | - | - | - | - |
| 1999 | - | - | - | - | - | - | - |
| 1998 | 1 | - | - | - | - | - | - |
| 1997 | - | - | - | - | - | - | - |
| 1996 | - | - | - | - | - | - | - |
| 1995 | - | - | - | - | - | - | - |
| 1994 | - | - | - | - | - | - | - |
| 1993 | - | - | - | - | - | - | - |
| 1992 | - | - | - | - | - | - | - |
| 1991 | - | - | - | - | - | - | - |
| 1990 | - | - | - | - | - | - | - |
| 1989 | - | - | - | - | - | - | - |
| 1988 | - | - | - | - | - | - | - |
| 1987 | - | - | - | - | - | - | - |
| 1986 | - | - | - | - | - | - | - |
| 1985 | - | - | - | - | - | - | - |

| year | T | NCP | TC | C/P | C/CP | h | g |
|------|---|-----|----|-----|------|---|---|
| 1984 | - | - | - | - | - | - | - |
| 1983 | - | - | - | - | - | - | - |
| 1982 | - | - | - | - | - | - | - |
| 1981 | - | - | - | - | - | - | - |
| 1980 | - | - | - | - | - | - | - |
| 1979 | 1 | 1 | 32 | 32 | 32 | 1 | 1 |

Notes. TP=total of publications, NCP=number of cited publications, TC=total citations, C/P=average citations per publication, C/CP=average citations per cited publication, h=h-index, g=g-index

Based on table 1 above, it can be seen that the highest number of cited publications (NCP) were in 2015, 2010 and 2011, which have an NCP value of 10 and 11. The highest number of cited publications from 1979 to 2023 was in 2015, namely 195 citations. Even though in 2020 it had the largest number of publications, namely 12 publications, 2015 still had a greater research impact. It can also be seen in table 1 that there were several years that did not have a citation and did not even have a publication, namely from 1980 to 2000.

In addition, the highest h-index and g-index values were in 2015 which had h-index and g-index values of 8 and 10 respectively. In other words, publications in 2015 had a major impact related to this research. . The number of publications that have been cited in 2015 was 10 with a total number of 195 citations, meaning that at least the average number of citations for each publication is 19 times.

3. Geographic Distribution

Figure 3 below is the geographical distribution of the publication author's country of origin. There are 32 countries that publish related to mathematical literacy abilities. Geographically, the distribution of the author's country of origin can be seen in the following figure.

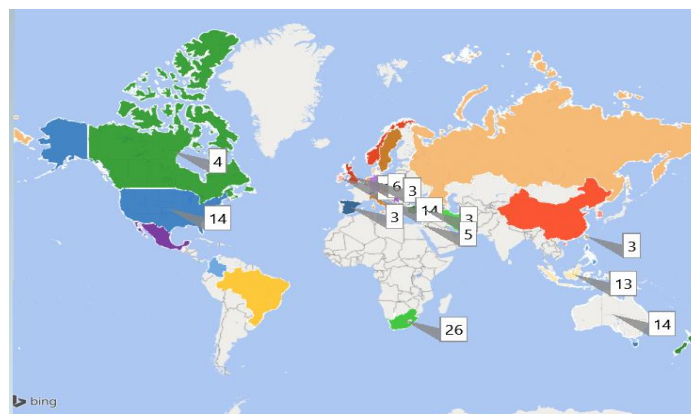


Figure 3. Geographic Distribution of Publications

Based on Figure 3 above, it can be seen that South Africa is the most influential country related to research on mathematical literacy skills in learning mathematics. It can be seen that the South African country has published 26 documents related to this field. The second country that has the greatest influence on this research is Australia, America and Germany which have published 14 documents related to mathematical literacy skills, and the third most influential country in this research is Indonesia which has published 13 documents.

4. State collaboration relations

The pattern of state collaboration will be shown in Figure 4 below. In looking at the relationship between these countries, researchers do not set a certain threshold. In this case, countries that have 1 document will be displayed, even though the country does not have a cooperative relationship with other countries. The countries shown in Figure 4 below with the total of 31 countries.

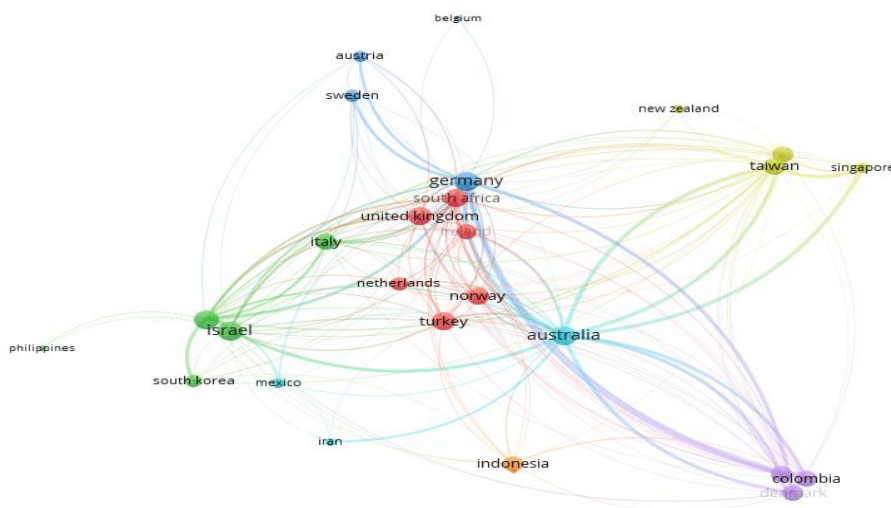


Figure 4. Geographic Distribution of Publications

In Figure 4 above it can be seen that the countries of South Africa, Australia, America, Germany and Indonesia have large circle diameters compared to other countries. This shows that these countries have a high level of cooperative relations with other countries. Based on the VOSviewer display, it can be seen that Germany, the United States, and Australia have cooperative relations with 22 countries while South Africa has cooperative relations with 20 countries and Indonesia has cooperative relations with 14 countries related to literacy in learning mathematics.

5. Journal ranking distribution

The distribution of journal rankings can be seen from the quartile (Q) value of journals related to mathematical literacy skills in learning mathematics. To determine the ranking of journals based on the quartile (Q) value, see the scimagojr website. The distribution of journal ratings can be seen in the following figure.

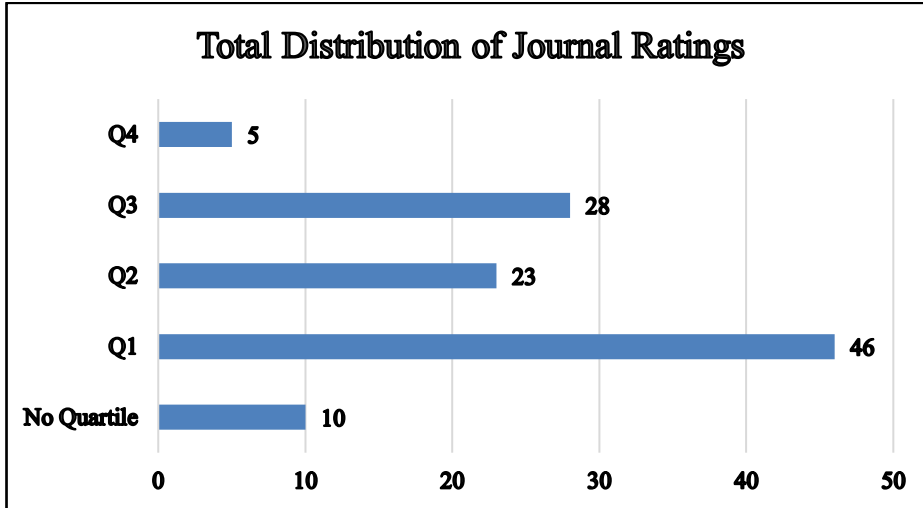


Figure 5. Ranking based on Journal Quartile values

Based on Figure 5 above, it can be seen that most publications in journals related to mathematical literacy skills in learning mathematics are at the Q1 ranking of 46 journals. Whereas for the second order there are publications in the Q3 journal ranking of 28. In addition, other publications are in the Q2 and Q4 journal rankings of 23 and 5 respectively. However, there are still 10 journals that do not have a quartile value, this means that writing related with mathematical literacy skills must be improved so that they can be published in journals that already have quartile values.

6. Research focus

The researchers does not set a threshold at this stage, namely the key words that must be entered at least 1 in each publication. In this case, all entered keywords will be displayed using VOSviewer. The keywords displayed are 40 as shown in Figure 6 below.

1 it can be seen that publications in 2015 have been cited 195 times by having h-index and g-index between these years with h-index = 8 and g-index = 10. This shows that research in 2015 had a major influence on research related to mathematical literacy skills in learning mathematics. The 10 articles with the highest number of citations published in 2015 can be seen in table 3 below.

Table 3. Articles published in 2015

| No | Author (year) | Title | Sources | Citation |
|----|---------------------------------|--|--|----------|
| 1 | (Geiger, Goos, & Forgasz, 2015) | <i>A rich interpretation of numeracy for the 21st century: a survey of the state of the field</i> | PRIMUS | 56 |
| 2 | (Van Hoof et al., 2015) | <i>Inhibiting natural knowledge in fourth graders: towards a comprehensive test instrument</i> | ZDM-Mathematics Education | 34 |
| 3 | (Geiger, Goos, & Dole, 2015) | <i>The Role of Digital Technologies in Numeracy Teaching and Learning</i> | International Journal of Science and Mathematics Education | 22 |
| 4 | (Dewantara et al., 2015) | <i>Assessing seventh graders' mathematical literacy in solving pisa-like tasks</i> | Journal on Mathematics Education | 21 |
| 5 | (Jablonka, 2015) | <i>The evolution of numeracy and mathematical literacy curricula and the construction of hierarchies of numerate or mathematically literate subjects</i> | ZDM - International Journal on Mathematics Education | 19 |
| 6 | (Tout & Gal, 2015) | <i>Perspectives on numeracy: reflections from international assessments</i> | ZDM - International Journal on Mathematics Education | 16 |
| 7 | (Venkat & Winter, 2015) | <i>Boundary objects and boundary crossing for numeracy teaching</i> | ZDM - International Journal on Mathematics Education | 9 |
| 8 | (Roth et al., 2015) | <i>The assessment of mathematical literacy of linguistic minority students: Results of a</i> | Journal of Mathematical Behavior | 8 |

| No | Author (year) | Title | Sources | Citation |
|-----------|------------------------------|--|----------------|-----------------|
| | | <i>multi-method investigation</i> | | |
| 9 | (North & Christiansen, 2015) | <i>Problematizing current forms of legitimized participation in the examination papers for mathematical literacy</i> | Pythagoras | 8 |
| 10 | (Verzosa, 2015) | <i>Reading the World with Calculus</i> | PRIMUS | 2 |

Table 3 above shows that research conducted by (Geiger, Goos, & Forgasz, 2015) has been cited 56 times. This shows that the research has been cited the most in 2015. Research conducted by (Geiger, Goos, & Forgasz, 2015) with the title " *A rich interpretation of numeracy for the 21st century: a survey of the state of the field*" . This article is a synthesis of the current literature relating to the concept of numeracy (also known internationally by other terms such as mathematical literacy), and the teaching, learning, and assessment practices associated with this construct. Numeracy is a concept used to identify the knowledge and abilities necessary to accommodate the mathematical demands of private and public life, and to participate in society as an informed, reflective, and contributing citizen.

Research conducted by (Van Hoof et al., 2015) regarding " *Inhibiting natural knowledge in fourth graders: towards a comprehensive test instrument*" which explains that a good understanding of rational numbers is an important part of mathematical literacy. A great source of difficulty is the imprecise application of natural number knowledge. The research literature points to three main aspects where natural number knowledge is inappropriately applied: density, operations, and size.

2. What is the geographical distribution of publications and work patterns the same between countries in research related to mathematical literacy skills in learning mathematics ?

In this geographic distribution, there are 4 countries that have the highest number of publications related to mathematical literacy skills in learning mathematics, namely South Africa, Australia, Germany, America and Indonesia. Which of the five countries has the most publications, is the South African country which has published 26 documents. This is in accordance with research conducted by (Matope & Chiphambo, 2022) which states that South Africa is the first country

in the world to offer Mathematical Literacy (ML) as a school subject. Based on the pattern of cooperation between countries shown in Figure 4, it can also be seen that there are 4 countries that have cooperative relations with 22 other countries. These countries are Australia, America Germany and Israel. However, in this cooperative relationship with other countries, Australia has 20 links, meaning that Australia has cooperative relations with 20 countries related to mathematical literacy skills.

3. How is the distribution of journal rankings based on quartile values related to mathematical literacy skills in learning mathematics ?

The distribution of journal levels is seen based on the quartile (Q) value. A total of 112 publications of which have been published as many as 46 on the value of Q1. The researchers shows in table 4 below with publications in more than 7 journals.

Table 4. Five Journals with the most articles

| Journal name | Number of articles | Quartile Value |
|--|---------------------------|-----------------------|
| International Journal of Science and Mathematics Education | 14 | Q1 |
| ZDM - International Journal on Mathematics Education | 13 | Q1 |
| Journal on Mathematics Education | 13 | Q2 |
| African Journal of Research in Mathematics, Science and Technology Education | 12 | Q3 |
| Educational Studies in Mathematics | 9 | Q1 |
| International Journal of Education in Mathematics, Science and Technology | 8 | Q3 |

In table 4 above it can be seen that the journal " International Journal of Science and Mathematics Education" has published 14 articles related to mathematical literacy in learning mathematics. In addition, the list of journals above can also be used as a goal for subsequent publications related to mathematical literacy in learning mathematics.

4. What is the focus of research related to mathematical literacy skills in learning mathematics ?

The focus of research related to mathematical literacy skills in learning mathematics is divided into 3 parts, namely 1) gender and students; 2) numeracy; 3) mathematics education.

The first research focus is gender and students. Research conducted by (Aufa & Manoy, 2022) shows that the literacy abilities of female students meet indicators in the process of formulating, implementing, and interpreting problems with appropriate solutions. Meanwhile, male students fulfill the indicators in the process of formulating and implementing them. Teachers need to make habituation to students to solve problems related to mathematical literacy. This means that the influence of gender is also very important in improving students' mathematical literacy skills if the teacher applies and familiarizes students with problems related to solving in everyday life.

The second research focus is numeracy. Research conducted by (Bennison, 2015; Callingham et al., 2015) says that integrating mathematical literacy effectively into teaching mathematics requires that teachers develop an understanding and conception of mathematical literacy in the classroom context as part of their capital or professional identity with respect to numeracy or math literacy. While the third research focus is mathematics education.

E. Conclusion

Based on the results and discussion, it can be concluded that 12 documents have been published in 2022. The trend of citations related to mathematical literacy in learning mathematics occurred in 2015, namely 195 total citations. South African countries are the most influential countries in publications related to this field, namely as many as 26 publications and 20 links in collaboration with other countries. A total of 112 published documents, 46 of which have been published in Q1 journals. The research focus related to mathematical literacy in learning mathematics, including, 1) gender and students; 2) numeracy; 3) mathematics education.

F. Limitations

The limitations of this study are: 1) The data analyzed comes from the Scopus *data base*, so there are many other data bases that can be used, such as Google Scholar and others. 2) this research only discusses related to mathematical literacy in learning mathematics so that there are still many other fields of education that can still be researched 3) this data was taken on 5 February 2023 which cannot reflect subsequent research so there might be slight differences.

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