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MATHEMATICS EDUCATION LEARNING AND TEACHING

Development of Teaching Devices Based on Ethnomathematics and RME to Enhance Mathematical Literacy: Bibliometric

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abstract

This study aims to examine the development of teaching materials based on ethnomathematics and Realistic Mathematics Education (RME) to enhance students' mathematical literacy. The research employs the PRISMA method (Preferred Reporting Items for Systematic Reviews and Meta-Analyses), encompassing the stages of identification, screening, eligibility, and inclusion of relevant literature. The literature review focuses on studies related to the integration of local culture into mathematics instruction through an ethnomathematics approach and the application of RME as a pedagogical strategy. The findings indicate that teaching materials incorporating ethnomathematics and RME are effective in improving students' conceptual understanding, critical thinking skills, and mathematical literacy. This study provides recommendations for curriculum developers and educators to integrate local cultural values into contextual and relevant mathematics learning.

Keywords:
Ethnomathematics, Realistic Mathematics Education (RME), Teaching devices, and Mathematical literacy.

INTRODUCTION

Mathematics is one of the disciplines that has an important role in the development of science and technology. Mathematics education at the primary school level is an important foundation for students to develop logical, critical and creative thinking skills. One of the main competencies expected from mathematics learning is mathematical literacy, which is the ability of students to formulate, apply, and interpret mathematics in various real-life contexts (Umbara & Suryadi, 2019; Isnani & Handoko, 2023). However, the results of international surveys such as the Program for International Student Assessment (PISA) show that the mathematical literacy of Indonesian students is still at a relatively low level compared to other countries (Nurqamar & Nur, 2022). This indicates the need for innovative efforts in learning mathematics at school.

Ethnomathematics and Realistic Mathematics Education (RME)-based learning approaches have become one of the relevant strategies to improve students' mathematical literacy (Khatimah & Fatimah, 2023). Ethnomathematics integrates elements of local culture in mathematics learning, so that students can understand mathematical concepts in their own cultural context. This approach not only strengthens students' cultural identity but also helps them connect math to everyday life (Leonard, 2018; Nugroho & Riyanto, 2019). Meanwhile, RME emphasizes the use of real problems as a starting point for learning, focusing on the process of exploration and mathematical modeling to find solutions (Abbasian et al., 2021). The collaboration between ethnomathematics and RME provides great potential in creating relevant, contextualized and meaningful learning experiences for students.

Previous research shows that the ethnomathematics approach has a positive impact on mathematics learning, especially in improving students' relevance and understanding of mathematical concepts. According to Payadnya and Wulandari (2024), ethnomathematics allows students to connect mathematics with local culture and experiences, which in turn can increase learning motivation. A study conducted by Payadnya and Wulandari (2024) in Indonesia showed that the integration of ethnomathematics in teaching tools can help students understand mathematical concepts contextually, as well as improve critical thinking skills. The study also confirmed that culture-based learning encourages students to appreciate traditional values in everyday life, which has an impact on more meaningful mathematics learning.

The Realistic Mathematics Education (RME) approach has also been proven effective in improving students' mathematical literacy. Laurens (2017) stated that RME allows students to learn mathematics through the exploration of real problems, which helps them develop mathematical modeling skills. Research conducted by Fauzi and Masrukan (2018) found that the implementation of RME in mathematics learning at the elementary level can improve students' ability to understand concepts, analyze data, and solve mathematical problems independently. In addition, research on the combination of ethnomathematics and RME, as conducted

by Yuliana et al. (2023), shows that combining these two approaches can provide better results in improving mathematical literacy. This combination not only makes learning more contextualized but also strengthens students' ability to connect math with real life and local culture.

This study aims to review the literature related to the development of teaching tools based on ethnomathematics and RME in an effort to improve the mathematical literacy of grade 5 elementary school students. This literature review is expected to provide a strong theoretical and empirical basis for the development of innovative and effective teaching tools. In addition, the results of this study can be a reference for educators, researchers, and curriculum developers in creating more inclusive and relevant mathematics learning.

METHODS

Population and Sample

This study used a systematic review method with a bibliometric approach to identify research trends (Silber-Varod et al., 2019) and obtain comprehensive information as a basis for decision making (Higgins et al., 2019). This study utilizes two tools, namely Scopus to search for articles and VOSviewer to visualize the search result data. Data sources were obtained from the Scopus database for the time period 2014 to 2024, accessed in December. The search was conducted using the keywords "RME," "ethnomathematics," and "mathematics literacy." From the search results in the Scopus database, a total of 1,988 articles were obtained. The articles were analyzed after a selection process using inclusion and exclusion criteria (Chalkiadaki, 2018; Ilma et al., 2023; Suwandi et al., 2023).

Table 1
Inclusion and exclusion criteria

Types of criteria	Participation	Exemption
Publication Year	2014-2024	less than 2014
Subject Area	Social Sciences, Mathematics, Physics and Astronomy	Beyond social sciences and mathematics
Type of Publication	Journals and Conferences	Books, Dissertations and more
Data Source	Scopus	Apart from Scopus
Type of Publication	All Open Access	other

We followed the systematic review stages based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework, which includes a network meta-analysis approach (Moher et al., 2009; Rodrigues-Silva & Alsina, 2023; van der Houwen & van Laar, 2020). This process consists of four main stages, namely Identification, Screening, Eligibility, and Included. In the Identification stage, article searches are conducted using the Scopus database. Next, the Screening stage is performed to filter out duplicate or inaccessible articles. The Eligibility stage utilized the inclusion and exclusion criteria detailed in Table 1 to select relevant

articles. The final stage, Included, involved analyzing the articles that had passed the selection. Bibliometric data analysis was conducted using the VOSviewer application to visualize information from the articles obtained. The data was analyzed through three main approaches: network visualization to see the relationship between elements, overlay visualization to show the progression of research over time, and density visualization to identify the most prominent research areas.

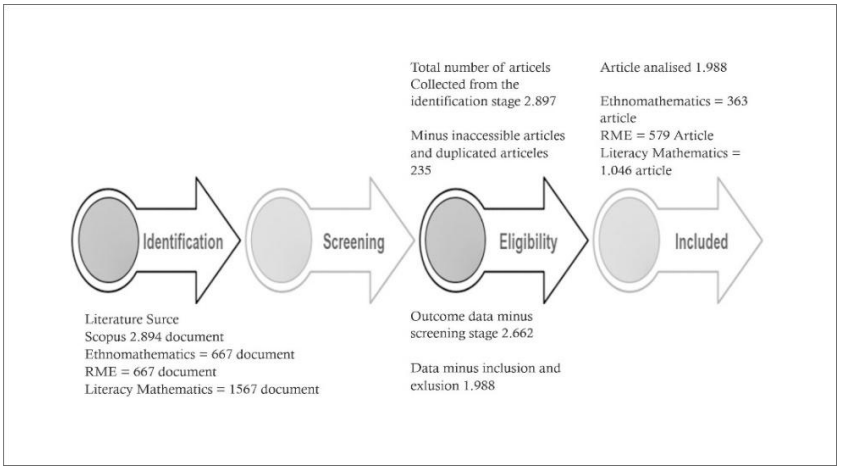

Figure 1
Stages of the PRISMA model

RESULT AND DISCUSSION

The results of the analysis of scientific publications on Ethnomathematics, Realistics Mathematics Education (RME) and Mathematical Literacy were identified based on the number of scientific publications, country of origin, type of publication, year of publication, and data source used. Analysis using VOSviewer focused on three types of analysis, namely network visualization, overlay visualization, and density visualization.

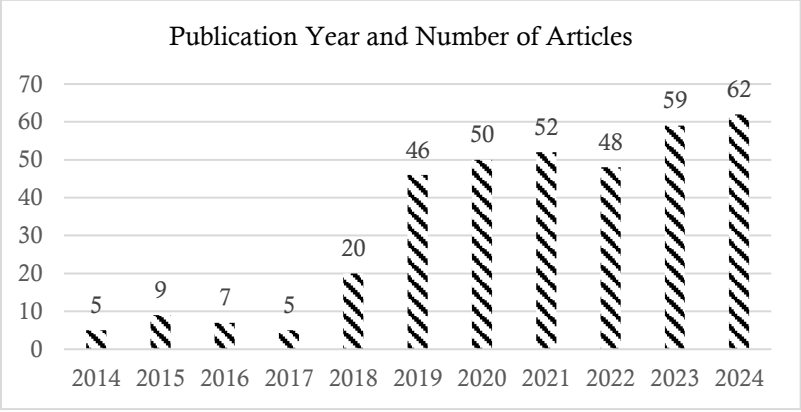

Figure 2
Scientific publications on the topic of Ethnomathematics are analyzed from the year 2014 to 2024 based on the number of articles.

From 2014 to 2017, the number of documents related to Ethnomathematics was relatively low at under 10 documents per year. However, in 2018 there was a significant spike, which was four times that of 2017. In 2017, there were five journal documents with the keyword Ethnomathematics in Scopus. But in 2018 the number reached twenty journals. This indicates that the theme of ethnomathematics-themed research has received special attention from researchers.

It can also be seen based on Figure 2, from 2018 to 2024 research on ethnomathematics from year to year has increased. Although it had decreased in 2022 with forty-eight documents, a year later or 2023 it increased again with the number of documents reaching fifty-nine journals. And the peak in 2024 reached sixty-two documents. If calculated in the past ten years, journals related to ethnomathematics amounted to three hundred and sixty-three documents.

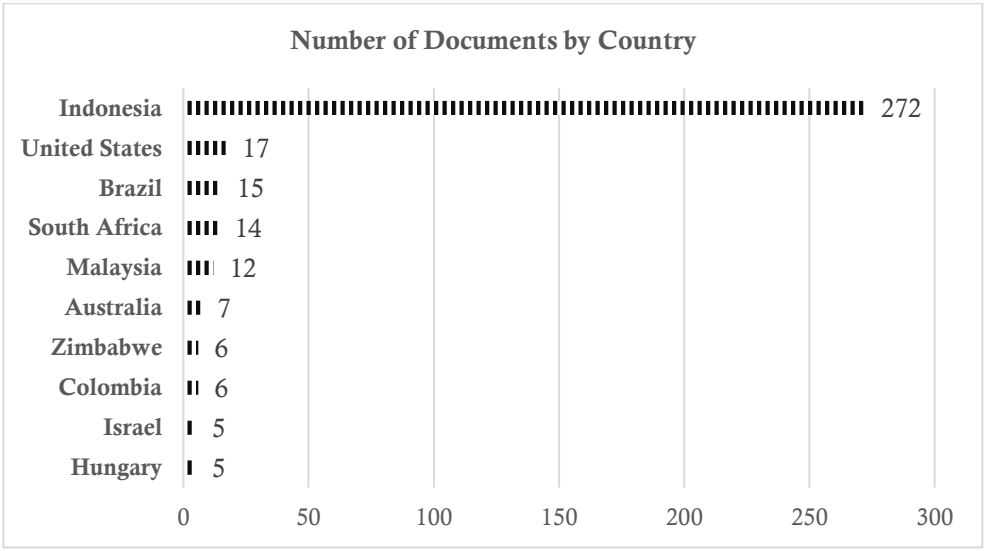

Figure 3
Scientific publications on ethnomathematics analyzed from 2014-2024 according to the country of origin

Of the three hundred and sixty-three journals, Indonesia dominates in the number of documents related to ethnomathematics, namely two hundred and seventy-two journals. This may be related to the many Indonesian cultures that researchers can explore. “Uncle Sam” followed in second place with seventeen documents. Interestingly, Brazil ranked third with fifteen documents. Brazil is the home country of Ubiratan D' Ambrosio. He is a professor from Brazil who first introduced the term ethnomathematics.

Following Brazil in fourth place is South Africa with fourteen documents. Although Malaysia shows lower research activity than South Africa, it remains active in exploring Ethnomathematics. Below Malaysia, there are Australia, Colombia, Zimbabwe, Hungary, and Israel with contributions of six or five

documents indicating that the theme of ethnomathematics is gaining attention globally. Overall, the distribution of Ethnomathematics research shows a stretch in every part of the world, with the prominent dominance of Indonesia, emphasizing the role of the archipelago in advancing educational innovation at the global level. The number of scientific publications in the form of Conference papers dominates as many as 196 articles compared to 167 documents.

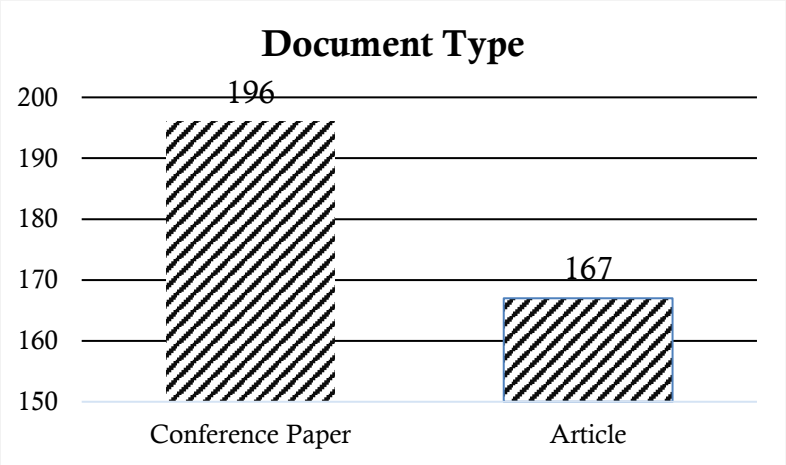

Figure 4
Scientific publications on the topic of Ethomathematics from 2014-2024 by type of publication

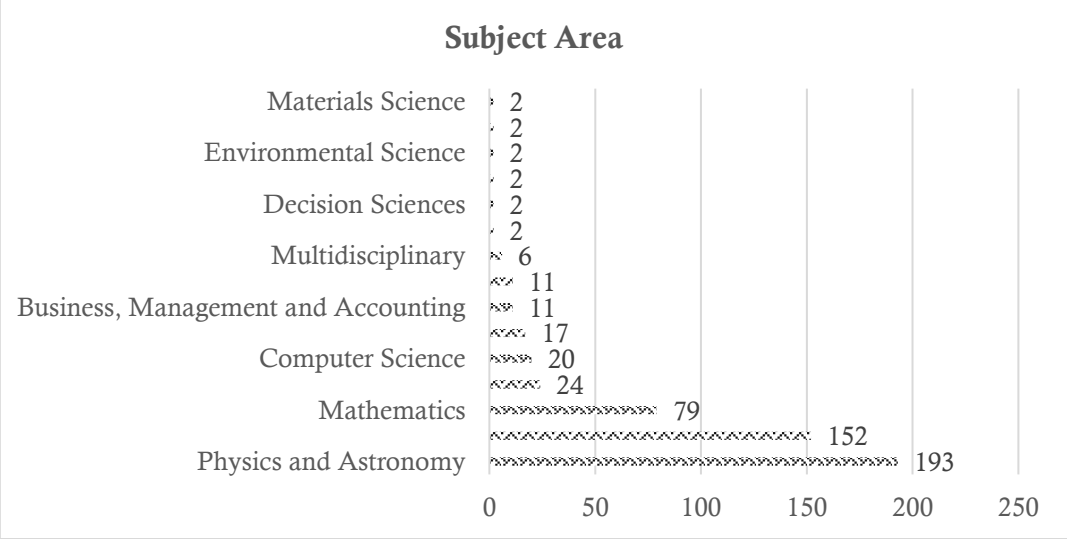

Figure 5
Scientific publications on Ethnomathematics analyzed from 2014-2024 according to the fields of science and mathematics

Based on the graifk or Figure 5, Physics and Astronomy ranked first in the distribution of documents related to ethnomathematics with 193 documents. This is

related because ethnomathematics deals with traditional astronomical knowledge used by various cultures, such as calendar determination based on the movement of celestial bodies or traditional navigation. Less than 50 documents apart from Physics and Astronomy, Social Sciences followed closely behind with 152 publications to be exact.

Social science is also closely related to ethnomathematics as it focuses on the relationship between mathematics and society. Social science also has a big role to play in understanding how mathematics is used in cultural practices, traditions or daily life in different communities. This includes analysis of traditional trading systems, math-based local games or heritage calculation methods.

The subject area of mathematics also received a sizable percentage of 79 articles Ethnomathematics is closely related to the study of how mathematical concepts emerge and are applied in local cultural contexts. Ethnomathematics studies usually involve exploring traditional forms of geometry, number systems in a particular culture, or symmetry patterns in arts and crafts.

Figure 5 shows that most of the documents relate to physics and astronomy, social sciences as well as mathematics. This suggests there is great potential to expand ethnomathematics research, especially in looking at how traditional mathematical concepts contributed to the development of modern science. And if this research is directed towards the social and humanities, more knowledge about traditional mathematics and its applications in local cultures can be documented and preserved.

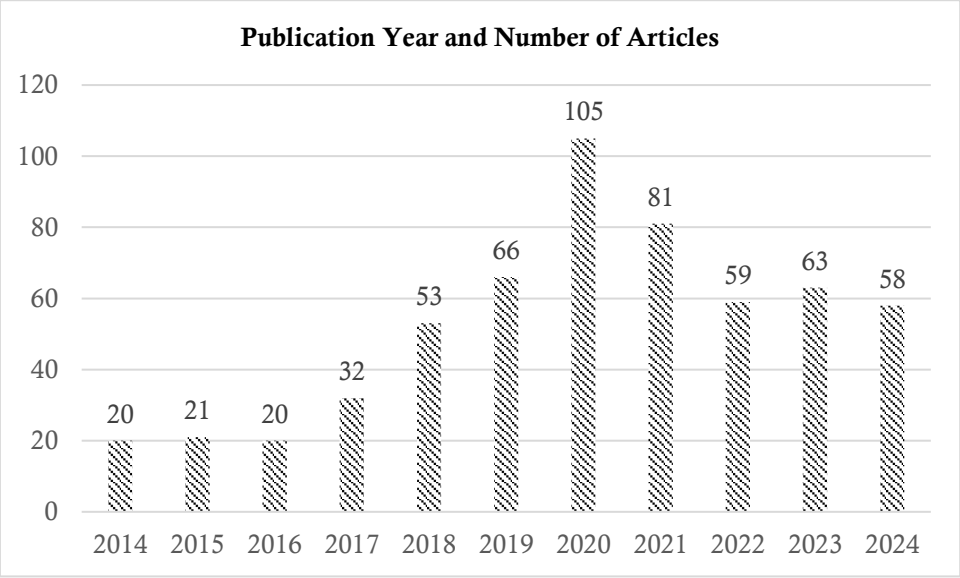

Figure 6

Scientific publications on the topic of Realistics Mathematics Education (RME) analyzed from 2014-2024 by number of articles

The RME Research Trend between 2016 and 2020, indicates a steady increasing trend from 2016 to peak in 2020. This suggests that RME received greater

attention among researchers during this period, which may reflect an increased interest in the application of the RME approach in various global education systems. A separate note in 2020 shows the highest number of documents, with more than 100 publications. This could be attributed to the growing number of studies highlighting the importance of RME in improving the understanding of mathematical concepts through realistic situations. In addition, the COVID-19 pandemic may have encouraged the exploration of innovative teaching methods, including RME approaches in distance education.This upward trend did not continue in the years after 2020.

A decline in the number of documents was seen starting in 2021 and continuing until 2024. Although there is still research production, the decline could reflect various factors such as a shift in research focus to other topics or approaches, or the challenges of implementing RME in the field.

But this state of research decline opens up opportunities for new initiatives to encourage more studies, particularly those that link RME with modern educational innovations. This trend also suggests that perhaps the focus has shifted from basic research towards implementation in the field. Future research may focus more on the effectiveness and long-term impact of RME.

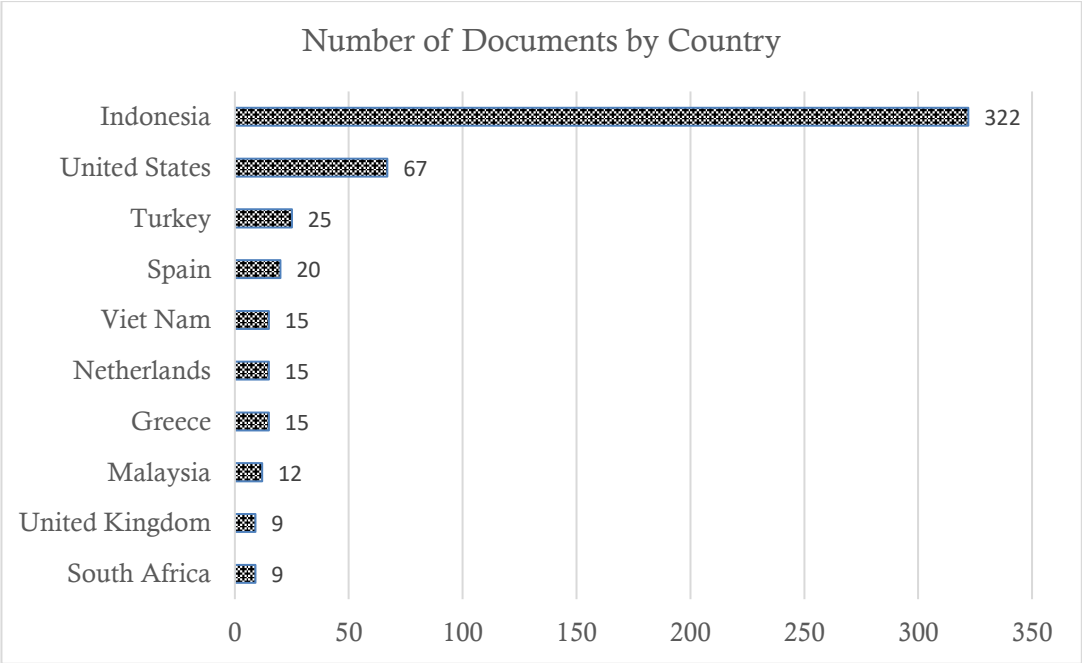

Figure 7
Realiatics Mathematics Education (RME) scientific publications analyzed from 2014-2024 by country of origin. Only the top 10 countries with the highest number of RME publications are shown in the figure

Figure 7 above, shows the number of RME (Realistic Mathematics Education) themed documents or journals by country or region. Indonesia tops the list with over 300 documents, reflecting the popularity and amount of research on RME in the country. The United States comes in second with around 100 documents, showing

significant though smaller interest than Indonesia. Meanwhile, countries such as Turkey, Spain, Greece, the Netherlands, Vietnam, Malaysia, South Africa and the United Kingdom have a much smaller number of documents, under 50 each.

The Netherlands, as the country of origin of RME development, has a relatively small number of documents compared to Indonesia. This may be because the RME approach has been integrated into educational practice in the Netherlands, so less new research has been conducted. Overall, Indonesia dominates the number of publications related to RME, reflecting the great interest and application in realistically based mathematics education, which is likely driven by national education policies or programs. However, other countries also show significant interest, albeit on a smaller scale. Based on Figure 8, the number of scientific publications in the form of journals dominates with 319 articles compared to conference papers with 260 documents.

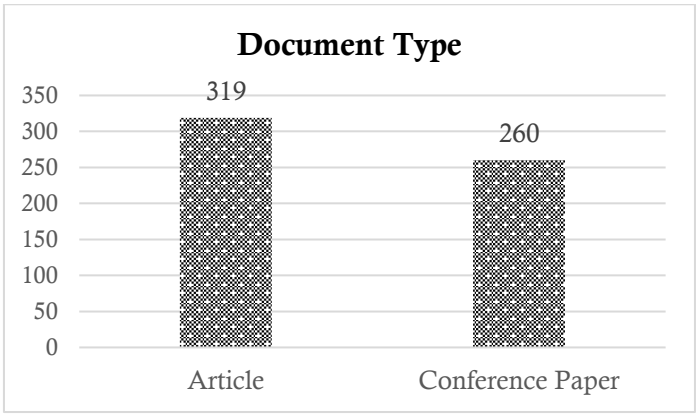

Figure 8
Scientific publications on the topic of RME from 2014-2024 by type of publication

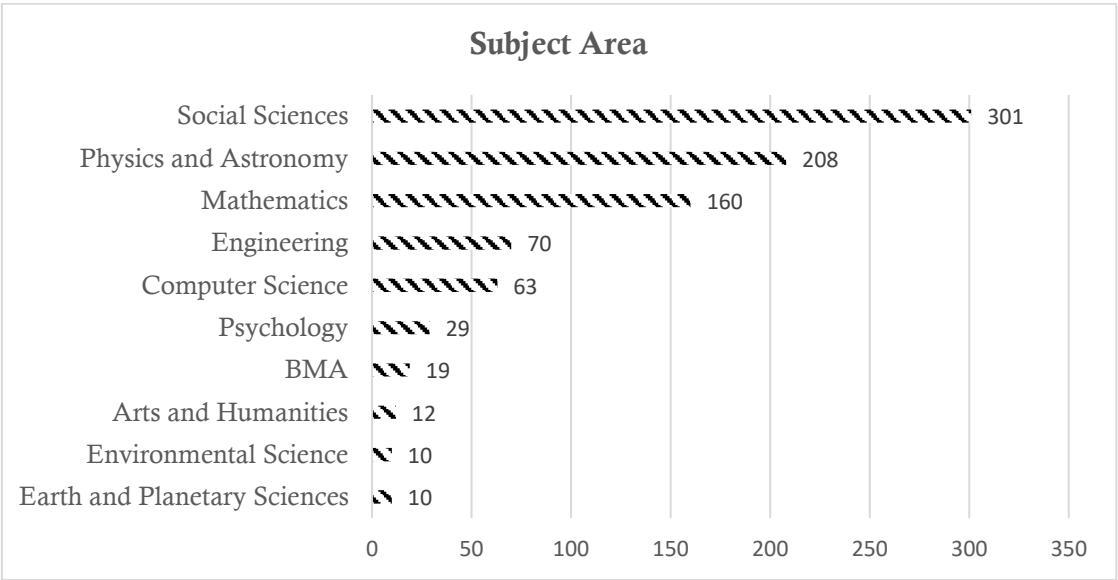

Figure 9
Scientific publications on Ethnomathematics analyzed from 2014-2024 according to Subject Area

Based on the pie chart visualization above or Figure 9, most of the documents with RME themes are in the Social Science field (32.2%), with 301 articles indicating that this approach is often explored in social, educational and policy contexts related to mathematics teaching. Physics and Astronomy came second with 22.2% or 160 documents, indicating that the RME approach is also used in natural science applications. Mathematics itself came in third with 17.1% (160 publications), reflecting the main focus of the approach in formal mathematics education.

Other fields that contributed publications were Engineering (70 articles), Computer Science (63 articles), and Psychology (29 articles), indicating the cross-disciplinary application of RME. Meanwhile, fields such as Business and Management (19 articles), Arts and Humanities (12 articles) and Earth and Environmental Sciences contributed less than 2% or 10 documents each. The contribution from the "other" field of 5.7% indicates that RME is also applied in areas that are not explicitly mentioned. This analysis shows that RME is not only used in mathematics education, but also has wider applications in various disciplines.

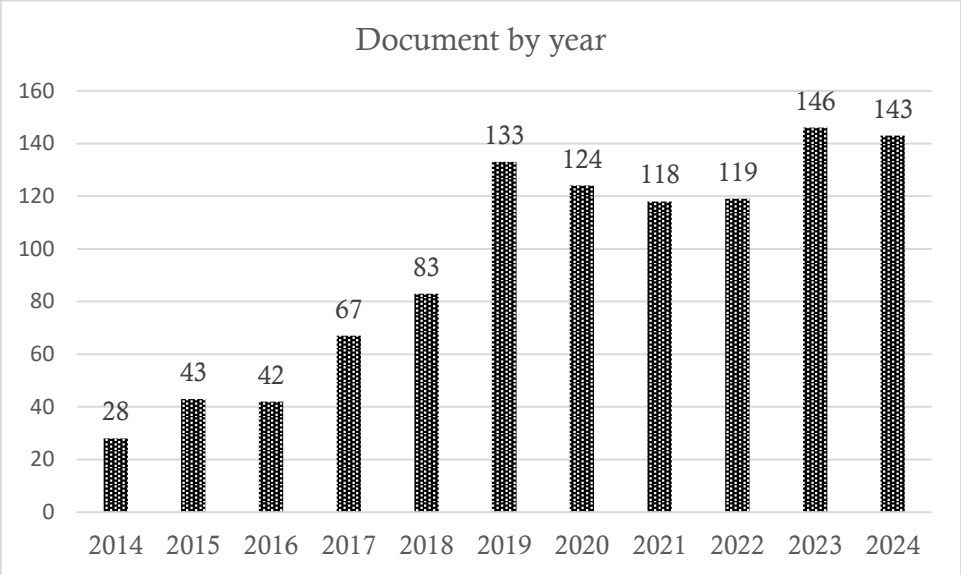

Figure 10
Document by year in literacy mathematics

Based on Figure 10 above, the number of mathematical literacy-themed documents experienced an increasing trend from 2014 to 2024. In 2014, the number of publications was quite low, around 25 documents. This number has consistently increased every year, especially in the period 2017 to 2019, where there was a significant spike to reach around 150 documents in 2019. This indicates a growing interest in mathematical literacy research during this period.

After the peak in 2019, the number of documents was seen to decrease slightly and stagnate in 2020 to 2021, but remained above the 100 document mark. This decline may be due to global disruptions such as the COVID-19 pandemic

impacting research production and academic publications. However, interest in this theme remains stable, reflecting the importance of mathematical literacy in global education and policy despite external challenges.

In 2022 to 2024, the number of documents again shows an upward trend. This increase may reflect the recovery of research activity after the pandemic as well as the growing attention to mathematical literacy as an important component of 21st century education. With the increasing need for critical thinking and numeracy skills, mathematical literacy has become one of the main focuses in many international education policies.

Overall, this graph reflects that mathematical literacy continues to be a relevant and important topic in research. The trend of increasing publications from year to year, despite some stagnation, shows the commitment of the academic community to explore this topic more deeply. With the global context increasingly emphasizing numerical literacy-based education, mathematical literacy is expected to remain a key focus in the future.

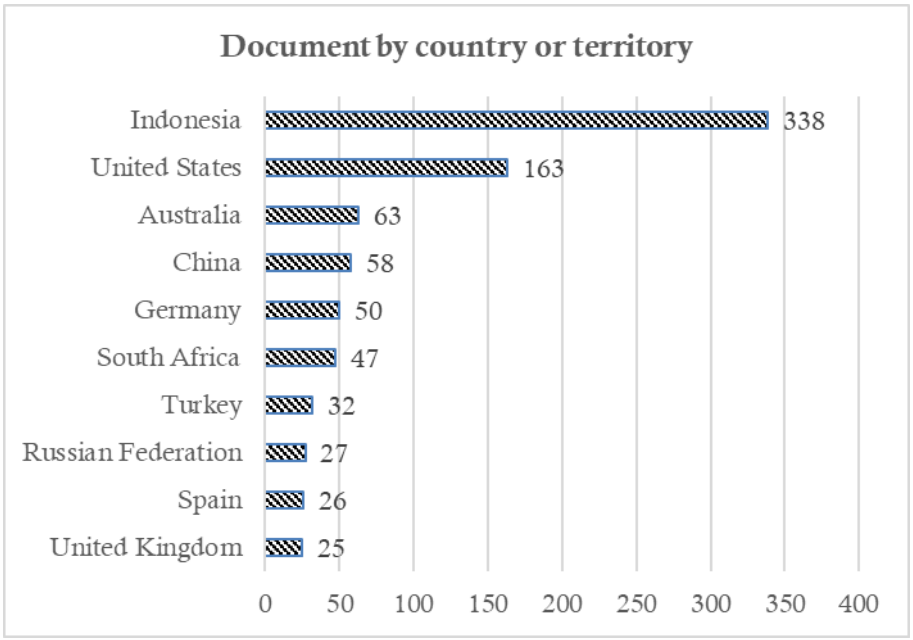

Figure 11

Mathematics Literacy scientific publications analyzed from 2014-2024 by country of origin. Only the top 10 countries with the highest number of RME publications are shown in the figure

Figure 11 above, shows the number of documents or journals themed on Mathematical Literacy by country or region. Indonesia tops the list with over 338 documents, reflecting the popularity and abundance of research on Mathematical Literacy in the archipelago. The United States comes in second with around 163 documents, showing significant though smaller interest compared to Indonesia. Meanwhile, countries such as Australia, China, Germany, South Africa, Turkey, Russia Spain and the UK have a much smaller number of documents, under 65 each.

However, Mathematical Literacy research activities remain active in their countries. This also negates the global concern about mathematical literacy. Overall, the distribution of Mathematical Literacy research shows activity in every part of the world, with Indonesia's dominance standing out, confirming the archipelago's role in advancing educational innovation at the international level. Based on Figure 12, the number of scientific publications in the form of journals dominates with 652 articles compared to conference papers with 394 documents

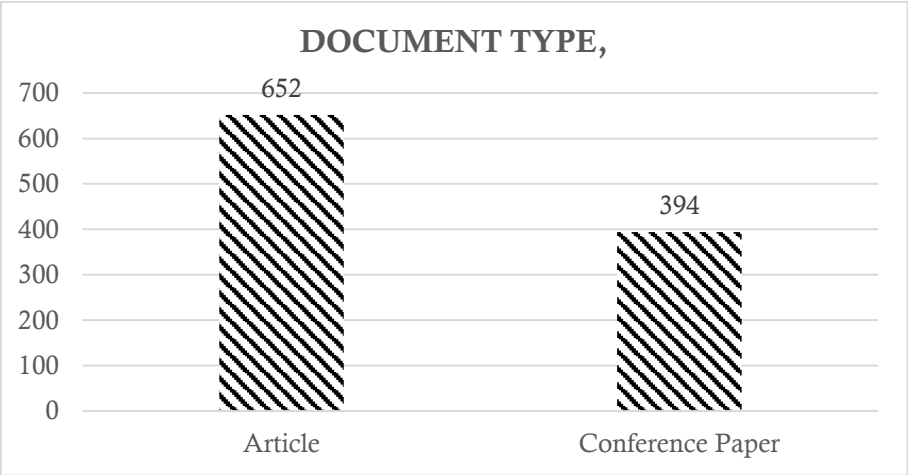

Figure 12
Document Type

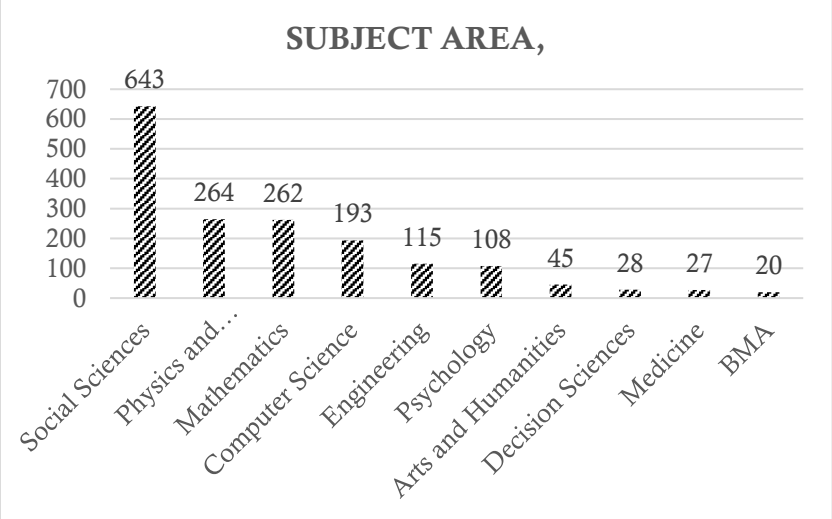

Figure 13
Subject Area

Based on the graph of the distribution of documents by subject area related to mathematical literacy, it can be seen that this study covers various disciplines with different proportions. Social Science dominates with 35.7% (643 document), which shows that social aspects play an important role in the study of mathematical literacy. This reflects the focus on how mathematical literacy affects social life, educational policy and community development. This approach often explores how

individuals or groups use math skills in social contexts, such as decision-making, economics and everyday interactions.

Physics and Astronomy and Mathematics have almost equal shares, 14.7% (264 document) and 14.5% respectively (262 document). This shows that mathematical literacy is also explored in depth in both pure and applied scientific contexts. In physics and astronomy, mathematical literacy plays an important role in understanding complex concepts, such as measurement, calculation and data analysis. Meanwhile, within the field of mathematics itself, research focuses more on developing effective teaching methods to improve students' mathematical literacy skills, both in understanding basic concepts and applying them in real situations.

The Computer Science field accounted for 10.7% (193 document), which shows that mathematical literacy is also closely related to technology and programming. It involves logical thinking, problem solving and data analysis skills, all of which are key components in computer science. With increasing digitization and technology, mathematical literacy skills are becoming increasingly important for understanding algorithms, artificial intelligence and big data management. This reflects the need for synergy between math education and information technology in the modern world.

Finally, several other fields such as Psychology (6.0% or 108 document), Engineering (6.4% or 114 document), and Arts and Humanities (2.5% or 45 document) show that mathematical literacy is multidisciplinary. Psychology might explore how math skills affect cognitive development, while engineering requires math literacy for project design and analysis. Arts and humanities also show links, for example in the analysis of patterns, symmetry, or even the application of math in music and design. This graphic confirms that mathematical literacy is not only important in science and education, but also has far-reaching impacts across different aspects of human life

NETWORK VISUALIZATION

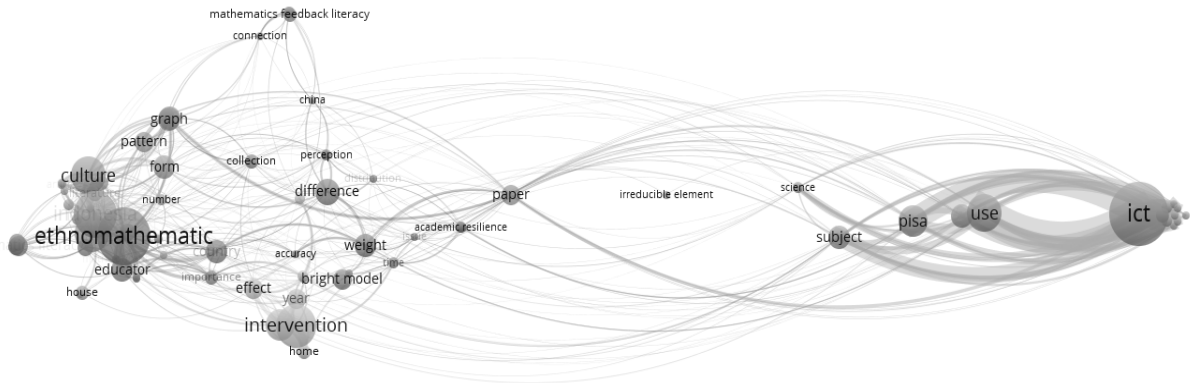

Figure 14
Network Visualization on VOS Viewer

Ethnomathematics plays an important role in connecting mathematical concepts with local cultures. In the VOS Viewer graph, ethnomathematics (red cluster) has a close relationship with concepts such as culture, pattern and graph. This shows that mathematics does not stand alone, but is part of the cultural practices inherited in society. Through an ethnomathematics approach, students can understand that mathematical patterns do not only appear in the classroom, but also in their traditions and daily lives (Mania & Alam, 2021).

Mathematical literacy, as seen in the green cluster, focuses on students' ability to apply mathematical concepts in a variety of real situations. Terms such as academic resilience and effect indicate that mathematical literacy is more than just understanding concepts - it includes critical thinking and problem-solving skills in real contexts. The relationship between mathematical literacy and ethnomathematics suggests that by integrating cultural contexts, students can more easily develop deep and meaningful mathematical literacy (Runtu et al., 2023).

The Realistic Mathematics Education (RME) approach also has a strong relationship with mathematical literacy and ethnomathematics. Although RME does not explicitly appear in the graph, concepts such as intervention and academic resilience indicate a reality-based learning approach. RME emphasizes the importance of using real situations in mathematics learning, which is in line with ethnomathematics' goal of bringing cultural realities into the classroom. By connecting mathematical theories with everyday experiences, students can better understand abstract concepts (Cendekiawaty & Sugiman, 2020).

Overall, this graph illustrates that ethnomathematics, mathematical literacy and RME complement each other in creating a more contextualized and relevant learning experience. Ethnomathematics provides a cultural base, mathematical literacy ensures conceptual understanding, and RME connects the two through real situations. This integrative approach not only improves students' understanding, but also makes mathematics more inclusive and appropriate to the needs of their society (Fauzan, Plomp, & Gravemeijer, 2013).

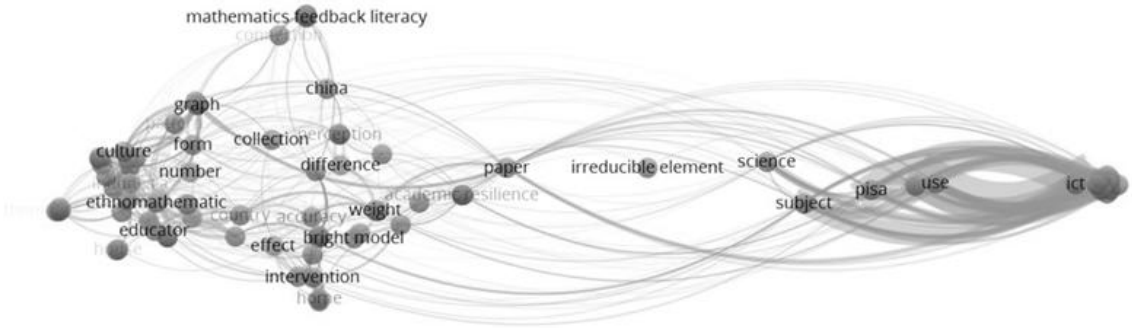

Figure 15
Overlay Visualization

Ethnomathematics in Mathematics Education

In this overlay visualization, ethnomathematics (shown on the left side of the graph) has strong connections with concepts such as culture, pattern and educator. These connections indicate that ethnomathematics plays an important role in understanding

how local culture can be an effective mathematics learning tool. Through cultural contexts, students can relate mathematical patterns and concepts to their daily lives, ultimately increasing their relevance and understanding of mathematics (D'Ambrosio & Rosa, 2017).

Mathematical Literacy and Concept Connectivity

Mathematical literacy is seen in the center of the graph, connected with terms such as difference, effect and academic resilience. This shows that mathematical literacy includes not only the understanding of concepts, but also the ability to apply them in various contexts and social situations. The integration of mathematical literacy with ethnomathematics provides a foundation for students to understand cultural differences in mathematical approaches, enriching their perspective on the application of mathematical concepts in various real-life scenarios (Fouze & Amit, 2017).

RME and Realistic Contexts

Although the term RME is not immediately apparent, concepts related to reality-based education, such as intervention and academic resilience, confirm the basic principles of RME. RME focuses on applying mathematics in real and relevant contexts, creating strong connections between formal knowledge and students' everyday experiences. This relationship is reflected in the graph through connections between cultural context (ethnomathematics) and understanding of mathematical concepts (mathematical literacy), confirming the importance of a realistic approach in mathematics education (Gravemeijer & Doorman, 1999).

Integrative Linkages and Educational Implications

This visualization shows that ethnomathematics, mathematical literacy and RME support each other in creating a more inclusive and culturally relevant mathematics education. The integration of ethnomathematics allows students to see mathematics as part of their daily lives, while mathematical literacy ensures that they have the skills to apply this knowledge. The RME approach then connects the two by utilizing real-world contexts as learning media, creating meaningful and contextualized learning experiences (Fauzan, Plomp, & Gravemeijer, 2013).

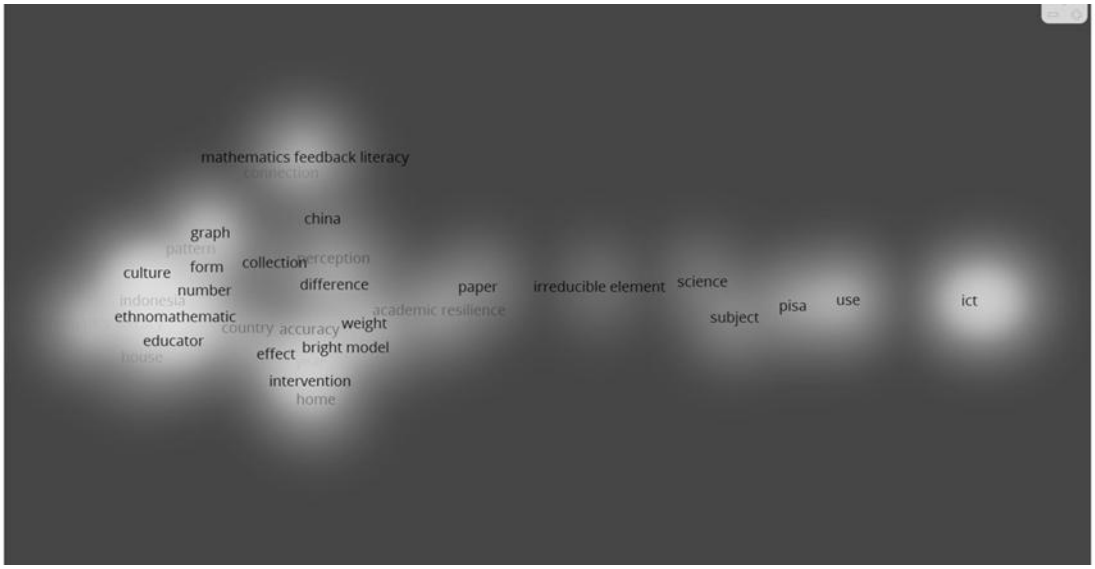

Figure16
Density Visualization

Density of Ethnomathematics Concept

In the density visualization, the area with bright yellow on the left side of the graph indicates a high focus on the concept of ethnomathematics. Keywords such as culture, number, and educator are closely interconnected, emphasizing the importance of cultural aspects in mathematics education. Ethnomathematics provides an understanding that mathematics is inseparable from cultural context, where mathematical patterns and concepts can be found in the daily lives of local communities (Hendriyanto et al., 2023; Turmuzi, Suharta, & Suparta, 2023). This shows that using culture as a context in mathematics education can enrich students' learning experiences.

Mathematical Literacy and Concept Integration

In the middle section of the graph, there is a strong connectivity between mathematical literacy and concepts such as difference, effect, and academic resilience. This density reflects the importance of mathematical literacy in helping students understand and apply mathematical concepts in various situations. Mathematical literacy is not just about numeracy skills, but also about how students connect mathematical concepts with real-world challenges (García-García & Dolores-Flores, 2021). Strong mathematical literacy allows students to develop better critical thinking and problem-solving skills.

Education (RME) and Realistic Context

Although RME is not explicitly mentioned, concepts such as intervention and academic resilience demonstrate elements of RME. The RME approach emphasizes the importance of real contexts in mathematics teaching, helping students connect everyday experiences with abstract concepts (Sitorus, 2016; Tong et al., 2022). In this graph, the interconnection between these concepts shows that a realistic approach in mathematics education strengthens students' ability to understand and apply mathematical knowledge contextually, especially when integrated with cultural elements from ethnomathematics.

Integration of Ethnomathematics, Mathematical Literacy, and RME

Overall, this density visualization shows that ethnomathematics, mathematical literacy, and the RME approach support each other in creating inclusive and contextual mathematics education. This integration allows students to develop a deeper understanding of mathematics by viewing it as part of culture and daily life. This approach also helps students improve their mathematical literacy, especially in understanding the application of mathematics in real contexts and local culture, creating a relevant and meaningful learning environment (Kurniawan, Purwoko, & Setiana, 2023; Manfreda Kolar & Hodnik, 2021).

CONCLUSION AND IMPLICATION

The analysis of the relationship between ethnomathematics, mathematical literacy, and Realistic Mathematics Education (RME) highlights the importance of a holistic approach to mathematics learning that integrates cultural context, literacy skills, and the application of concepts in real-life situations. Ethnomathematics emphasizes local cultural values, helping students understand the relevance of mathematics in everyday life, while mathematical literacy focuses on the ability to comprehend, interpret, and apply mathematical concepts critically. RME supports this by using real-world situations to

bridge abstract concepts and students' experiences. The integration of these three approaches creates relevant, contextual, and inclusive learning, enhancing students' understanding of mathematics and their ability to apply it in real-world contexts.

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