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Mapping research trends in ethnomathematics within mathematics education: A bibliometric study

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Abstract:
Ethnomathematics integrates cultural values and local knowledge into mathematics education, fostering contextual and inclusive learning. However, a comprehensive mapping of its scholarly development is still lacking, prompting the need for a bibliometric analysis to explore its contributions and future directions. This study analyses the development of ethnomathematics studies in education using a bibliometric approach based on data from Scopus during the period 2009–2024. This study aims to identify publication trends, authors, publishers, and influential journals, including patterns of relationships between keywords, collaboration between authors, and geographical distribution of publications. The identification results are used to see an overview of the contribution and implications of ethnomathematics in mathematics education. A total of 254 selected articles were analysed using the PRISMA model, R software with the biblioshiny package, and the VOSviewer application. The analysis results show growth with Indonesia as the most significant contributor. The dominant keyword is Ethnomathematics, which focuses on cultural integration in mathematics teaching. This study emphasises the importance of the ethnomathematics approach in improving students' understanding and learning outcomes, enriching cultural insights, and strengthening international collaboration in educational research. The results also show that ethnomathematics has received growing attention in mathematics education research, as reflected in the increasing number of publications and thematic focus in recent years. Recommendations for further research include a deeper exploration of the values of ethnomathematics and its effectiveness in learning.

Keywords: Bibliometric; Ethnomathematics; Mathematics Education; Research Trends.

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Introduction

Rapid technological advances in the modern era have significantly impacted the transformation in various areas of life, including culture. However, the success of technological innovation depends on the influence of the socio-cultural environment and the perceptions of each individual who receives it (Tverskoi et al., 2022). Technological development has positive and negative impacts because it can determine social development and cultural values in society (Pan & Kwon, 2023). The broader influence of technological development can help societies within a country become more innovative by leveraging the positive aspects of culture that support creativity and change (Saldanha et al., 2021). Thus, technological development can maximise its role in various fields, including education, producing a future golden generation.

In education, technological developments must be balanced with integrating cultural values to ensure students' attitudes and behaviours align with prevailing norms. Given that Indonesia is a nation rich in culture (Alfarisi et al., 2023), teacher competence in integrating cultural attitudes and values into education is essential for students to understand them from elementary school (Supriyadi et al., 2024). Furthermore, instilling cultural values early in education can help students improve their character and positively influence the quality of their future generations (Astawa & Jendra, 2022). It is supported by research suggesting that multicultural-based learning can improve students' critical thinking skills, character development, and emotional intelligence (Praswanti et al., 2023). Therefore, in the context of mathematics education, ethnomathematics exists as a learning approach that integrates mathematical concepts with local cultural contexts, enabling students better to understand the role of mathematics in their daily lives.

Mathematics is an abstract science, requiring a unique approach to understanding it to help students grasp it. This situation demands a learning approach that can bridge mathematical concepts with students' realities. Ethnomathematics presents one solution because it focuses on understanding the relationship between culture and mathematics simultaneously (Thomas & Jacob, 2021), thus making it easier for students to grasp mathematical concepts more concretely. Ethnomathematics involves incorporating non-formal mathematics, such as traditional mathematics, into the classroom to improve student academic achievement (Fouze & Amit, 2021). Based on this, numerous studies have shown that ethnomathematics has been proven to significantly contribute to enhancing students' understanding and learning outcomes in mathematics (Herawaty, Sarwoedi, et al., 2019; Herawaty, Widada, et al., 2019; Kencanawaty et al., 2020). By presenting culture-based mathematics, students are encouraged to understand abstract concepts and learn the practical uses of mathematics in everyday life. This approach is expected to increase conceptual understanding, learning motivation, and foster appreciation for local cultural values.

Ethnomathematics offers a unique and relevant learning approach within a local cultural context. Cultural integration in mathematics teaching has increased student motivation and engagement, signalling a potential shift towards more inclusive educational practices (Supriyadi et al., 2024). Applying ethnomathematics also plays a role in developing students' positive character, encompassing academic, social, and moral aspects (Payadnya & Jayantika, 2022). Furthermore, the ethnomathematics approach is considered more easily accepted by students because the learning material directly relates to their background and everyday environment (Mairing et al., 2024).

Thus, ethnomathematics enriches students' mathematical understanding while fostering a love of their homeland and preparing the younger generation to preserve cultural heritage and contribute to the nation's progress.

Numerous studies have examined ethnomathematics in learning, focusing on cultures from various regions worldwide. Some of these studies include the architecture of traditional Sasak houses in Indonesia (Fauzi et al., 2022), Filipino folk games (Abay & Parola, 2024), and geometric shapes in carpet motifs, Pictures, mosque ornaments, and local clothing in Turkish culture (Ergene et al., 2020). In addition to these specific studies, several comprehensive studies have been conducted using a systematic review or scoping review approach. Batiibwe and Sarah (2024) systematically reviewed 61 articles from various databases to identify the role of ethnomathematics in mathematics education, while Sunzuma & Umbara (2025) examined ethnomathematics-based technology in Indonesia. Kyeremeh et al. (2023) also systematically reviewed the integration of ethnomathematics in geometry learning. Although these studies make essential contributions to understanding ethnomathematics from various perspectives, they still have limitations in terms of global coverage and analysis of research development patterns.

Previous studies have several limitations that need to be addressed. First, most existing systematic or scoping reviews focus on specific geographic contexts or topics, thus failing to provide a global picture of the development of ethnomathematics research. Second, although bibliometric studies such as Deda et al. (2024) examine publication trends in ethnomathematics between 2012 and 2022, these studies have not yet thoroughly analysed patterns of international collaboration, the geographic distribution of publications, and the contributions of various countries to the development of ethnomathematics. Therefore, a more comprehensive bibliometric analysis approach is needed to address these gaps.

Bibliometric analysis is an effective tool to overcome the limitations of previous studies by providing insight into scientific contributions and research developments by identifying research trends in related fields (Sumiharsono et al., 2023). The analysis can be descriptive, looking at the number of published articles, or evaluative, analysing citations to determine the influence of these articles on further research (McBurney & Novak, 2002). The results of bibliometric analysis are maps that can be visualised in the form of tables and Pictures to facilitate researchers in understanding the relationships between various aspects of the identified studies (Çağlayan Akay et al., 2022; Wulandari et al., 2023). This approach allows for identifying keyword co-occurrence patterns, analysing collaborations between authors, and mapping publication distribution by country. It can provide a comprehensive picture of the dynamics of ethnomathematics research development globally. This study uses bibliometric analysis to explore the application of ethnomathematics in learning more broadly and comprehensively than previous studies.

This study emphasises research trends related to ethnomathematics in ethnomathematics learning in learning with its main research questions, including: (1) How has the number of publications and citations related to ethnomathematics in learning developed over time?; (2) Who are the most influential authors, publishers, and journals in ethnomathematics research based on the number of publications and citations?; (3) What are the 10 most influential publications based on the number of

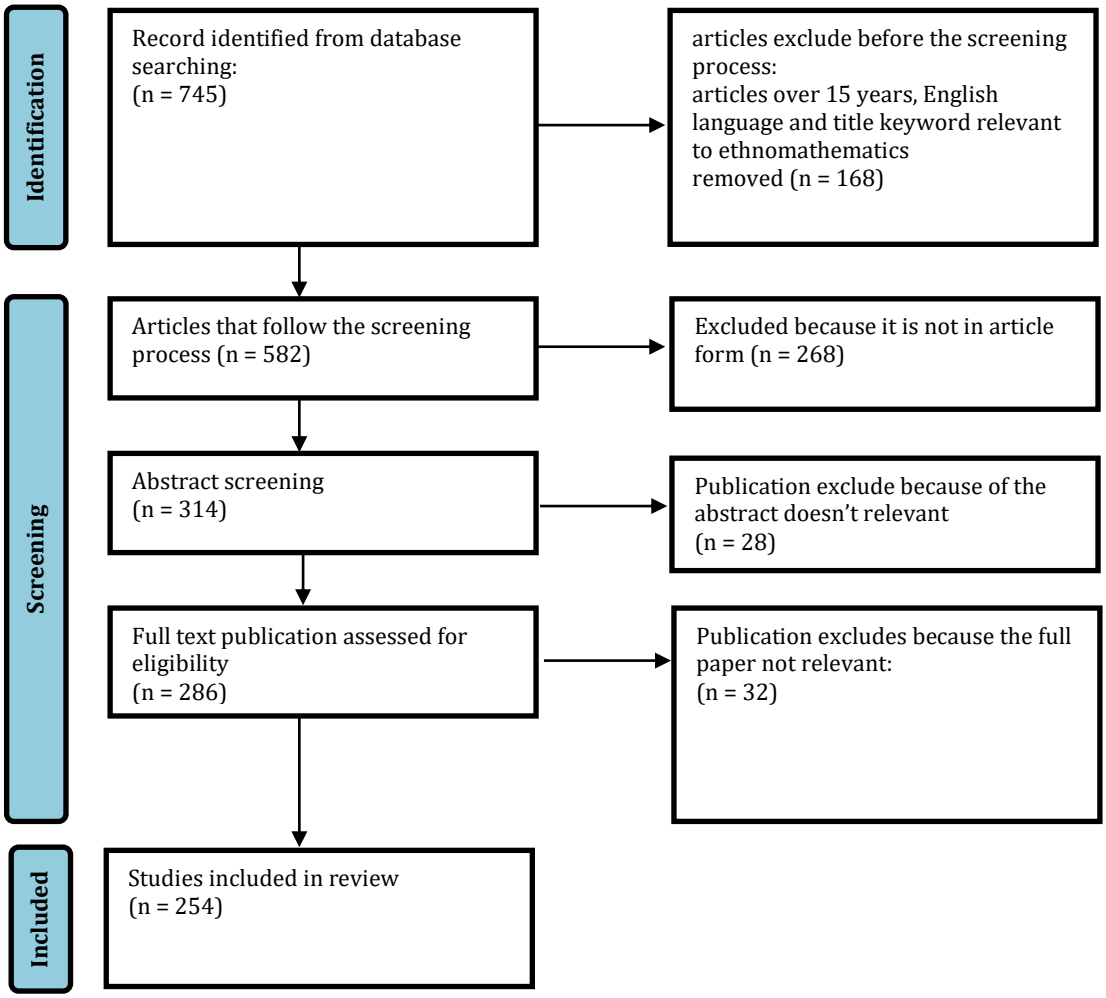
citations, and how have they impacted the development of ethnomathematics?; (4)What is the pattern of relationships between keywords (co-occurrence) in ethnomathematics research, and what topics are most often studied together?; (5)What are the patterns of collaboration between co-authors and distribution of publications by country?; and (6) How does ethnomathematics contribute to mathematics education?. The research questions above will provide a comprehensive overview of the landscape of ethnomathematics research in learning and help in understanding the future development of ethnomathematics.

Methods

This study is a bibliometric study of research trends related to ethnomathematics. Bibliometrics are widely used by researchers for several reasons, namely to find out article trends, research constituents, and what forms of collaboration occur in the research field. Using bibliometrics will help in knowing the development and dynamics of research on a global scale (Donthu et al., 2021; Zahra et al., 2021). Data collection in bibliometric research has many trusted sources in the academic field, such as Scopus, Web of Science, and Google Scholar, all of which are the primary databases in scientific literature publications (Pham et al., 2024). In this study, the dataset used came from the Scopus dataset.

This review uses only data from Scopus due to its consistent indexing and metadata quality. However, this approach could include relevant studies from other databases such as WoS, DOAJ, or Google Scholar, particularly those of a regional or non-English nature. Future research is recommended to utilise multiple databases for more comprehensive results. Data from the Scopus dataset were then screened to identify articles that met the established research criteria. The criteria used in this study were that they must be related to ethnomathematics, published between 2009 and 2024, and published in articles. The PRISMA model was used in this study to ensure data validity and reliability (Ciptono & Noviasari, 2023). The first step was identifying articles related to the keyword "ethnomathematics" in the Scopus database, resulting in 745 articles. The articles were then listed based on the years 2009 to 2024, resulting in 582 articles for screening. The next stage was to filter the publication type. The publication format used in this study must be articles. Therefore, the screening process resulted in 268 articles and 314 articles being included in the screening. An analysis was then conducted based on the abstracts for relevance to ethnomathematics, resulting in 28 irrelevant articles and a final selection of 286.

Next, an assessment was conducted on articles that passed the second screening stage. This stage involved a feasibility test to determine whether the published articles honestly discussed ethnomathematics and were not publications related to the study. At this screening stage, the author selected articles by reading each, resulting in 254 articles being included and 32 being excluded. The feasibility test results indicated that all articles that passed the second stage were worthy and honestly discussed ethnomathematics. In the fourth stage, 254 articles from the Scopus dataset were used to determine research trends related to ethnomathematics. A diagram of the screening stage can be seen in Picture 1.



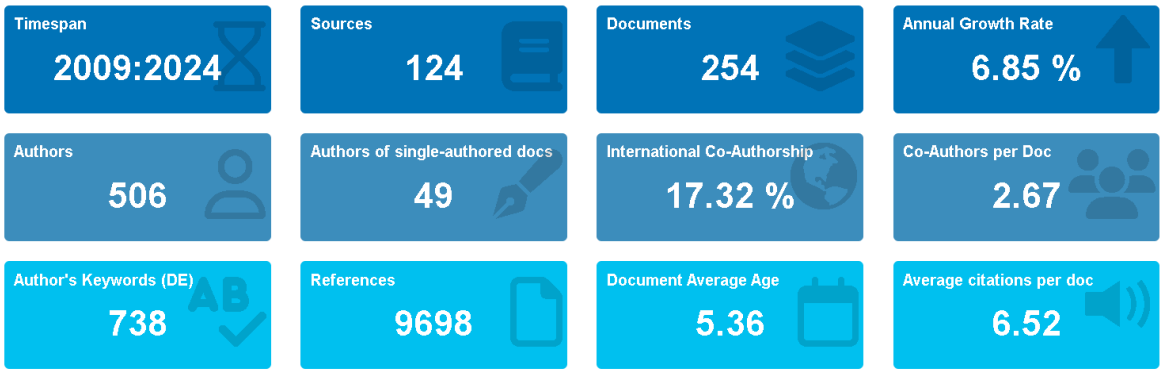
Picture 1. Flowchart of PRISMA Model Criteria

In this study, researchers use bibliometric analysis to conduct data analysis. In this study, researchers focus on publication trends related to ethnomathematics. What is seen is the trend of research publications related to the topic of ethnomathematics from 2009-2024. In addition, an analysis will also be carried out on which countries publish the most with ethnomathematics and the collaboration of published articles. In addition, it is also essential to see how keywords are often used in research related to ethnomathematics and what ethnomathematic topics are frequently cited by researchers. The analysis in this study used the R program with the biblioshiny package. Biblioshiny's results display publication trends in graphs, keyword analysis, and co-occurrence, making it highly suitable for bibliometric research. Furthermore, to deepen the relationship between keywords, the Vosviewer application was used to understand the relationship between each topic in depth.

Results and Discussion

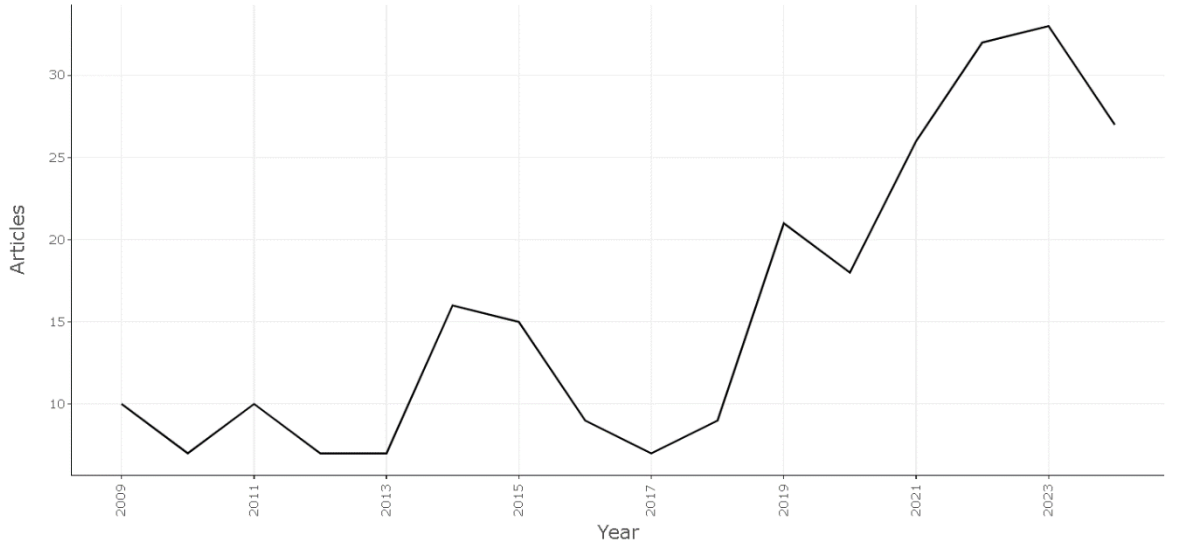
The following research results are the results of a bibliometric analysis using the R program, which are displayed according to the research questions. The results displayed

will be able to answer research questions related to trends in ethnomathematics research, as well as map the results of the relationship between each article based on keywords with the help of Vosviewer. The analysis results, such as the main information, can be seen in Picture 2.



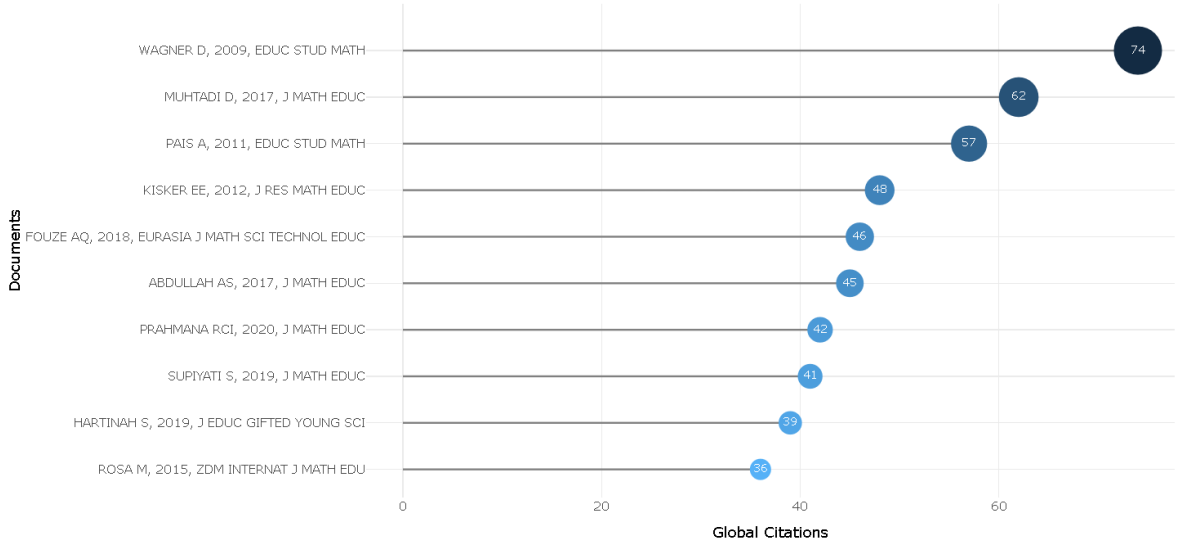
Picture 2. Main Information

Picture 2 provides an initial summary of the bibliometric analysis related to ethnomathematics of 254 documents published from 2009 to 2024. There are 124 contributing sources with 506 authors, 49 single. Documents with collaboration between authors in each country show a percentage of 17.32% while the total number of references cited is 9698. The annual growth of identified publications shows a positive trend of 6.85%. This percentage shows that publications related to ethnomathematics in education have increased during this period, indicating that this topic is getting more attention among scholars. It reflects the relevance of ethnomathematics in education as an essential and growing study. Furthermore, the trend of publications related to ethnomathematics can be seen in Picture 3.



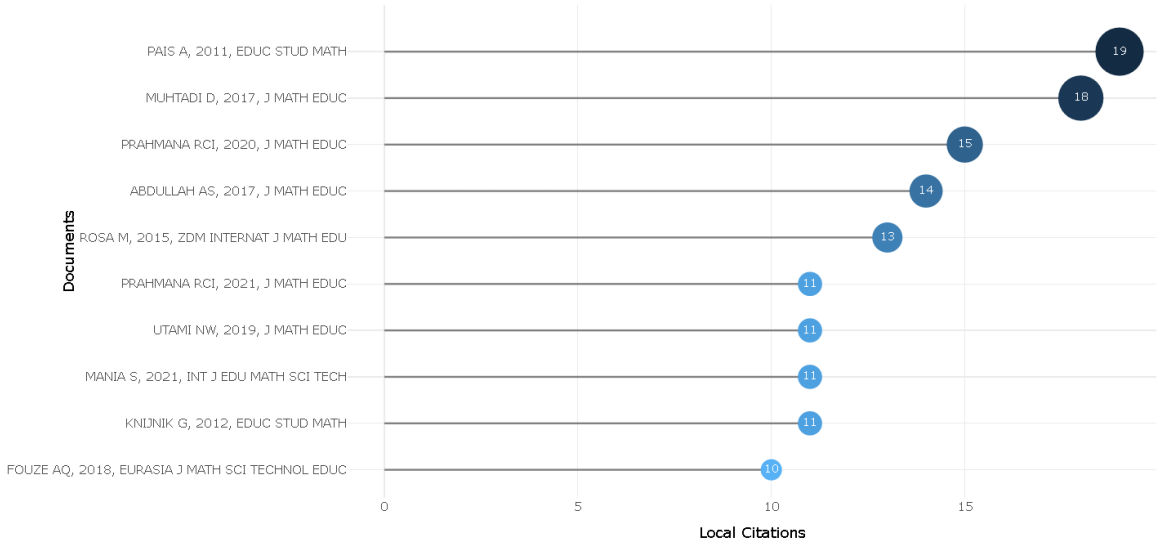
Picture 3. Publication Trend

Picture 3 shows the trend of publications related to ethnomathematics in education, showing fluctuations over the past decade. From 2009 to 2024, publications in this field experienced an upward trend. In 2023, the increase in the publication trend was significant. Furthermore, after learning about the trend of research related to ethnomathematics, Picture 3 displays the results of the 10 most cited articles related to ethnomathematics.



Picture 4. Top 10 Global Citations

Picture 4 The most cited documents globally in the context of ethnomathematics studies are shown in Picture 4. The most cited document is Wagner D's publication published in the journal Educational Studies in Mathematics in 2009, with 74 citations. Muhtadi D's publication in the Journal of Mathematics Education in 2017 became the second with 62 citations. Followed by the publication Pais A in third place with 57 citations. The more a document is cited, the more it indicates its impact or influence on other documents that cite it (Belter, 2015). The results related to 10 papers with authors from Indonesia who are the most included in the top 10 are quoted on a local scale, as shown in Picture 5.



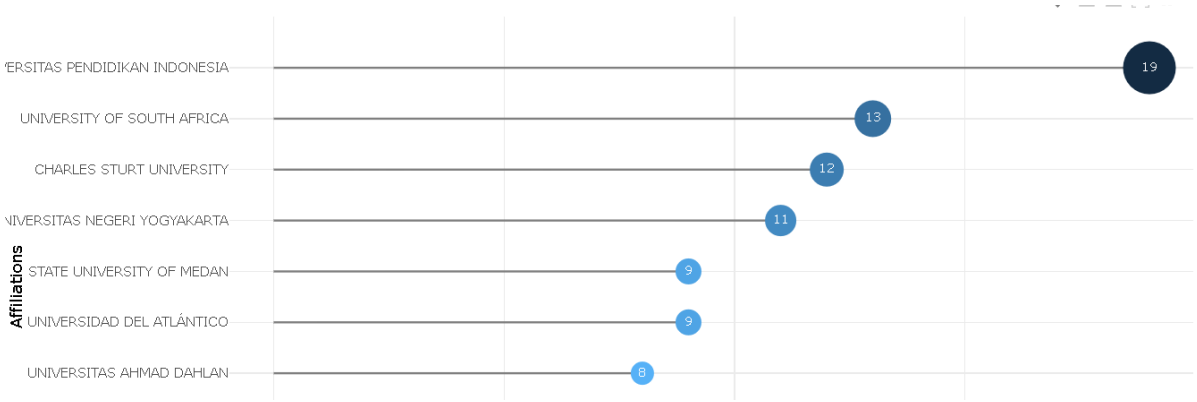
Picture 5. Top 10 local citations

Picture 5 shows the most cited documents on a local scale. The first rank is shown by the publication by Pais A, published in the Educational Studies in Mathematics Journal in 2011, with 19 citations, followed by the publication of Muhtadi D with 18 citations. At the same time, the third position is the publication of Prahmana RCI, which has been cited 15 times. The significance of these authors implies that their contributions tackle essential and urgent matters in mathematics education in local or regional settings, especially those concerning ethnomathematics. The elevated citation counts may indicate the significance of their frameworks, methodologies, or discoveries for other researchers operating in comparable socio-cultural contexts. This trend highlights the increasing scholarly focus on incorporating local knowledge and cultural traditions into mathematics education, potentially fostering the advancement of ethnomathematics as a valid and significant area of research. Furthermore, to find out the authors who have published the most publications related to ethnomathematics from 2009 to 2024, see Table 1.

Table 1. Author publication

Author	Article
Oliveras ML	9
Albanese V	8
Maharaj A	7
Owens K	7
RCI Prachma	7
Sunzuma G	7
Knijnik G	6
Orey DC	6
Blanco-Alverez H	5
D Ambrosius U	5

Based on Table 1, the most productive authors in ethnomathematics research topics are shown. The author with the most publications is Oliveras ML with 9 articles, followed by Albanese V, Maharaj A, and Owens K, with 8, 7, and 7 articles respectively. Furthermore, Picture 6 shows the most relevant affiliation with journals.



Picture 6. Most Relevant Affiliation

The publication search on local wisdom in education shows the contribution of various academic institutions worldwide. It is shown through the most relevant affiliations in Picture 6. The trend of the most pertinent affiliations of publications on related topics shows the dominance of Indonesian universities. The Indonesian University of Education is ranked first with 19 articles, followed by the University of South Africa with 13 articles, Charles Sturt University with 12 articles, and Yogyakarta State University with 11 articles. It shows that the most significant contribution in this study comes from various institutions that play an essential role in scientific production related to ethnomathematics. The most frequently used keywords can be seen in Table 2.

Table 2. Most frequently used keywords

Author	Article
Ethnomathematics	181
Mathematics Education	24
Geometry	15
Culture	13
Mathematics	10
Curriculum	6
Ethnomathematic Approaches	6
Indigenous Education	6
Teaching	6
Ethnography	5

Table 2 shows the most relevant keywords that often appear in research related to ethosmathematics. It was found that the word "Ethnomathematics" was the most dominant keyword, appearing 181 times. Far below it is followed by the word

"Mathematics Education" with a frequency of 24. Several keywords appeared after that: "Geometry", "Culture", "Mathematics", respectively, 15, 13, 10 times. Then with many, each 6 times, namely the keywords "Curriculum", "Ethnomathematic Approaches", "Indigenous Education", "Teaching". Previously, in 2009-2017, the most used keyword was still "Ethnomathematics" with 74 keyword usages, then the keyword "Mathematics Education" was 18 keyword usage, and "Indigenous Education" was 5 uses. After that, in 2018-2024, the most keywords were used, namely "Ethnomathematics", followed by "Geometry" with a frequency of 13, and "Culture" with some frequency of 10. The analysis of the most frequently used keywords shows that "Ethnomathematics" is the primary focus and concern in publications related to ethnomathematics.

Table 3. Country Scientific Production

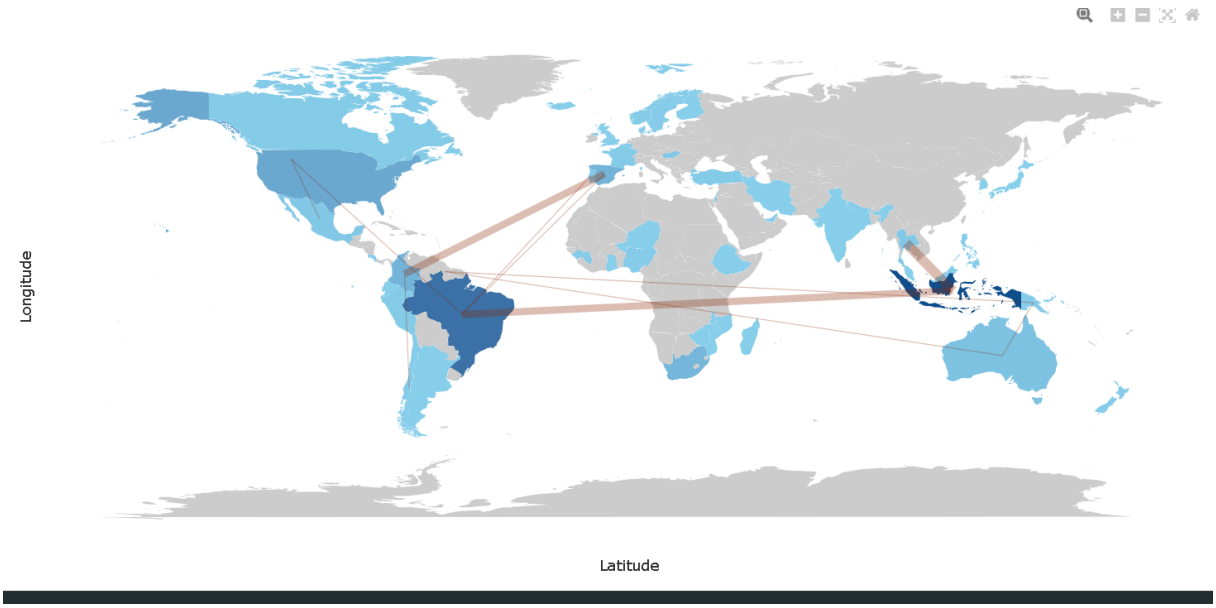
Country	Article
Indonesia	56
Brazil	30
USA	13
Colombia	8
South Africa	7
Australia	6
Israel	6
Zimbabwe	6
Spain	5
Norway	4

Meanwhile, to see the country's contribution to the study of ethnomathematics based on the number of related articles, Table 3 is presented. It is known that Indonesia has the most authors related to the topic of ethnomathematics, with a total of 56 articles. This number is far behind the second country, namely Brazil, with 30, followed by the USA with 13. Then Colombia with 8 articles and South Africa with 7 articles. While for countries such as Australia, Israel, and Zimbabwe each has 6 articles.

Table 4. Country Collaboration Map

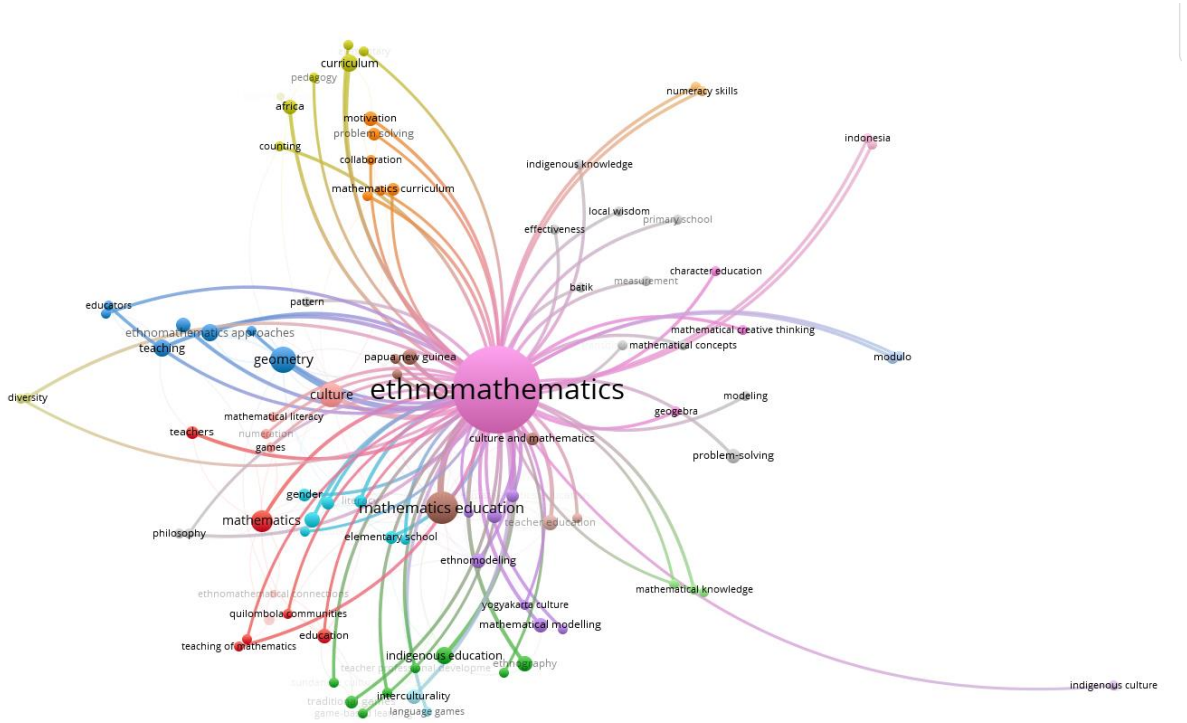
Country		Article
Australia	Guinea	2
Australia	Papua New Guinea	2
Brazil	Portugal	2
Brazil	Spain	2
Brazil	USA	2
Colombia	Chile	2
Guinea	Papua New Guinea	2
Indonesia	Brazil	3
Indonesia	Thailand	4
Spain	Colombia	3
USA	Mexico	2

Table 4 illustrates the collaboration of each nation in ethnomathematics publications. Cooperation among nations in pertinent research remains relatively limited. Every country participates in a minimum of 2 publications, except for the partnership between Indonesia and Thailand, which features 4 publications, and the collaborations involving Indonesia, Brazil, Spain and Colombia, each comprising 3 publications. Interestingly, Brazil dominates every cooperation between countries as its partner country, followed by Indonesia. It indicates that Indonesia holds a key position in ethnomathematics research. A potential explanation for this is Indonesia's abundant cultural and ethnic diversity, which creates a conducive environment for ethnomathematical investigation. Moreover, the growing emphasis on incorporating local knowledge in mathematics education at a national level may encourage Indonesian researchers to participate in regional and global collaborations. These elements enhance Indonesia's role as a significant participant in the worldwide discussion on ethnomathematics. The description of the distribution of cooperation between countries can be seen in Picture 7.



Picture 7. Country Collaboration Map

Picture 7 shows the collaboration of each country above, which can be visualised in Picture 7. The dark blue on the map of Indonesia and Brazil indicates that the government has become a centre of collaboration between countries in producing publications on related topics. Limited global cooperation indicates profound structural, political, and economic issues, especially regarding South-South relationships. Nevertheless, robust bilateral relations, such as those between Indonesia and Thailand, illustrate how common geography, institutional structures like ASEAN, and aligned national goals can assist in surmounting these obstacles. Promoting more organised regional partnerships might provide a pathway to wider global involvement. As for viewing topics related to ethnomathematics from each article used as a data source, the relationship can be seen based on keywords with the help of VOSviewer in Picture 8.



Picture 8. Topic related to Ethnomathematics

Picture 8 shows that publications related to ethnomathematics cover several discussion topics ranging from ethnomathematics, Mathematics education, Geometry, and others. These topics show the great potential of ethnomathematics for further research to continue to be adapted and applied in the world of education.

The study results showed that the number of publications between 2009-2024 was very significant. It is in line with the results of bibliometric analysis of previous studies, which showed an increasing trend until 2019 (Deda et al. 2024; Tamur, Nurjaman, et al., 2023; Tamur, Wijaya, et al. 2023). Furthermore, the downward trend from 2019 to 2021 was mediated by the impact of COVID-19, as seen from the results of previous studies in 2019 (Tamur et al. 2022). It makes sense because, during COVID-19, little research was conducted due to social restriction policies (Tamur, Jehadus, Negara, Siagian, Marzuki, et al., 2021). M. Tamur, Ndiung, et al. (2023). Furthermore, Indonesia has the most significant number of articles discussing the theme of ethnomathematics in Scopus. Indonesia's significance in ethnomathematics studies arises from a harmonious mix of policy support, academic motivation, cultural richness, and global participation. Instead of a random outcome of national production alone, it signifies a deliberate and strategic incorporation of indigenous knowledge into teaching methods and academic work. This model may inspire other multicultural countries aiming to decolonise and localise their mathematics education. It aligns with research obtained by (Kusuma et al., 2024; Pradana et al., 2022). According to Kusuma et al. (2024), in Indonesia, there is an ethnomathematics association, a professional organisation engaged in culture-based mathematics education and learning. This association aims to develop progressive and innovative culture-based mathematics education and learning.

The most frequently discussed topics by looking at the keywords in ethnomathematics are mathematics and geometry education. It is because the

ethnomathematics approach is effectively used in teaching geometry material. It aligns with research conducted by Verner et al. (2019), which also underlines the importance of including cultural elements in mathematics education. In addition, Sunzuma & Maharaj (2022) investigated the views of teachers in Zimbabwe on geometry from an ethnomathematics perspective. The results showed that most teachers believed that geometry was closely related to culture, and they linked geometry teaching to students' cultural backgrounds. In addition, most teachers felt that understanding geometry could be obtained through participation in traditional cultural activities. These results emphasise the importance of including cultural aspects in geometry teaching.

Research by Ariani and Hariyadi (2024) discusses cultural integration in other learning fields, namely the ethnoscience method based on laboratory practice in physics learning. Furthermore, research conducted by Deda et al. (2024) discusses the global trend of ethnomathematics studies from 2012 to 2022. A significant difference between this study and the study by Deda et al. lies in the data sources. This research retrieves data from the official Scopus website, whereas Deda et al. did not use data directly from Scopus. In addition, the results presented in this study include several aspects that were not covered in Deda et al.'s research, such as the Country Collaboration Map and Most Relevant Affiliation. Other research also discusses the development of ethnomathematics in Indonesia in the last decade, but the systematic review method is used (Kusuma et al., 2024). In 2023, research related to ethnomathematics in Indonesia was also conducted using SINTA-indexed journals (Turmuzi et al., 2023).

Based on the analysis of some of the studies above, the core novelty of this research is the use of the PRISMA model in the framework used in filtering data according to the purpose of the study, which is then used in bibliometric analysis using an approach. Furthermore, the feasibility test in this study filters articles by not taking reviews-related articles. In contrast to most previous studies that only used a direct bibliometric approach without a transparent screening system, this study attempted to apply elements of PRISMA to improve the traceability and structure of the literature selection process. In addition, the method used in this study is to use bibliometrics using SCOPUS-indexed journals from 2009 to 2023, and focuses on cultural integration in mathematics education. In addition, this study also shows how vital ethnomathematics is in mathematics education, both in terms of contribution and implications.

Ethnomathematics investigates how "ad hoc" practices and problem solutions develop into methods, how methods develop into theories, and how ideas develop into scientific discoveries (D'Ambrosio, 2007). Teachers can use culture as a learning material to become a context-based learning process (Nur et al., 2020). Cultures that contain ethnomathematics elements are very diverse. The results of published articles show that ethnomathematics contributes very well to mathematics education. The contribution made by ethnomathematics to mathematics education is by adding cultural elements to learning activities or assessments. This application impacts the results of more interesting learning and higher assessment results quoted from the articles analysed. The implications of this study are to provide an overview to researchers that there are still many opportunities to explore existing cultural forms. Moreover, the potential of Indonesian culture that can be integrated into ethnomathematics is very diverse. However, reviewing the same culture can provide opportunities for different perceptions of mathematical material. It is because ethnomathematics is a form of

ethnographic research, in which the main instrument is the researcher (Adam, 2010). In addition, ethnomathematics for mathematics education implies that ethnomathematics is essential as one of the variations of pedagogical methods, learning, and mathematics teaching. Because learning associated with local culture is a more meaningful learning process because students can understand the material in a real-life context (Asmara, 2019). Ethnomathematics applied in learning is crucial to understanding students' culture and cultural relations with learning. Based on this, the recommendation for further research is to identify the values of ethnomathematics that have been studied, especially in mathematics education. In addition, other identifications can be carried out that aim to determine the effectiveness of the application of ethnomathematics in learning on student learning outcomes, which can then be used to identify further research needs in the topic of ethnomathematics.

Conclusion

This study shows that ethnomathematics has excellent potential for teaching more contextual and culturally relevant mathematics. Indonesia dominates the contributions in this study, reflecting the richness of local culture, which is the basis of ethnomathematics studies. Bibliometric analysis shows significant growth in related publications, with the keyword Ethnomathematics as the primary focus. In addition, international collaboration is still relatively limited, although some essential partnerships involve Indonesia. This study emphasises the importance of cultural integration in mathematics education to improve students' understanding of mathematical concepts and enrich local values. The contribution made by ethnomathematics to mathematics education is by adding artistic elements to learning activities or assessments. This application impacts the results of more interesting learning and higher assessment results quoted from the articles analysed. In addition, ethnomathematics for mathematics education implies that ethnomathematics is essential as one of the variations of pedagogical methods, learning, and mathematics teaching. These results also open up opportunities for further research on the impact of ethnomathematics-based interventions on students' mathematical reasoning, problem-solving skills, and cultural identity development, particularly by exploring underrepresented cultural contexts or local wisdom from diverse regions.

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