



Scientometric Analysis of Ethnomathematics-Based Development: A Systematic Literature Review

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Abstract: Ethnomathematics-based research and development play a vital role in connecting cultural heritage with mathematics to enhance students' understanding and appreciation of mathematical concepts. This study employs a scientometric indicator analysis to explore the development of ethnomathematics-based research from 2014 to 2024. Using bibliometric methods and network visualization via VOSviewer software, 614 articles from Scopus and ProQuest databases were analyzed to examine trends in publication, author profiles, types of developed products, and development model preferences. The findings reveal a steady annual increase in publications, peaking in 2020. Indonesia accounts for 83.33% of the studies, highlighting national dominance. Most articles were authored by lecturers and final-year students, with a primary focus on developing instructional tools such as learning designs and teaching materials (each at 16.67%). The general design model was the most utilized (55.56%), followed by the Plomp and ADDIE models. Limited documentation and the absence of digital versions of local culture-based products were identified as key motivations behind the development efforts. This study also maps keyword co-occurrences and author collaboration networks to visualize the direction of research. The dominance of practical-oriented outputs highlights a need to emphasize evaluation and long-term implementation stages. Moreover, the lack of global contributions suggests the importance of cross-national collaboration to broaden ethnomathematics research perspectives. Overall, this scientometric review offers strategic insights and identifies opportunities to strengthen product design, methodological rigor, and global engagement in ethnomathematics-based education research. Future developments must prioritize standardized evaluation aspects that are rooted in local cultural contexts. In addition, the integration of technology in the form of interactive digital media should be enhanced to meet the needs of 21st-century learning. These findings provide a valuable reference for researchers seeking to design culturally responsive educational products and encourage more collaborative and sustained research in the field of ethnomathematics.

Keywords: scientometric, development, ethnomathematics.

■ INTRODUCTION

In recent decades, the world of education has increasingly recognized the importance of contextual approaches that accommodate the cultural background of learners. One approach that has received widespread attention is ethnomathematics, a way of understanding and teaching mathematics that is rooted in local cultural practices and values. This approach was pioneered by D'Ambrosio and developed as a bridge between formal mathematical knowledge and cultural practices embedded in society (D'Ambrosio, 2001). This approach not only enriches mathematics learning conceptually but also strengthens students' cultural identity and bridges the gap between academic knowledge and everyday experience. In the philosophy of Realistic Mathematics

Education (RME), ethnomathematics is also in line with the idea that mathematics is a social construction derived from human cultural activities.

The 2014–2024 timeframe was chosen in this study because, since 2014, there has been an increase in the number of publications on ethnomathematics-based development, both in quantity and thematic diversity. This year also marks the widespread implementation of the 2013 Curriculum, which emphasizes the integration of local culture in learning, as well as a growing number of educational journals that began to be indexed in international databases such as Scopus and ProQuest. Additionally, the rise of digital platforms supporting the integration of culture and technology in mathematics learning has further advanced research in this area.

Globally, the ethnomathematics approach has gained widespread attention for its potential to bridge the gap between formal mathematics and the cultural practices and values of communities. Cross-national studies show that cultural elements such as traditional weaving (Hortelano & Lapinid, 2024; Thompson, 2024b, 2024a; Trimble, 2019), rituals (Dominikus, Madu, & Bale, 2025; Kamid et al., 2021), architectural patterns (De Los Santos, 2021; Zuliana, Dwiningrum, Wijaya, & Purnomo, 2023), traditional agricultural activities (Pathuddin, Kamariah, & Mariani, 2023), local measurement or calculation systems (De Los Santos, 2021; Tuominen, 2023; Umbara, Wahyudin, & Prabawanto, 2021), and geometric ornaments on cultural artifacts (De Los Santos, 2021) have been successfully used as authentic contexts for mathematics learning. This initiative aligns with international trends that promote learning, which is inclusive, culturally relevant, and responsive to learner diversity. Therefore, the development of ethnomathematics-based learning is not only academically significant but also crucial for strengthening cultural identity, enhancing learning participation, and promoting social engagement in mathematics education worldwide.

In the Indonesian context, the ethnomathematics approach has its significance due to the richness of local culture spread across various regions. This is in line with the spirit of the Merdeka Curriculum, which encourages personalization and contextualization of learning based on local wisdom. Thus, ethnomathematics-based development is not only academically relevant but also supports the strengthening of students' character and national identity.

The development of ethnomathematics-based learning products such as modules, teaching media, and contextualized curriculum designs has been widely undertaken in various contexts. However, most studies remain limited to case-based approaches or focus on specific local traditions without analyzing broader trends or author collaboration networks. This has resulted in a lack of documented and standardized teaching resources. Many of the developed products are experimental, non-digitized, and difficult to replicate or scale up. Moreover, there have been limited studies that systematically map the overall contributions of research in this field, including publication trends, development objectives, types of products, and collaborative patterns. The absence of such comprehensive mapping can lead to fragmented knowledge development, duplication of efforts, and discontinuity in innovation. For researchers, it hinders the identification of research gaps and the formulation of relevant and innovative questions. For practitioners, it restricts access to consolidated insights that could guide effective implementation. These limitations reinforce the urgency of conducting bibliometric mapping that can

scientifically explain the current landscape, visualize research trajectories, and uncover the potential for future ethnomathematics-based development in education.

One relevant innovation is the use of ethnomathematical contexts in the development of mathematics learning materials aligned with international standards such as PISA. A recent meta-analysis by Pratama & Yelken (2024) confirmed that integrating ethnomathematics significantly enhances students' mathematical literacy, including their reasoning and problem-solving abilities. Integrating traditional games into mathematics learning not only enriches the learning context, but also able to increases students' interest, understanding and learning achievement in a multicultural context (Fouze & Amit, 2018). In addition to game contexts, the utilization of cultural craft practices is also part of the ethnographic-mathematics approach. For example, in the *trenzado* study, mathematical structures were found in the craft process through graph analysis and combinatorics that represented the relationship between cultural activities and mathematical concepts (Albanese, Oliveras, & Perales, 2014). Similar findings emerge from coastal ethnomathematics research, such as in coastal cheese production systems, where mathematical concepts like geometric solids, measurement, and proportionality are embedded in local practices. Study by Olivero-Acuna et al. (2025) found that integrating these coastal cultural contexts into mathematics instruction can increase student motivation and deepen real-world concept understanding.

These findings resonate with international research on GeoGebra integration within socio-cultural learning contexts. For instance, Ndagijimana et al. (2024) demonstrated in Rwanda that embedding GeoGebra in culturally relevant learning environments enhanced students' understanding of geometric concepts and boosted motivation and collaboration through reflective, context-aware exploration. These findings mirror international studies on GeoGebra-based visualizations in culturally situated geometry learning. For example, research by Ziatdinov & Valles (2022) demonstrated that combining modeling, visualization, and programming in GeoGebra enhances collaborative and reflective learning of geometry within socio-cultural contexts, nicely aligning with the principles behind the Ethnobra model. Technological advances also offer exciting possibilities for ethnomathematics learning media. For instance, Bertrand, Sezer, & Namukasa (2024) demonstrated that embedding augmented reality and virtual reality tools within culturally responsive pedagogy can enhance students' spatial reasoning, engagement, and appreciation of culturally situated mathematical concepts. Moreover, from the educators' perspective, training prospective teachers in designing culture-based interactive tasks has proven its contribution in creating learning activities that encourage students' ability to build arguments, evaluate solutions, and relate mathematics to their daily practices (Cervantes-Barraza & Araujo, 2023).

Scientometric studies present a relevant approach to fill the void of systematic studies in development-based ethnomathematics research. This study used bibliometric data from two international databases, Scopus and ProQuest, to illustrate research dynamics quantitatively and visually. The combination of these two databases was chosen to broaden the scope and increase the representativeness of the analysis. Scopus is known to excel in indexing internationally highly reputable journals. At the same time, ProQuest covers a wide range of institutional publications, research reports, and proceedings that are often not indexed in Scopus. Thus, using both allows for a more comprehensive mapping of ethnomathematics research, both globally and locally. Besides showing

publication trends, the scientometric analysis in this study also identified institutional contributions, country distribution, dominant keywords, and collaboration patterns between authors. Unfortunately, scientometric studies on this topic are still limited, as most previous bibliometric studies have focused on STEM fields, inclusive education, or general pedagogy, and have not covered ethnomathematics across time and regions. While studies such as Lamim Netto, Dos Santos, & Meneghetti (2020) provided an international bibliographic review focusing on philosophical and epistemological perspectives of ethnomathematics, and Deda, Disnawati, Tamur, & Rosa (2024) analyzed global trends from 2012 to 2022 using bibliometric tools; these studies did not specifically address aspects related to the types of developed products, preferred development models, or practical design outputs. In contrast, this study complements and extends the existing literature by focusing on development-oriented contributions, including the mapping of instructional tools, evaluation models, and author collaboration networks, offering a more applied and product-based scientometric perspective on ethnomathematics research.

In line with this urgency, this study offers original contributions through three elements of novelty: first, the integration of data from two large databases, namely Scopus and ProQuest, to obtain a broad and representative bibliographic coverage; second, the explicit focus on publications that emphasize the development-oriented aspects of ethnomathematics products, different from studies that only describe implementation; and third, the presentation of visual mapping of author collaboration networks and the distribution of main keywords to identify potential future development directions and research synergies.

Against this background, this study aims to conduct a bibliometric exploration and mapping of publications related to ethnomathematics-based development in the period from 2014 to 2024. The analysis focused on the dimensions of publication trends, geographical distribution of institutions and countries, types and orientations of products developed, development model approaches used, keyword distribution, and collaborative networks between researchers. The findings of this study provide strategic insights into the direction of evolution and dynamics of ethnomathematics development research. The findings also provide a reference that is more contextual, integrative, and sustainable for practices and policies in mathematics education.

■ METHOD

Research Design

This study used an exploratory bibliometric design that aims to map, identify, and analyze global trends in research related to ethnomathematics-based development over ten years from 2014 to 2024. This study combined a quantitative approach based on bibliometric analysis with network visualization using VOSviewer software. Through this design, the research was conducted systematically from the literature data search to the analysis of publication trends, popular keywords, author collaboration patterns, and the type and purpose of the development products studied in the selected articles.

Search Strategy

The literature search in this study was conducted in January 2025 using two major academic databases: Scopus (<https://www.scopus.com/>) and ProQuest (<https://www.proquest.com/>). Other widely used databases in the field of education, such

as Web of Science and ERIC, were not included due to access limitations and overlap in indexed content. Scopus and ProQuest were selected based on their broad coverage of peer-reviewed educational and interdisciplinary journals, their compatibility with bibliometric tools, and their ability to provide exportable metadata for analysis. The keywords used were a Boolean combination of the terms “development” and “ethnomathematics”, which were searched in the title, abstract, and keywords sections of the articles. This specific choice aimed to target studies focused on product creation or instructional design. However, it may have excluded broader ethnomathematics research not using the term “development”, leading to reduced data. This is acknowledged as a key limitation, and future studies are encouraged to apply broader search terms to capture a wider scope. In the ProQuest database, the search filters included the publication type of scholarly journals, the period from 2014 to 2024, and the publication language in Indonesian and English. From the search results, 507 documents were obtained. Meanwhile, in the Scopus database, the filters used included document types in the form of articles and conference papers, with the same period and keywords. The search from Scopus resulted in 107 documents. Thus, the total initial data obtained from the two databases was 614 documents. Figure 1 displays the PRISMA flow diagram that provides an overview of the literature search and filtering process. Out of 80 full-text articles assessed for eligibility, 44 were excluded because they did not meet the criteria of focusing on the development of ethnomathematics-based educational products. These excluded articles typically fell into categories such as theoretical or philosophical discussions, curriculum analysis without product output, or general ethnomathematics exploration without any instructional tool development. To clarify this decision-making process, a summary table is provided in the appendix with sample titles and specific exclusion reasons.

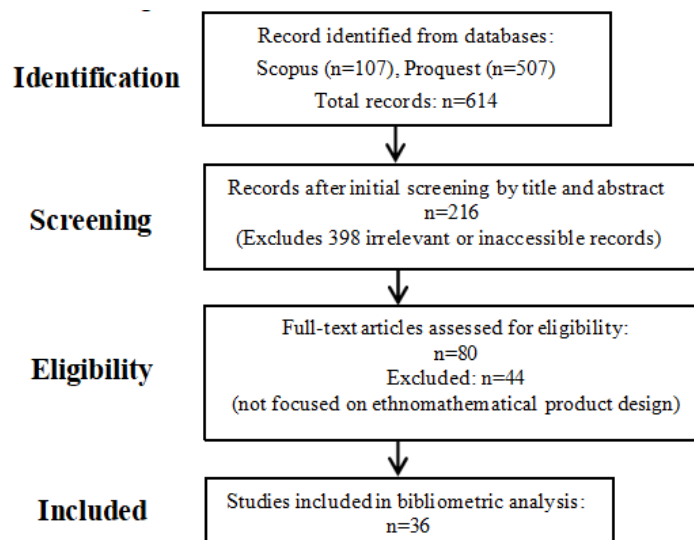


Figure 1. Identification, screening, and inclusion of the studies

Inclusion and Exclusion Criteria

The literature analyzed in this study was selected based on its suitability to the focus of the study, namely the development or design of ethnomathematics-based learning

products. Inclusion criteria included scientific articles that explicitly mentioned product development, were published in academic journals or scientific proceedings, were available in full-text format, and were published between 2014 and 2024. Articles in English from both databases (Scopus and ProQuest) were included in the selection. Meanwhile, articles that only discussed ethnomathematics concepts in general without producing concrete products, non-scientific articles such as editorials and short reviews, and publications that could not be accessed in full were excluded from the analysis. The selection process was conducted manually by two independent reviewers who checked the title, abstract, and content of the articles. Both reviewers independently coded all 36 included articles based on the predefined inclusion and exclusion criteria. To assess inter-rater reliability, Cohen's Kappa coefficient was calculated and yielded a value of 0.82, indicating substantial agreement. Any discrepancies were resolved through discussion until consensus was reached. This double coding process and high inter-rater reliability represent a key methodological strength of the study, ensuring the objectivity and consistency of article selection. From a total of 614 articles obtained, 36 articles met the criteria and were further analyzed bibliometrically. All articles analyzed in this study are included in the reference list.

Data Analysis

Data analysis was conducted using several techniques, namely descriptive analysis and content analysis. Descriptive analysis was carried out to describe the characteristics of publication data, such as the number of publications per year and the distribution of publications by country, purpose, development model, and products produced. Content analysis was conducted to identify the development objectives, models used, types of products developed, research gaps, and emerging topic trends. The content analysis followed a systematic coding protocol. First, all full-text articles were imported into a spreadsheet for data extraction. Each article was read in detail and coded manually by two independent reviewers using a structured coding sheet. The coding categories were predefined based on the study's research questions and included: (1) development objectives (e.g., instructional improvement, cultural preservation); (2) type of product (e.g., module, teaching media, curriculum); (3) development model used (e.g., ADDIE, Plomp); and (4) level of implementation (e.g., pilot, classroom-tested). Any disagreements between reviewers were discussed until consensus was reached to ensure consistency and accuracy. In addition, bibliometric content was analyzed using VOSviewer software version 1.6.20 to visualize the co-occurrence of keywords and co-authorship networks. VOSviewer enables the construction and graphical representation of bibliographic maps, facilitating the identification of research clusters and collaboration patterns (Eck & Waltman, 2017). The parameter used was association strength as a normalization method, with a minimum threshold of three keyword occurrences and two for author names. The threshold of three was chosen to balance the inclusion of frequently used terms while minimizing noise from infrequent or isolated keywords that do not represent broader research patterns. Articles that explicitly mentioned product development were further analyzed, with a total of 36 articles selected from the initial 614 articles.

■ RESULT AND DISSCUSSION

The following findings are derived from the systematic content analysis of 36 selected articles, as described in the Methods section. The coding process yielded consistent and structured insights into the development objectives, models used, and types of products produced.

A bibliometric analysis on ethnomathematics-based product development was conducted on 36 documents obtained from Scopus and Proquest databases. The findings from this analysis can help us understand significant research developments from 2014 to 2024, obtain literature relevant to the topic under study, and identify opportunities for research collaboration on ethnomathematics-based product design. In addition, the analysis also provides an overview of the trends of the most studied topics, the countries or institutions that are most active in this field, as well as the researchers who have made significant contributions. By mapping the relationships between keywords, authors, and publication sources, this study also reveals the direction of development of ethnomathematics scholarship in the context of product design and development. The findings are expected to serve as an important reference for future researchers in designing more focused studies and encouraging collaboration across disciplines and regions.

Number of Publications per Year

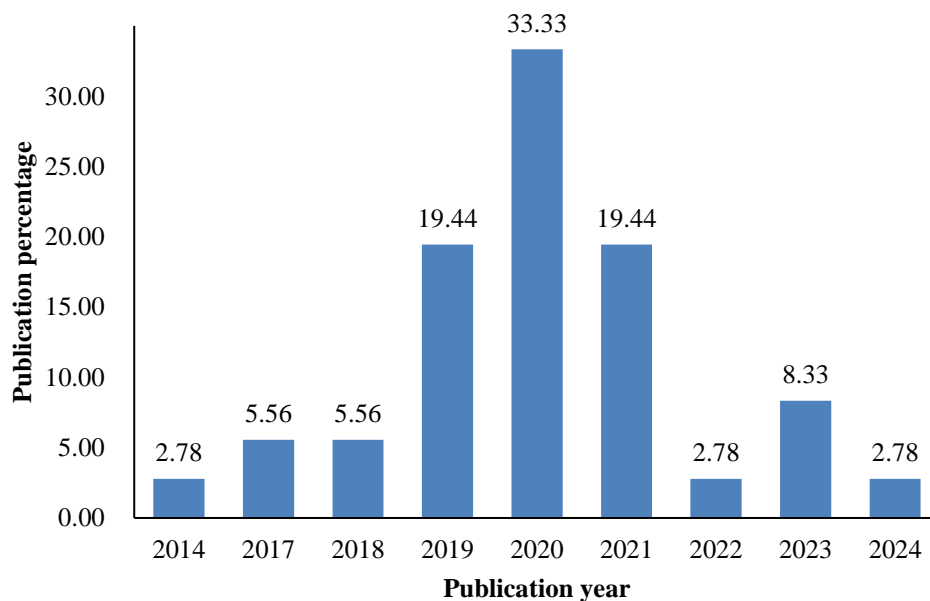


Figure 2. Number of publications per year

The graph shows the yearly percentage distribution of the 36 analyzed publications related to ethnomathematics-based product development from 2014 to 2024. In 2014, the number of publications was very low, only 2.78% of the total. There was a slight increase in 2017 and 2018 by 5.56% and 5.5%, respectively. A significant increase was observed in 2019 (19.44%), and reached its peak in 2020 to 33.33%, signaling a surge in interest

in this theme in that period. After 2020, there was a gradual decline, although in 2021 it remained relatively high (11.44%). The number of publications dropped dramatically in 2022 (2.78%), but experienced a slight increase in 2023 (8.33%), and decreased in 2024 (2.78%).

The publication pattern showed the highest spike in 2020, followed by a decline, likely influenced by academic dynamics during and after the COVID-19 pandemic. The pandemic may have catalyzed a temporary increase in research output due to increased availability of time during lockdowns, the urgency to develop digital and contextualized learning tools, and shifts in funding toward educational innovation. However, these findings also suggest that interest in ethnomathematics-based development research has not shown a stable trend in recent years. This decline could also be due to a shift in research focus to more pressing areas during the crisis. In addition, lack of funding and limited access to the field may have also become obstacles to the sustainability of local culture-based product development.

Publication Distribution by Country

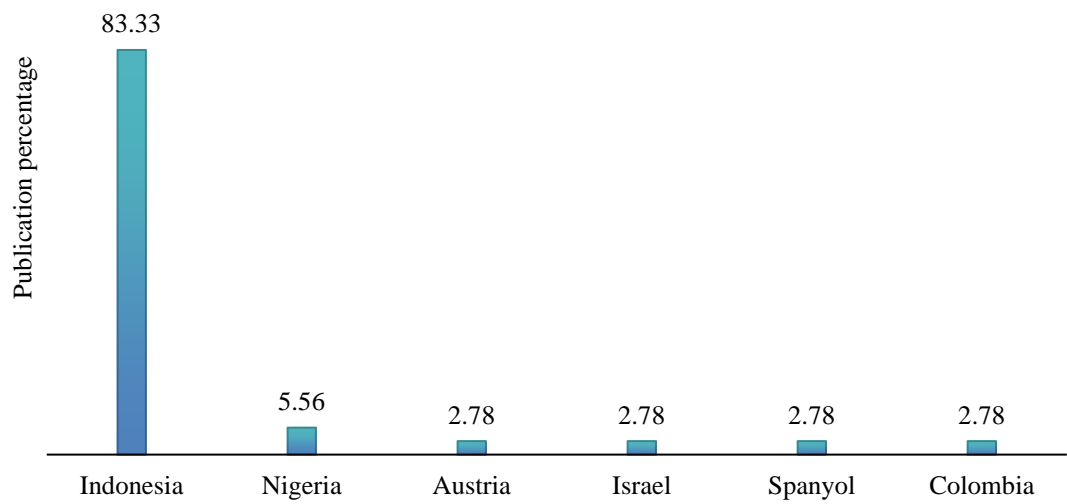


Figure 3. Publication chart by country

A review of the Scopus and ProQuest databases shows that most of the publications on ethnomathematics-based development come from Indonesia (83.33%). It is followed by Nigeria with 5.56%, then Austria, Israel, Spain, and Colombia, each contributing 2.78%. The high number of publications from Indonesia shows that the topic of ethnomathematics is highly relevant and rapidly growing in the country, which has a rich culture and high ethnic diversity. Both are important factors in the ethnomathematics approach. In addition, national education policies such as the 2013 Curriculum and Merdeka Curriculum, which encourage the integration of local wisdom, are also driving the emergence of contextual research in mathematics education.

The dominance of Indonesia in this publication also reflects the strong attention of academics to the preservation of local culture through learning media. However, this dominance may also pose certain challenges. It could create a research landscape that is

overly centered on specific cultural contexts, potentially limiting the diversity of perspectives and comparative insights across different regions. Furthermore, it may inadvertently discourage cross-national collaboration or the inclusion of other culturally rich but underrepresented communities. This situation also indicates that the development of ethnomathematics remains localized and has not yet become a widespread concern at the global level. The lack of contributions from other countries could be due to several factors, such as the limited indexation of local journals into international databases, the use of non-English languages in publications, or differences in research priorities.

The implication is that while Indonesia has strong potential as a center for ethnomathematics development, cross-country and cross-cultural collaboration remains very much open and needs further expansion. This mapping can be an important basis for encouraging international cooperation in developing culturally based educational approaches, as well as opening dialogue between nations on local practices and values in mathematics education. It is also important that the study of ethnomathematics not only develops in the national context but also makes a meaningful contribution to the global education discourse that is inclusive and multicultural.

Objectives

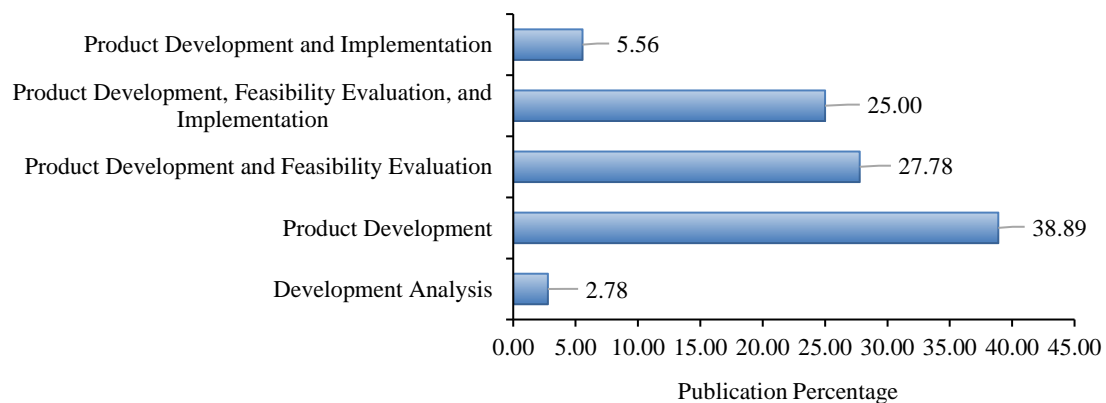


Figure 4. Development of research objectives

The graph shows that most articles (38.89%) focused on the initial stages of product development, such as the creation of modules, learning media, or teaching tools, without proceeding to feasibility testing or application. Articles that included feasibility testing amounted to 27.78%, while those that involved all three stages (product development, feasibility testing, and implementation) totaled 25.00%. Only 5.56% of articles directly implemented the product without feasibility testing, and 2.78% specifically analyzed the development process.

This finding suggests that most of the research is still at the early experimental level. This may be influenced by time constraints, resources, or the drive to produce immediate publication outcomes. On the other hand, the emergence of a significant proportion in the feasibility and application categories reflects a shift towards a more holistic research approach.

The implication is that ethnomathematics development research requires further strengthening in terms of validation and long-term implementation. The lack of emphasis on reflecting on the development process is also an important gap that has not been addressed in the literature, even though this aspect is crucial for continuous improvement. Future research needs to emphasize in-depth evaluation and documentation of the process to ensure replicability and relevance of the product in various learning contexts.

Development Model

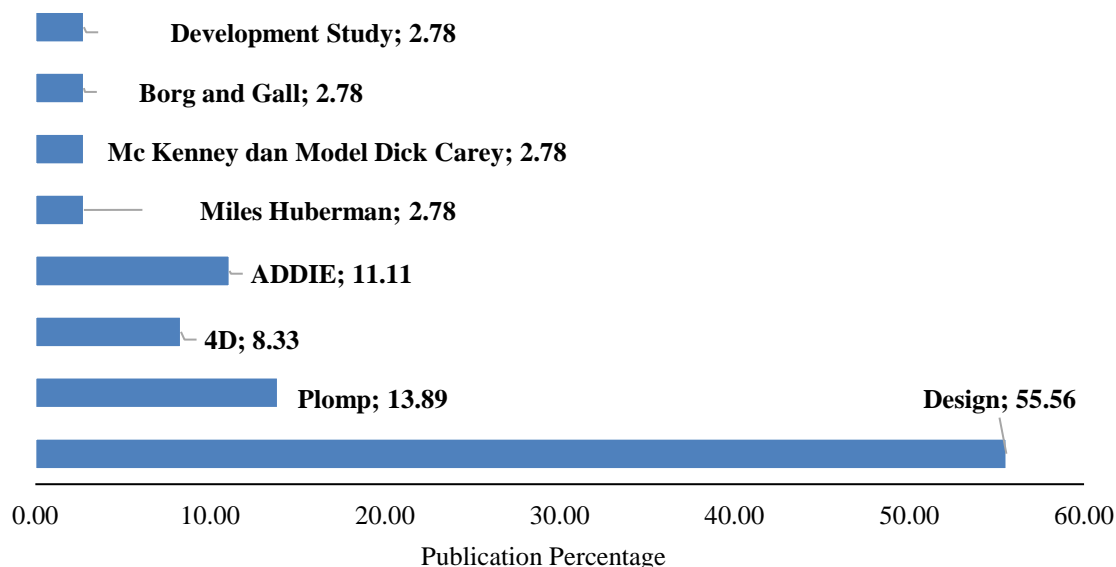


Figure 5. Development model

The graph shows that the most widely used development model is the common design model, which appeared in 55.56% of the articles. This raises critical questions: Is this dominance due to the model's flexibility and accessibility, especially for novice researchers? Or does it reflect limited methodological training and awareness of alternative frameworks? It may also signal a pragmatic orientation within an emerging field, where producing tangible outputs is prioritized over methodological rigor. While these possibilities require further investigation, acknowledging them sharpens the interpretation of current trends and highlights the need to strengthen research design capacity in future development-oriented studies. The Plomp model was used in 13.89% of the articles, ADDIE in 11.11%, and the 4D model in 8.33%. Other models, such as those by Miles and Huberman, Borg and Gall, and McKenney and Dick Carey, were used in only 2.78% of publications each.

The predominance of the general design model indicates that many researchers do not explicitly refer to a standardized model framework, but rather adapt the development steps as needed. This is understandable as the majority of the research was conducted in local contexts that demanded flexibility in methods and limited time. The graph shows the yearly percentage distribution of the 36 analyzed publications related to ethnomathematics-based product development during the 2014–2024 period.

The significant use of the Plomp and ADDIE models suggests that some researchers are beginning to adopt a systematic and structured approach. Both models emphasize important stages such as needs analysis, design, evaluation, and revision, which are appropriate for complex and contextualized ethnomathematics-based products. This adoption is an indicator that some research has moved towards more academic and tested development practices.

Meanwhile, the lack of use of models such as those by Miles and Huberman, Borg and Gall, and McKenney and Dick Carey could be due to the level of complexity of the stages or the focus of the models, which are more suitable for deeper qualitative and evaluative research. The implication is that development in ethnomathematics is currently predominantly geared towards the creation of practical products rather than deep conceptual exploration. This indicates a need to improve methodological capacity and diversify development models to make research findings more valid, applicable, and replicable across different contexts.

The implication is that if we want to produce products that are more valid, replicable, and widely relevant, future researchers need to consider more systematic models. The dominance of Indonesia in the articles analyzed also affects the choice of model, because the local context encourages flexibility, but at the same time, there is also a need to increase methodological capacity in order to achieve stronger and more standardized development results.

Products Produced

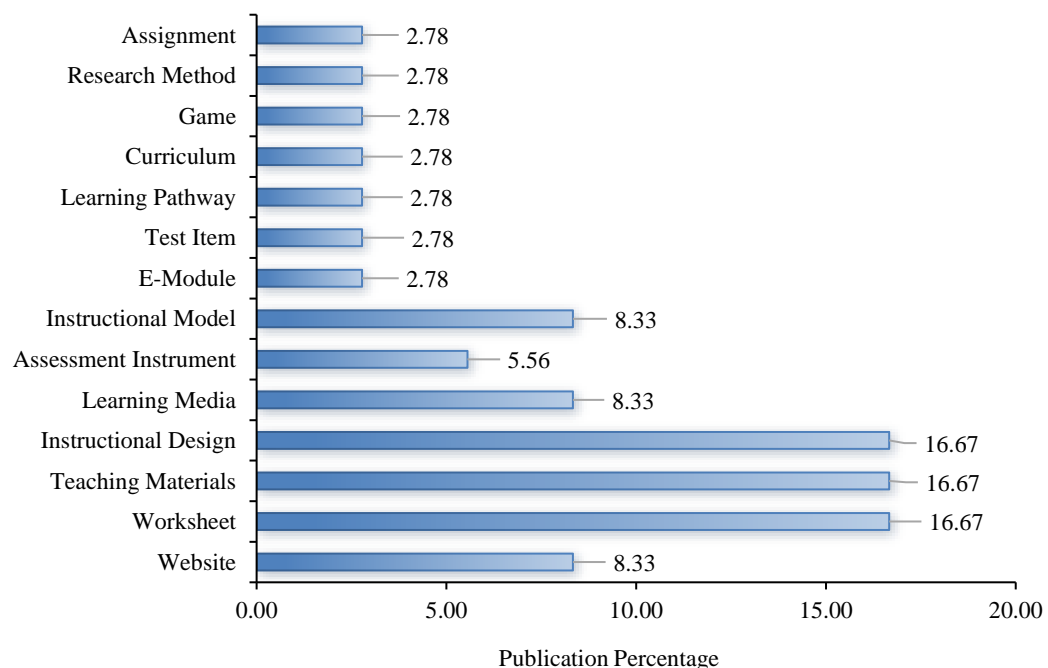


Figure 6. Products in ethnomathematics research

The graph shows that products in ethnomathematics research are predominantly learning designs, teaching materials, and worksheets, each appearing in 16.67% of the

total articles analyzed. Other products, such as learning media, learning models, and web, came in second with 8.33% each, while assessment instruments only accounted for 5.56%. More complex and conceptual products, such as curriculum, research methods, games, and learning pathway design, were at the lowest level (2.78% each).

The predominance of practical and directly applicable products reflects the pragmatic approach taken by researchers, especially those from Indonesia, who are the main contributors. This can be explained by two factors: (1) the drive to produce outputs that support rapid implementation in the classroom, especially in the context of the Merdeka Curriculum, which emphasizes personalization and local wisdom; and (2) limited resources, time, and access to technology in the regions, which makes the development of digital and evaluative products less of a priority.

The presence of learning media (8.33%) and the website (8.33%) indicates that there are early initiatives for technology integration, but they remain limited. This could be due to low digital literacy or supporting infrastructure in the research location. Meanwhile, the low percentage of assessment instruments (5.56%) indicates that evaluation has not been the main focus in ethnomathematics development, even though the effectiveness of the products is important to be measured.

Products such as games, learning pathways, and curricula still have a low percentage, suggesting that development in ethnomathematics has not reached the systemic level or deep pedagogical innovation. This could also reflect the lack of cross-disciplinary collaboration, such as with curriculum, educational technology, or psychometrics experts.

The implication is that development research in ethnomathematics is still dominated by contextual learning at the micro level. The dominance of Indonesia as the main contributor results in product patterns that tend to be pragmatic, tailored to local needs, and realistic implementable. To develop ethnomathematics as a global and transformative approach, an expansion of product types, an increase in evaluative quality, and encouragement of cross-institutional and cross-field collaboration are needed.

Keyword Co-Occurrence Analysis

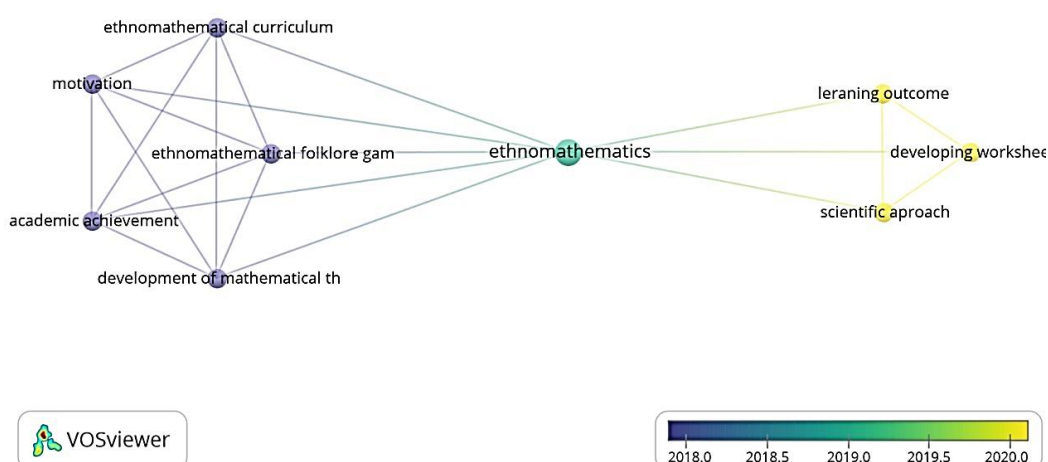


Figure 7. Keyword co-occurrence

The results of the co-occurrence analysis of the keywords show that “ethnomathematics” is the central keyword that appears the most and is connected to various other keywords. This shows that all the topics analyzed are indeed focused on ethnomathematics-based development. Visually, there are two main groups based on the linkage of keywords and the time of their appearance. The first group, marked by blue to purple colors (2018- 2019), represents the conceptual and pedagogical focus of the study. Keywords in this group include ethnomathematical curriculum, ethnomathematical folklore game, motivation, academic achievement, and development of mathematical theory. This group emphasizes the importance of integrating local culture in the curriculum, as well as the influence of ethnomathematical approaches on student motivation and achievement.

The second group, shown in bright yellow (2019-2020), shows a shift in the direction of research to a more applicable domain. Keywords such as learning outcomes, developing worksheets, and scientific approach indicate that research is starting to focus on developing teaching products, evaluating learning outcomes, and applying a scientific approach in ethnomathematics-based media development. This change shows that ethnomathematics research initially departed from theoretical studies and local cultural values. However, over time, many researchers have started to develop concrete teaching products and test their impact on student learning outcomes. This shift could be influenced by curriculum policies that emphasize contextual learning and learning outcomes, especially in Indonesia, as the most dominant country in publications.

The implication is that these research developments show that ethnomathematics is no longer just a concept, but is integrated into learning practices. However, it remains evident that keywords related to in-depth evaluation, assessment, or technology have not emerged significantly. This suggests that there is a great opportunity ahead to expand ethnomathematics research towards digitizing learning, culturally-based evaluation, and collaborative approaches across the field.

Co-authorship Analysis

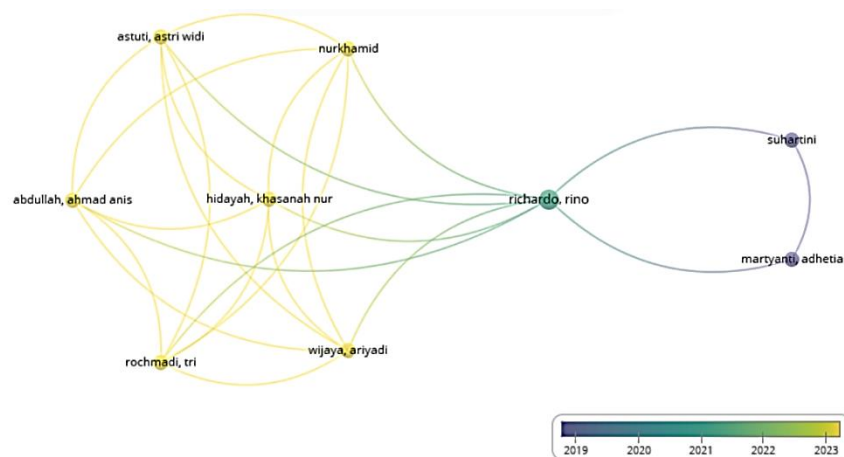


Figure 8. Co-authorship

The figure above illustrates the co-authorship network of authors involved in publications on ethnomathematics with a development-based approach. Several authors

are forming a closely connected collaborative network, as indicated by the numerous lines linking the nodes. This suggests that in ethnomathematics research, team collaboration is both intensive and well-organized. The network is divided into two main clusters. The first cluster, represented in yellow, consists of authors who were actively collaborating around the period of 2019–2021. This group includes researchers such as Abdullah, Ahmad Anis, Astuti, Astri Widi, Hidayah, Khasanah Nur, Rochmadi, Tri, and Nurkhamid (Abd Rahman et al., 2023; Purwoko, Astuti, Arti, & Widiyono, 2019; Richardo et al., 2023; Widiyasari, Astriyani, & Vianka Irawan, 2020; Zuliana et al., 2023). The strength of their collaboration is visible from the thick lines connecting the nodes. The second cluster, shown in purple, highlights more recent collaborations in the 2022–2023 period. Authors such as Suhartini and Martyanti, and Adhetia appear to be actively working together in recent publications.

Notably, Richardo serves as a central connecting node bridging the two clusters (Richardo, Martyanti, & Suhartini, 2019). His role appears significant in sustaining collaborative ties across both earlier and more recent research teams. This central position reflects his important role in ensuring the continuity of research in development-based ethnomathematics. The color gradient from yellow to green to purple represents the chronological progression of publications, visually capturing the temporal dynamics of this research network.

This scientometric review showed that the topic of ethnomathematics-based development has increased significantly in recent years. The highest spike in publications occurred in 2020, indicating increased attention to contextual approaches and local culture in mathematics education, especially in response to learning challenges during the pandemic (Rosa & Orey, 2011). However, fluctuations after 2020 suggest that interest in this theme has not fully stabilized, possibly due to research dynamics and changes in the direction of global academic priorities (Azis & Febriana, 2023).

Geographically, Indonesia dominates with more than 80% of publications. This shows the intense attention of Indonesian researchers to ethnomathematics, supported by cultural diversity and educational policies that encourage the integration of local wisdom in learning (Marlissa, Juandi, & Turmudi, 2024). In contrast, the contributions of other countries such as Nigeria, Austria, and Colombia remain limited. This may be due to the use of local languages in publications or limited indexation in international databases (D'Ambrosio, 2001).

The research objectives in the articles analyzed mainly focused on the early stages of product development, such as modules, teaching materials, and worksheets. However, a significant proportion also included feasibility testing and application, indicating a trend towards more applied and comprehensive research (Badriah & Sukati, 2021). However, few studies focus solely on application without feasibility testing, and those that reflectively analyze the development process are also minimal.

In terms of development models, most articles use a general design approach that does not explicitly refer to a particular model. The flexibility of this approach allows researchers to adapt the stages of development to their cultural conditions and local context (Plomp & Nieveen, 2013). This pattern seems to be closely related to the main focus of the research on practical products such as learning designs, teaching materials, and worksheets, which are easier to develop without having to follow a complex model.

Development models such as ADDIE and Plomp are widely used as they offer more systematic stages, especially for studies that want to include feasibility testing and evaluation (Branch, 2009; Thiagarajan, Semmel, & Semmel, 1974). However, the limited development of assessment instruments and evaluation tools suggests that the evaluative dimension has not been a major concern in many studies. This is also reflected in the scarcity of digital products such as web-based platforms or interactive learning media where evaluation mechanisms are typically essential to measure user engagement, learning outcomes, and system usability. The absence of robust evaluation instruments may hinder the development and implementation of such technology-enhanced products, indicating a broader gap in integrating systematic assessment within ethnomathematics-based educational design.

The products obtained show that researchers tend to focus on developing teaching tools that are applicable and can be used directly in the learning process. Learning design, teaching materials, and worksheets are the most dominant types of products, while evaluative aspects such as assessment instruments and questions have not been the main focus (Yulianti, Suprijono, & Yani, 2022). Technology-based products such as digital and web learning media have also begun to emerge, but have not yet developed extensively.

On the other hand, the strong pattern of collaboration between authors in Indonesia can also explain the dominance in the number of publications. Many studies are conducted in teams, especially between lecturers and students, which not only accelerates the product development process but also encourages increased publication output. This collaboration strengthens the local research culture and contributes to the major focus on development based on the local cultural context.

The keyword co-occurrence map shows a shift in research direction from conceptual and pedagogical aspects towards a more practical and product-based approach. Keywords such as ethnomathematical curriculum and folklore game were common in the early years, while keywords such as developing worksheets and scientific approach appeared in more recent publications (Milton & Orey, 2016). This indicates the transformation from theoretical studies to media development and evaluation of ethnomathematics-based learning. Finally, the co-authorship analysis shows that researchers in this field have a fairly close collaboration network. This indicates that ethnomathematics-based development research is largely conducted in teams, often within institutional or regional collaborations. Authors such as Richardo Rino, Astri Widi Astuti, Nur Khamid, and Khasanah Nur Hidayah appear in central positions, suggesting their key roles in bridging collaborations across different groups. According to Hirsch (2005) such centrality often reflects significant scholarly influence and the capacity to connect otherwise separate subgroups within a research field. The color gradient also reflects ongoing contributions from 2019 to 2023, with stronger network density observed in more recent years, highlighting a growing and organized research ecosystem.

■ CONCLUSION

Based on the bibliometric analysis of 36 articles from the Scopus and ProQuest databases, it can be concluded that research related to ethnomathematics-based development showed a significant increase in trend in 2020 but subsequently experienced fluctuations. Indonesia has been the most active country in publishing this study, suggesting the relevance of the ethnomathematics approach in the context of local culture-

based education. Methodologically, most studies relied on general design models with limited use of systematic evaluation tools. While product-oriented outputs dominated, the lack of digital media and validated assessments reflects gaps in rigor and technological integration.

Most research objectives still focus on product development, with a small proportion involving feasibility testing and implementation. The development models used tend to be flexible, with a dominance of general design approaches, followed by systematic models such as ADDIE, Plomp, and 4D. The products obtained are mostly teaching tools such as learning designs, teaching materials, and worksheets, while aspects of evaluation and technology receive less attention.

Keyword analysis shows a shift in themes from the conceptual theme to a more applicative and evaluative approach. Meanwhile, co-authorship analysis shows a strong collaborative network between researchers, especially in Indonesia, which indicates a solid and organized teamwork structure in this field.

This study is limited by its keyword selection and database scope, which may have excluded relevant studies not using the term “development” or not indexed in Scopus and ProQuest. Future research should apply broader search strategies and explore additional databases to capture a more comprehensive view of the field. Future efforts should emphasize feasibility testing and implementation stages to ensure ethnomathematics-based development goes beyond the design phase. Researchers are encouraged to adopt diverse and participatory models, develop digital products, and create robust evaluation instruments. Teachers need support and training to implement culturally grounded materials effectively, including in digital formats. Policy makers should facilitate collaboration across researchers, educators, and communities, and allocate resources for developing and scaling ethnomathematics-based educational tools.

Future studies should integrate feasibility testing and valid evaluation tools to ensure implementation readiness. Researchers are encouraged to co-develop products with teachers and curriculum experts while also exploring digital formats such as mobile apps or interactive platforms. Teacher training programs must support the integration of ethnomathematics into diverse classrooms. Policymakers should institutionalize partnerships between universities, schools, and cultural institutions to sustain culturally grounded educational innovation.

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■ APPENDIX

Table 1. Sample of excluded articles and specific reasons

No.	Title	Year	DOI/Source	Reason for Exclusion
1	Ethnomathematics: Exploration of Mathematical Concepts on the Process of Madurese Salt Production	2024	https://doi.org/10.22342/jpm.v18i1.pp59-78	Focuses on ethnographic exploration of cultural practices; no instructional product developed
2	Conexiones etnomatemáticas en el aula con el trompo de tapitas	2023	https://funes.uniandes.edu.co/20307/	Explores classroom implementation and cultural connections; no standardized or replicable product
3	Ethnomathematics and the Philosophy of Mathematics Education	2017	https://link.springer.com/article/10.1007/s13394-017-0231-5	Theoretical discussion lacks the development of educational tools or materials
4	Exploring Zimbabwean Mathematics	2020	https://doi.org/10.1007/s11858-020-01134-z	Examines cultural mathematical practices; does not address educational product design