Systematic literature review: Implementation of ethnomodelling in mathematics learning

Muhammad Zia Alghar *, Dwi Setiawati Radjak
Universitas Islam Negeri Maulana Malik Ibrahim, Malang, Jawa Timur, 65144, Indonesia
* Corresponding Author. Email: muhammadzia1904@gmail.com

Abstract: The increase in research on ethnomathematics in mathematics education, along with the rise in research on ethnomodelling. It triggers an increasing need and interest in how ethnomodelling is applied in mathematics learning. This study aims to review the literature on implementing ethnomodelling in mathematics learning. This research method is a systematic literature review with the PRISMA model. The research data are ethnomodelling-themed studies in mathematics learning published from 2019 to 2023 and obtained through the Google Scholar database. The articles obtained were 17 articles published in various countries. The results showed the implementation of ethnomodelling in mathematics learning, including different mathematical concepts, cultural objects, and ethnomodelling approaches. Also presented are contributions from various researchers and countries that have applied ethnomodelling in mathematics learning. The results of this study contribute to researchers, teachers, and practitioners in the form of a review of various ethnomodelling studies within the scope of mathematics concepts. So, they can be used as guidelines in developing culture-based mathematics learning strategies.

Keywords: Culture, Ethnomodelling, Ethnomathematics, Mathematical learning

INTRODUCTION

One of the studies that has become a trend in the world of mathematics and mathematics education in the 21st century is ethnomathematics (Nuryadi et al., 2021; Tamur et al., 2023). Since D’Ambrosio proposed ethnomathematics in 1977, research on ethnomathematics has snowballed (Ari, 2022). The increase in ethnomathematics-themed publications indicates this development, the number of ethnomathematics-based learning tools, and the use of ethnomathematics as a course in various universities (Akbar et al., 2023; Rosa & Orey, 2019; Tamur et al., 2023). That is in line with Nuryadi et al. (2021) and Hidayati and Prahmana (2022) that the rapid increase in ethnomathematics studies occurs yearly in national, international, and Scopus-indexed journals. Thus, ethnomathematics is one of the topics that has become a byword in mathematics education today.

Ethnomathematics is defined as the techniques, arts, and styles (tics) that explain, organize, and connect mathematics (mathema) with the natural culture of a society (ethno). In this definition, mathematics acts as an instrument of knowledge to understand and organize the life of a culture (Alghar & Jamaluddin, 2024; Ari, 2022). Ethnomathematics is a set of techniques for studying and explaining mathematical knowledge developed by a particular cultural group (Albanese & Perales, 2020; Alghar & Marhayati, 2023). Ethnomathematics aims to investigate and understand how a sociocultural group constructs, develops, applies, and
disseminates its mathematical knowledge so that it can be recognized by its group and widely legitimized (Cortes & Orey, 2020; Rosa et al., 2016). Ethnomathematics is a bridge that tries to connect and appreciate mathematical values within a cultural group (Alghar et al., 2022, Alghar et al., 2023).

Studies in ethnomathematics have grown after D'Ambrosio presented six dimensions in ethnomathematics. The dimensions in question are educational, historical, cognitive, conceptual, epistemological, and historical (Albanese & Perales, 2020; Cortes & Orey, 2020). The development of ethnomathematics is also shown in the category of cultural objects studied. These categories include artifacts, mentifacts, and sociofacts (D'Ambrosio, 2015; Dutra et al., 2023). Mentifacts are ideas, values, and beliefs passed down across generations in a cultural group. Artifacts manifest forms and mechanisms developed or inherited in a cultural group. In comparison, socio-facts mean the structure, status, and organization that influence a cultural group's social behavior, knowledge, and mathematical skills. Thus, the dimensions and objects of culture in ethnomathematics have evolved.

The development of ethnomathematics accelerated in the 21st century after Prof Milton Rosa and Prof Daniel Clark Orey developed an in-depth study of ethnomathematical practices. This study emerged after Rosa and Orey saw the study of ethnomathematics as too philosophical and minimal in its application. Various criticisms emerged from teachers who saw ethnomathematics as something excellent but experienced confusion in applying it in the classroom (Rosa et al., 2020; Rosa & Orey, 2019). Another criticism is that ethnomathematics as a study only brings out the mathematics unique to the culture. There is no continuation of the exploration of mathematics that has been discovered to be brought down to the realm of academic mathematics and taught to students (Cortes & Orey, 2020). Ethnomathematics only examines mathematics in a culture. There is no procedure or requirement to uncover the mathematical models found, bring them into academic mathematics, and teach them to students. Thus, a new approach is needed in ethnomathematics to elaborate, integrate, and recognize cultural mathematical models with formal mathematical in the academic domain.

According to Orey (2017), A deep dive into the mathematical models found in traditional ethnomathematics was needed. That resulted in a new approach that brings the mathematical models of culture into the classroom, called ethnomodelling (Cortes & Orey, 2020; Dutra et al., 2021). Ethnomodelling is an alternative approach that examines the scope of mathematics developed in a cultural context as a practical application of ethnomathematics to mathematical modeling concepts. Ethnomodelling enables a generalized understanding of the mathematical knowledge practiced by cultural group members and extends the experience of academic mathematical concepts (Dutra et al., 2023; Santos & Madruga, 2021). Ethnomodelling is a deepening of ethnomathematics that applies cultural mathematical modeling to the classroom (Orey, 2017). Ethnomodelling is an intersection of ethnomathematics, mathematical modeling, and cultural anthropology. The intersection that ethnomodelling creates makes it necessary to bring mathematical models of culture, study them alongside academic mathematical models, bring them into the classroom to introduce them to students, and foster an appreciation of the culture learned (Alghar & Jamaluddin, 2024; Oliveira et al., 2021). The scope of ethnomathematics and ethnomodelling is presented in Figure 1.

Research on ethnomodelling is growing with the emic, etic, and dialogic approaches (Oliveira et al., 2021; Rosa et al., 2020). The emic approach is concerned with the practical views of members of a cultural group regarding mathematics developed and applied by their cultural group. The etic approach relates to how teachers, educators, and academics view the mathematical knowledge acquired and produced by members of cultural groups. Meanwhile, the dialogic approach relates to the complementary emic and ethic approaches. The dialogic approach enables communication about mathematical knowledge between members of cultural groups and academics to disseminate mathematical expertise to future generations (Cortes & Orey, 2020; Santos & Madruga, 2021). Emic, etic, and dialogic approaches are local, global, or both perspectives on mathematical knowledge within a cultural group.
Several studies related to ethnomodelling have been conducted, including the exploration of mathematical models in cultural ornaments (Alghar & Jamaluddin, 2024; Alghar & Marhayati, 2023), calculations for the construction of traditional houses (Umbara et al., 2021), basket making (Santos & Cassela, 2021), and cultural sculptures (Delfiol & Rosa, 2023). Ethnomodelling research is also conducted theoretically, such as the importance of dialogical approaches, political actions that affect ethnomodelling, and in-depth discussions on the intersection of ethnomodelling and ethnomathematics (Orey & Rosa, 2022; Rosa et al., 2020). Some researchers have also involved mathematics learning with ethnomodels, such as modeling function concepts from the context of markets and chocolate plantations (Cortes & Orey, 2020; Santos & Madruga, 2021); geometry modeling in coffee plantations (Dutra et al., 2021); and algebraic modeling in corn plantations (Jesus & Madruga, 2023).

Although there have been various studies related to ethnomodelling, the quantity of ethnomodelling research has not been as massive as ethnomathematics. Yet ethnomodelling has a more practical contribution to mathematics learning than ethnomathematics. The contribution of ethnomodelling can direct students' understanding of how mathematical models develop in people's lives and are applied in a cultural group. In addition, learning mathematics with ethnomodelling will construct students' understanding of formal mathematics directly and foster mutual respect for community traditions and local customs. Therefore, this research tries to summarise various ethnomodelling research directly related to mathematics learning. Thus, this research aims to review the literature on applying ethnomodelling in mathematics learning. Hopefully, this research can be the beginning and reference for other studies in viewing ethnomodelling as an approach that can be used directly in the classroom. The questions that form the basis of this research are:

- **RQ1**: What are the research trends of ethnomodelling in mathematics learning in 2019-2023?
- **RQ2**: What are the levels of education where ethnomodelling is used in mathematics learning?
- **RQ3**: What are the mathematical concepts used in ethnomodelling-based mathematics learning?
- **RQ4**: Which cultures from which countries use ethnomodelling in mathematics learning?

**METHOD**

This research uses a systematic literature review method. The data processed is primarily in articles related to ethnomodelling published in national and international journals. The stages of this research include data collection, data analysis, and conclusion drawing (Hidayati & Prahmana, 2022). Data was collected through the Google Scholar database facilitated by the publish or perish application. Keywords used in the data search included 'ethnomodelling', 'ethnomodel,' 'ethnomodelagem,' and 'mathematics learning'. Data was analyzed by reflecting
on the inclusion and exclusion criteria and the PRISMA protocol (Hendriyanto et al., 2023). Data analysis was carried out with the help of Ms. Excel's and Mendeley's application to categorize the findings of each article. That is done by converting the metadata obtained from publish or perish into .ris form. Then, the metadata is completed manually in the Mendeley application. The complete metadata was converted into a .csv form and categorized in Ms. Excel. Categorization was based on the study's title, year of publication, country of publication, journal name and edition, author's name, mathematical concept, type of ethnomodelling approach, and culture studied.

**Inclusion and Exclusion Criteria**

Inclusion and exclusion criteria aim to determine which data fulfill the criteria for study and which do not. Data that fulfill the inclusion criteria will be used as research data. Conversely, data that meet the exclusion criteria are not used by researchers. The selection of inclusion and exclusion criteria was based on the form of publication, year of publication, title & keywords, and publication content. Limiting the type and year of publication aims to verify the novelty and quality of the literature. The selection of titles and keywords aimed to focus on the scope of the study. Meanwhile, the publication's content, which focuses on mathematics learning, seeks to make the novelty and usefulness of this research have a clear contribution to the world of mathematics education. The inclusion and exclusion criteria in this study are shown in Table 1.

<table>
<thead>
<tr>
<th>Inclusion</th>
<th>Exclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data are articles from journals with verified ISSN.</td>
<td>Data in the form of book sections, proceedings, final assignments, or journals that do not have an ISSN.</td>
</tr>
<tr>
<td>The research article has the title or keywords ethnomodelling.</td>
<td>The research article did not have the title or keyword ethnomodelling.</td>
</tr>
<tr>
<td>The article presents research on ethnomodelling in learning.</td>
<td>Articles do not present research on ethnomodelling in learning. Instead, they are theoretical or exploratory.</td>
</tr>
</tbody>
</table>

**Research Instruments**

The instrument used in this study is an observation sheet containing inclusion and exclusion criteria and PRISMA provisions. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) is one of the approaches used in the literature study research method. The process in PRISMA consists of the stages of identification, screening, eligibility, and inclusion. The PRISMA process makes the data reviewed, verified, and fulfills the criteria.

**Population and Sample**

The population in this study is research on ethnomodelling published in the Google Scholar database through the Publish or Perish application. Data was collected based on research titles and keywords "ethnomodelling" or "ethnomodel". As a result, researchers obtained 638 data related to ethnomodelling or ethnomodel. Then, the 638 data were converted into .ris format for analysis with the help of the Mendeley application. The study followed the PRISMA protocol and considered the inclusion-exclusion criteria in Table 1. The PRISMA protocol used includes the identification, screening, eligibility, and stages, as presented in Figure 2.
In the identification stage, researchers obtained 638 data based on the keywords "ethnomodelling" and "ethnomodel" in Google Scholar with the Publish or Perish application. Researchers also added 11 data that researchers already had before related to ethnomodelling. The data was then converted into .ris format for analysis in the Mendeley application.

In the screening stage, 649 data were selected by looking for data duplication and adjusting the inclusion-exclusion criteria in Table 1. The inclusion-exclusion criteria used are data sourced from journals with ISSN and research published in 2019-2023. As a result, researchers excluded 338 data published not in the 2019 to 2023 timeframe and did not come from journals with ISSN. So, from the screening stage, 218 data were obtained.

At the eligibility stage, the researchers completed the metadata of the 218 data by completing abstracts, keywords, author names, volumes, and article numbers in the Mendeley application. Next, the researcher conducted two analyses. The first analysis aims to obtain ethnomodelling research trends in 2019 and 2023. At the same time, the second analysis seeks to get data that matches the inclusion and exclusion criteria.

The first analysis was conducted by converting 218 data into .csv format and categorizing with the help of Microsoft Excel. Categorization was done based on the year of publication of the research as well as the author's name. That is so that researchers can see the growth trend of ethnomodelling research each year in the 2019-2023 range. In addition, researchers can also see the contribution of ethnomodelling writers in the 2019-2023 period.

The second analysis reviewed each abstract, keywords, and research results. The review process was done by adjusting the inclusion-exclusion criteria in the first, third, and fourth parts. In the review process, researchers used an AI-based translator application, deepl.com, to translate articles not in English. The results of the review showed that 43 data were not...
published in the form of articles, 94 data did not have the theme of ethnomodelling as a whole, 38 data discussed ethnomodelling theoretically, and 26 data addressed the exploration of ethnomodelling without linking it to mathematics learning. Thus, the eligibility stage produced 17 data that met the inclusion-exclusion criteria.

At the included stage, the researcher obtained 17 pieces of data. The data were then reviewed and categorized using Microsoft Excel. The review was done by thoroughly re-reading the article and noting the critical points. The categorization was done by sorting the 17 articles based on the year of publication, author's name, research title, ethnomodelling approach, level of education studied, mathematics concepts used, and culture learned. The results of this review are presented in the form of descriptions, tables, and figures in the results and discussion section.

**RESULTS AND DISCUSSION**

Results

**Number of Ethnomodelling-Themed Research in 2019-2023**

Various studies related to ethnomodelling have increased from 2019 to 2023. The various ethnomodelling studies have different research methodologies, such as exploratory studies of mathematical models, comparison of theoretical studies, and application of ethnomodelling in mathematics learning. The development of these studies is summarised quantitatively in the graph presented in Figure 3.

![Figure 3. Development of ethnomodelling-themed research in 2019-2023](chart.png)

As shown in Figure 3, 23 ethnomodelling studies were published in 2019. In 2020, ethnomodelling research increased by 15 studies to 38 studies. In 2021, ethnomodelling research experienced a significant increase to 62 studies. In 2022, ethnomodelling research decreased by 18 from the previous year to 44 studies. Meanwhile, in 2023, ethnomodelling-themed research increased again to 51 studies. Thus, ethnomodelling research is experiencing a positive development trend every year.

The increase in ethnomodelling-themed research is also in line with the increase in research related to ethnomathematics. That is presented by Nuryadi et al. (2021) and Tamur et al. (2023), who state that research about ethnomathematics has increased in the last ten years in reputable national and international journals. The increase is also due to the variety of exploratory studies related to ethnomodelling, which has led to the opening up of various ethnomodelling research in mathematics learning. In addition, the increase in ethnomodelling research is also due to the development of theoretical thinking about ethnomodelling, especially in emic, etic, and dialogic approaches. Curriculum developments in Brazil, Indonesia, and Nepal, which have made culture essential for students, have made ethnomodelling increasingly researched, developed, and applied (Schwingel et al., 2022; Sharma et al., 2020; Umbara et al., 2021).
Ethnomodelling Research Authors in 2019-2023

The increase in ethnomodelling-related research is inseparable from the contributions of researchers who consistently publish their work on ethnomodelling. As D’Ambrosio has always popularised ethnomathematics, Milton Rosa and Daniel Clark Orey have played a vital role in publishing ethnomodelling research. The contributions made by Rosa and Orey include the development of ethnomodelling from philosophical and theoretical studies, approaches, and explorations to applications in mathematics education. In addition, Rosa and Orey always collaborate with researchers from various countries and fields of mathematical expertise, which makes ethnomodelling increasingly developed across countries and various mathematical fields. As Figure 4 shows, Milton Rosa and Daniel C. Orey dominated ethnomodelling research from 2019 to 2023.

Figure 4. Contributions of the top eight ethnomodelling-themed authors in 2019-2023

Based on Figure 4, Milton Rosa is the top author on the theme of ethnomodelling, with 68 publications in 2019-2023, followed by Daniel C. Orey with 64 publications. Apart from being researchers who popularised ethnomodelling, Rosa and Orey are consistent and like to contribute with various other researchers to conduct ethnomodelling research. Rosa and Orey also consistently publish their work in various reputable journals, proceedings, and book chapters at the national and international levels. Zulma E. D. F. Madruga contributed with 18 ethnomodelling-themed studies, followed by Diego P. D. O. Cortes with seven studies. Pablo de Carranza, Fransico Cordero, Uba Umbara, and Jaya B. Pradhan contributed to five ethnomodelling studies.

Ethnomodelling Research in Mathematics Learning

Based on data processing and analysis using the PRISMA method, 17 studies related to ethnomodelling and its implementation in mathematics learning were obtained. These 17 studies from journal publications were published in various countries. The 17 data consist of various ethnomodelling studies related to community cultures, such as coffee farming, chocolate, corn, trade, cultural areas, soap making, and handicrafts. In addition, the 17 studies show various school to college-level mathematical concepts within the scope of ethnomodelling. The 17 studies are presented in Table 2.

Based on the data presented in Table 2, 17 studies related to ethnomodelling in mathematics learning were found from 2019-2023. The research titles offered consist of various languages. That shows that researchers from multiple countries have conducted ethnomodelling research in mathematics learning. In line with D’Ambrosio’s (2015) statement, research in ethnomodelling is performed according to the cultural context in the community. Coastal, highland, and mountain residents use mathematical models that grow organically to solve various societal problems (Cordero et al., 2019; Dutra et al., 2023; Rosa & Orey, 2019; Sharma et al., 2020). One of them is the mathematical method the Cubação community uses in solving land problems with unstructured landforms (Rosa & Orey, 2019).
In addition, the diversity of the cultural objects studied is presented in Table 2. That makes ethnomodelling research flexible because it adapts to the culture that develops in the local community. This statement is in line with the research of Dutra et al. (2023), Jesus and Madruga (2023), and Santos and Madruga (2021) that various agricultural activities, such as rice, coffee,
corn, and chocolate farmers, use mathematical concepts that are unconsciously used in daily activities. Table 2 also shows that various mathematical concepts can be constructed into mathematical models in diverse cultures and community activities in multiple countries.

**Ethnomodeling Research in Mathematics Learning in Various Countries**

![Figure 5. Country scope in ethnomodelling research related to mathematics learning](image)

Based on the data presented in Figure 5, 17 studies related to ethnomodelling in mathematics learning were found from 2019-2023. The 17 studies include research from 5 different countries. Brazil leads with 11 studies. The many studies conducted in Brazil cannot be separated from the role of Daniel C. Orey, Milton Rosa, Madruga, and other Brazilian researchers who consistently produce ethnomodelling work in mathematics learning. Argentina and Turkey followed with two studies each on ethnomodelling. Angola and Nepal followed with one study each on ethnomodelling in mathematics learning.

Various ethnomodelling studies in mathematics learning conducted by multiple countries show that ethnomodelling studies apply. That means that ethnomodelling research can be involved in multiple mathematics learning in numerous countries, according to the curriculum in force in the country. Furthermore, Figure 5 also shows that the theme of ethnomodelling in mathematics education is starting to be studied and developed by various countries. That indicates that many mathematics lessons have begun appreciating, respecting, and integrating local culture into mathematics learning.

On the other hand, the dominant development of ethnomodelling is influenced by the curriculum in a country that provides space for the application of culture in education. For example, the national curriculum in Brazil values national culture as a color taught in education (Rosa & Orey, 2022; Schwingel et al., 2022). Meanwhile, in Nepal, the education system is shifting from focusing on memorization to concentrating on the knowledge process that students construct. In this case, mathematical knowledge construction can be approached from local cultural activities (Sharma et al., 2020). In addition, some educational practitioners in various countries have begun to try to bring ethnomathematics and ethnomodelling into the scope of formal mathematics. One of the aims is to introduce students to the importance of appreciating local cultural mathematics (Albanese & Perales, 2020; Ari, 2022).

**Research on Ethnomodelling in Mathematics Learning by Level of Education**

Based on the data presented in Figure 6, there is a diversity of education levels applied in ethnomodelling research. High school and university students are the subjects who play the most role in ethnomodelling research, with a percentage of 25%. High school and university students were involved as participants who constructed mathematical models based on the culture they explored. Furthermore, mathematics teachers and junior high school students engaged in various ethnomodelling studies with a percentage of 25%. In this case, mathematics
teachers can act as subjects and supervisors in ethnomodelling research. Teachers can help students find mathematical models in a culture they explore.

![Level of Education in Ethnomodelling Research](image)

**Figure 6.** Education level in ethnomodelling research related to mathematics learning

Then, elementary students and lecturers are the least active participants in ethnomodelling research, with a percentage of 5%. The lack of ethnomodelling research at the elementary school level is because elementary school students do not study abstract mathematics. That makes it difficult for students to construct the mathematical model found. On the other hand, the minimal role of lecturers in ethnomodelling research is due to lecturers only being supervisors and prominent researchers in mathematics learning who apply ethical, emic, and dialogic approaches in ethnomodelling.

However, the data presented in Figure 6 still has geographical limitations. The variety of ethnomodelling research conducted locally and in local languages allows for a range of other research that this article has not captured. In addition, the limited role of ethnomodelling in primary school mathematics learning provides a glimmer of hope. It is hoped that future research can fill this potential by developing, applying, and publishing various ethnomodelling research in mathematics learning in primary schools.

**Discussion**

The results show that various studies have examined and developed ethnomodelling. This literature review aims to evaluate and summarise the research on ethnomodelling in mathematics learning and identify research links and gaps. This research plays a role in opening insights, displaying research trends, and providing various gaps in ethnomodelling research in education. Insights are provided by an in-depth discussion of different theoretical studies that lead ethnomathematics into ethnomodelling (D'Ambrosio, 2015; Orey, 2017). Research trends are shown by the development of ethnomodelling research in the last five years, presented by renowned researchers from various countries.

In comparison, the research gap is shown by exposing the various potentials of ethnomodelling that are still minimally carried out in several research scopes, such as at the primary school level and in developed countries. Researchers also found that the challenge in ethnomodelling is globalization, which is increasingly eroding cultural groups using their inherited cultural mathematics (Ergene et al., 2020; Sharma et al., 2020). The results of this literature research on ethnomodelling will be discussed in four sections: the level of education, the approach taken, the country applied, and the mathematical context used.

First, most research focuses on ethnomodelling at the secondary school, university student, and mathematics teacher levels. With a percentage of about 20% to 25%, this result shows that students' ability to construct a mathematical model can be approached by ethnomodelling in mathematics learning (Rodrigues et al., 2021). In addition, the ability of high school students, university students, and mathematics teachers who have reached the formal operational level
makes it easy to bring concrete things into abstract forms and solve problems scientifically (Cordero et al., 2019; Rosa & Orey, 2019; Schwingel et al., 2022). That contrasts with primary school students’ minimal participation in ethnomodelling research. Primary school students are still reaching the concrete operational cognitive level, so they are not yet perfect in modeling a phenomenon into a formal mathematical form (Sharma et al., 2020). Thus, researchers, teachers, and practitioners can use ethnomodelling according to students’ cognitive level in mathematics learning.

That is in line with the theory of children’s cognitive development presented by Piaget (1971), which states that children cannot solve abstract things. At the concrete operational stage, problem-solving is still not optimal and is still dominated by fundamental knowledge (Pegg & Tall, 2005). The mathematical modeling done in children at this stage, such as primary school students, is still not good. Children cannot use symbols to abstract mathematical phenomena in a culture (Pegg & Tall, 2005; Piaget, 1971). In contrast, children in the formal operational stage, such as junior high school students, high school students, and adults, can use various symbols and abstractions to solve problems (Pegg & Tall, 2005). So, the application of ethnomodelling by junior high school, high school, and college students will work well.

Second, in terms of ethnomodelling approaches, the studies reviewed have used emic, etic, and dialogic approaches in mathematics learning. Interestingly, the three methods were carried out by students. Students carry out the emic approach by interviewing, understanding, and digging up various cultural information about farmers, historians, traders, and community leaders. The interaction between students and sources aims to dig up information and fosters mutual respect, appreciation, and care for the culture that develops in their society (Cortes & Orey, 2020; Santos & Madruga, 2021). The emic approach trains students' cognitive and affective domains, especially in building a sense of caring, cooperation, tolerance, and self-confidence (Conrado & Fonseca, 2021).

On the etic approach, students classify, analyze, and model the information obtained. The etic approach makes students understand the importance of finding as much information as possible related to the problem, researching in-depth, and testing the results they see. That trains students' ability to use the academic mathematics they have acquired to solve everyday problems found in community activities (Santos & Cassela, 2021). In other words, the ethical approach directly introduces students to how academic mathematics plays a role in society and indirectly directs students to conduct mini-research to solve everyday problems (Delfiol & Rosa, 2023; Madruga, 2023).

The dialogical approach is a combination of emic and etic. The dialogical approach is done by looking at cultural mathematics from the perspective of cultural groups and formal mathematics from academic groups (Rodrigues et al., 2021; Rosa & Orey, 2019). Students try to understand how mathematical constructions presented by a cultural group are then represented in formal mathematical form with their knowledge (Madruga, 2023). For example, when students conduct interviews about mathematical calculations made by traders. Students try to interpret the mathematical calculations into a formal mathematical model with their knowledge (Cortes & Orey, 2020). Teachers and researchers act as facilitators, as mathematical constructions are organically built by students in a dialogical approach with local traders.

Third, in the context of the region, ethnomodelling research is still dominated by research originating from Latin American countries. That shows the seriousness taken by the government in integrating culture into mathematics learning, such as in Brazil, Peru, and Argentina (Jesus & Madruga, 2023; Schwingel et al., 2022). However, some countries outside Latin America, such as Turkey, Angola, and Nepal, have started to apply ethnomodelling in learning (Ari, 2022; Santos & Cassela, 2021; Sharma et al., 2020). That means that ethnomodelling is flexible, applicable, and can adapt to the culture that exists and develops in a country. It also shows that ethnomodelling research has begun to be researched, developed, and applied by various countries worldwide.
In addition, the high public awareness of the value of culture implements ethnomodelling in learning a growing and sustainable thing. For example, teachers in Brazil are implementing maths learning in the context of building construction for students from construction workers’ families (Conrado & Fonseca, 2021). Similarly, teachers who teach maths to students who come from corn farming families do the same (Jesus & Madruga, 2023). The approach impacts students’ more authentic understanding of the application of mathematics in solving various life problems (Conrado & Fonseca, 2021; Madruga, 2023).

Finally, ethnomodelling research has penetrated various mathematical concepts in the context of ethnomodelling research. Geometry, algebra, statistics, probability, and analysis are branches of mathematics in which several concepts are used in emic, ethic, and dialogic ethnomodelling approaches (Albanese & Perales, 2020; Cordero et al., 2019; Delfiol & Rosa, 2023). This finding shows that ethnomodelling can diffuse in various mathematical concepts and the prevailing culture in society. In addition, implementing ethnomodelling in different mathematics concepts makes ethnomodelling an alternative for teachers, researchers, and practitioners in community culture-based mathematics learning.

CONCLUSION

The development of research related to ethnomodelling has brought a positive new color to mathematics education. The existence of cultural diversity, mathematical contexts, and various approaches in ethnomodelling presents a specific application of ethnomathematics. This research provides a more comprehensive understanding of the insights, potential, and implications of ethnomodelling in mathematics learning through a systematic literature review. The results show that ethnomodelling research in mathematics learning can be categorized based on the type of culture used, the mathematical concepts found, the contributing countries, and the approach used. The culture used as the object of ethnomodelling research can adjust to the culture of the community. Mathematical studies applied by ethnomodelling include geometry, algebra, statistics, probability, and analysis. Geographically, ethnomodelling research is dominated by Latin American countries. However, some countries are applying it according to their cultural context. The approaches used in various studies include emic, etic, and dialogic approaches.

This study contributes to researchers, teachers, and practitioners by reviewing different ethnomodelling research in mathematics learning. The positive implications of various ethnomodelling studies are shown by the growth of the teacher’s role as a facilitator, the mathematical knowledge that students construct directly, and moral values in respecting the culture of others. In addition, researchers found that collaboration between researchers and practitioners from various countries helped expand the impact of ethnomodelling research. The continued cooperation further characterizes the integration of culture, mathematics, and education to meet the needs of diverse students in today’s globalized world.

DECLARATIONS

Author Contribution: MZA: Conceptualization, Writing, Validation and Supervision - Original Draft, Editing and Visualization; DSR: Writing - Review & Editing, Formal Analysis, and Methodology.

Funding Statement: This research was funded by collaborative funding between the authors.

Conflict of Interest: The authors declare no conflict of interest.

REFERENCES


Ergene, Ö., Çaylan, B., & Yazıcı, E. E. (2020). Ethnomathematics activities: Reflections from the


Orey, D. C. (2017). The critical-reflective dimension of ethnomodelling. In M. Rosa, L. Shirley, M. E. Gavarrete, & W. V. Alangui (Ed.), *Ethnomathematics and its Diverse Approaches for Mathematics Education* (pp. 329–354). Springer. [https://doi.org/10.1007/978-3-319-59220-6_14](https://doi.org/10.1007/978-3-319-59220-6_14)


