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Ethnomodelling Indigenous Knowledge for Decolonizing Mathematics Education: Insights from The Passaungang Tau Heritage Site

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ABSTRACT

This study is grounded in the growing global discourse on epistemological inclusivity and culturally responsive mathematics education, which recognizes indigenous knowledge as a legitimate source of mathematical learning. The study aims to identify the mathematical meanings embedded in the Passaungang Tau cultural heritage site and examine their pedagogical implications for the decolonization of mathematics education through an ethnomodelling approach. An ethnographic qualitative design was employed, with data collected through observation, semi-structured interviews, documentation, and cultural interpretation involving community elders, cultural practitioners, and traditional stakeholders in the Gantarang Keke community, South Sulawesi, Indonesia. The findings indicate that the Passaungang Tau site contains implicit mathematical knowledge reflected in spatial geometry, traditional measurement systems, and numeracy practices rooted in local socio-cultural traditions. Through an ethnomodelling framework, these practices were systematically translated into formal mathematical concepts. Preliminary findings also suggest that culturally contextualized mathematics learning enhances students' engagement, conceptual understanding, and cultural awareness. Ethnomodelling is therefore positioned as a transformative pedagogical approach that bridges indigenous knowledge and formal school mathematics while supporting the development of contextualized and culturally sustaining mathematics instruction.

Keywords: Ethnomodelling, Ethnomathematics, Indigenous Knowledge, Decolonizing Mathematics Education, Culturally Responsive Pedagogy

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1. INTRODUCTION

For a long time, mathematics has been framed as a universal, value-neutral body of knowledge, often separated from the sociocultural contexts in which it developed and is applied. However, contemporary research has increasingly challenged this view, showing that mathematical knowledge is socially constructed, culturally embedded, and historically situated (Bishop, 1991; Valero, 2020). This shift gave rise to the field of ethnomathematics, which examines how mathematical ideas emerge, are presented, and are applied across different cultural practices (D'Ambrosio, 1985; Rosa & Orey, 2021). At the same time, critical perspectives in mathematics education have argued that knowledge production is never neutral: it is shaped by researchers' positions and socio-historical contexts, which in turn shape how mathematics is defined and taught (Foote & Gau Bartell, 2011).

According to Meaney & Trinick (2020), Indigenous knowledge systems are valid sources of mathematical thinking, encompassing spatial reasoning, measurement systems, and counting practices rooted in daily cultural activities. Research conducted Prahmana & D'Ambrosio (2020) and Umbara et al. (2021) confirmed that the local mathematical structures embedded in cultural artifacts and traditional customs can be integrated into formal education. Marshall (2023) and Nolan & Xenofontos (2023) noted that this integration improves students' conceptual understanding, strengthens their cultural identity, and boosts their learning engagement. Combined with the sociocultural perspective put forward by Gresalfi & Hand (2019), this line of research demonstrates that mathematics learning is inherently deeply tied to identity construction.

Ethnomathematics research is a field dedicated to uncovering the mathematical content inherent in diverse cultures. It has accumulated considerable progress to date, yet one long-standing problem has remained unsolved: mathematical knowledge rooted in specific cultures has never been able to be transformed into systematic classroom teaching content. Numerous prior studies have consecutively undertaken one common task: proving that mathematical-related concepts are hidden within a wide range

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of cultural activities and cultural products. For example, Supiyati et al. (2019) identified embedded geometric concepts in the architecture of the Sasak people; in the same year, Pathuddin & Raehana (2019) documented mathematical concepts in the traditional foods of the Bugis people, and discussed whether these contents could serve as materials for mathematics learning. In more recent research, Hidayah et al. (2025) sorted out the ethnomathematical ideas hidden in the Wiwitan Methik Pari ritual, while Rahmawati et al. (2026) discovered geometric shapes and patterns in the traditional snacks of the Sasak people.

The value of these studies is clear: all of them confirm that mathematical knowledge is indeed embedded in various cultural activities, and that the set of mathematics taught in schools is not the only valid form of mathematics. However, their core work onlystay at identifying these hidden ethnomathematical elements within cultures, documenting them, and explaining what they are. No study has proposed a systematic process to convert these scattered elements into formal, general mathematical expressions, and then organize them into learning content that can be directly integrated into classrooms.

This widespread flaw aligns precisely with the perspective put forward early on by D'Ambrosio & Rosa (2017): they long argued that ethnomathematics research must not stop at merely recognizing mathematical practices within cultures, but must take a further step to develop actionable, teaching-related measures that can integrate these contents into mainstream mathematics education. Put simply, what this field currently lacks is not the ethnomathematical knowledge that has already been documented. Mathematical contents hidden in cultures around the world have been uncovered by many scholars. What is truly lacking is a systematic, mature framework that can smoothly convert these culturally rooted mathematical ideas into teaching content suitable for standard classrooms.

It so happens that a research method called ethnomodelling can fill this gap. It can build an orderly connection channel between culturally rooted indigenous mathematical knowledge and formal school mathematics. Rosa & Orey (2021) broke down ethnomodelling into three interrelated pathways: emic, etic, and dialogic. By advancing step-by-step through these three pathways, indigenous mathematical content can be transformed into usable teaching materials. The first is the emic pathway. It requires researchers to first understand local people's mathematical ideas from the perspective of insiders within the culture. They must not impose external standards to alter these ideas arbitrarily from the outset, but must preserve the meanings, practices, and classification methods originally recognized within the cultural context, and retain the original form of indigenous mathematics completely and accurately. Next is the etic perspective. Its task is to interpret these culturally rooted practices using external, formal mathematical classifications for academic analysis. It must not stop at merely understanding local usages, but must also align these indigenous practices with the general set of mathematics taught in schools, establish clear connections between indigenous cultural knowledge and academic mathematics, and enable the two sets of knowledge to communicate with each other. Finally, the dialogic pathway requires the emic and etic perspectives to collaborate and interact. It is not enough to simply piece the two sets of knowledge together; instead, indigenous cultural mathematical knowledge and formal academic mathematical knowledge must be refined and aligned with each other, and finally transformed into meaningful, interconnected mathematical expressions. At the same time, the respective origins of both must be preserved: the original intent of the indigenous culture is not distorted, and the norms of formal mathematics are also satisfied.

This method is not merely theoretical; it has been supported by empirical research that confirms its feasibility: (Umbara et al., 2021) verified that ethnomodelling can transform the mathematical ideas hidden in the calculation activities of Indonesia's Cigugur Indigenous people into academic mathematical concepts, including the specific contents taught in classrooms such as counting, integer operations, sets, relations, congruence, and modular arithmetic. Through this complete process of emic, etic, and dialogic pathways, ethnomodelling no longer stays at the level of "descriptively identifying mathematics within culture", but can systematically transform these contents into formal mathematical knowledge, and even organize them into materials for the classroom, smoothly integrating them into formal educational settings.

At the same time, global discussions surrounding the decolonization of mathematics education have further strengthened the core understanding that Indigenous knowledge holds epistemological legitimacy and pedagogical value. Decolonization efforts work to break the dominance of Eurocentric mathematical perspectives and integrate diverse ways of knowing into educational practice, and these ideas have received support from academic research (Garcia-Olp et al., 2022; Shultz et al., 2024). In multicultural and postcolonial contexts, this approach is especially well-suited, and it can advance inclusivity, equity, and cultural sustainability in education (Giroux & Nolan, 2025; Govender et al., 2026).

Within the local Indonesian context, practices that integrate Indigenous wisdom into education are supported by an independent curriculum that promotes contextualized, culturally responsive learning. Ethnomathematics provides a strategic pathway to achieve this policy goal, as it can connect mathematical concepts to students' real-life experiences (Nurhusain et al., 2025). Indonesia is home to diverse cultural resources, and past studies have unearthed mathematical meanings in architecture, food-related practices, and various cultural rituals (Hidayah et al., 2025; Pathuddin et al., 2021; Rahmawati et al., 2026; Supiyati et al., 2019). However, most of these studies have remained at the descriptive level, lacking a systematic framework to transform cultural knowledge into formal mathematics learning. Research that links cultural heritage sites to mathematics education through rigorous theoretical and methodological approaches remains very scarce.

The Passaungang Tau cultural heritage site offers a distinctive configuration of culturally embedded mathematical knowledge. Although traditional measurement systems based on the human body are also found in other cultural contexts, the specific practices identified at Passaungang Tau are embedded in the construction and use of a culturally significant stone-enclosed arena and are interconnected with local concepts of spatial balance, symmetry, and symbolic numeration. For comparison, the Nuabosi community in East Nusa Tenggara uses anthropometric units such as jengkal, hasta, depa, and footsteps in the construction of traditional houses, weaving, games, and customary activities (Bude et al., 2025). Similarly, traditional Minangkabau craftsmen have used dapo (fathom), eto (cubit), jangko (span), tampok (hand), and jari (finger) in constructing rumah gadang (Fitriza et al., 2019). These examples indicate that non-standard, body-based measurement is a recurring feature of indigenous mathematical practices, but they also demonstrate that such systems are culturally situated and function differently across communities. At Passaungang Tau, the use of depa and footsteps is embedded specifically in the spatial organization and construction of the stone-enclosed arena, where measurement practices are associated with dimensions, balance, and the ordering of the cultural space. The site therefore provides an opportunity to examine not merely the existence of non-standard measurement, but how measurement, spatial reasoning, and symbolic numeration operate as an interconnected system of situated mathematical knowledge.

Previous ethnomathematics research has already demonstrated the pedagogical potential of culturally embedded mathematical practices. For instance, Supiyati et al. (2019) identified mathematical concepts in Sasaknese architecture, while (Prahmana & D'Ambrosio, 2020) connected mathematical patterns in Yogyakarta batik with geometry learning and cultural values. More directly, Umbara et al. (2021) employed an ethnomodelling approach to transform the calculation practices of the Cigugur Indigenous community into formal mathematical concepts. These studies demonstrate important progress from cultural exploration toward educational application. However, research specifically examining the Passaungang Tau heritage site has not yet systematically connected its spatial geometry, traditional measurement practices, and culturally symbolic numeration within an integrated ethnomodelling framework. The present study therefore does not claim that the mathematical potential of cultural heritage has been previously unexplored; rather, it addresses a more specific gap by systematically interpreting the interconnected mathematical practices of Passaungang Tau and mapping them onto formal mathematical representations and potential classroom learning contexts.

Accordingly, this study centers on two core goals: exploring the mathematical meanings embedded in the site and systematically interpreting these meanings through an ethnomathematical modeling approach. This approach involves three core processes: (1) identifying the mathematical concepts inherent in the site's cultural practices, (2) interpreting these practices as mathematical models, and (3) exploring their potential integration into mathematics learning.

This study proposes an integrated ethnomathematical modeling framework, which transforms the system of local cultural practices in heritage sites into formal mathematical knowledge and instructional structures. This framework fills the long-standing gap between ethnomathematical explorations and their implementation in classrooms, and anchors the connection between learning and students' sociocultural identities. This study also advances research in related fields in two aspects: First, it overcomes the limitations of previous descriptive analyses, establishes a connection framework between cultural knowledge and formal mathematics, and expands the boundaries of ethnomathematical research. Second, it provides a foundation for integrating local knowledge into mathematics teaching, and supports culturally responsive inclusive practices that not only address local needs, but also contribute to global discussions on related topics.

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2. RESEARCH METHOD

A. Research Design

This study adopts a qualitative research design rooted in ethnomathematics and ethnomodelling, with the aim of uncovering the mathematical connotations embedded in the pottery cultural heritage site of Passaungang Tau. Qualitative research was selected because this study focuses on interpreting the meanings of cultural practices, symbols, and spatial structures within their original context, rather than conducting quantitative statistics; supporting citations for this approach are drawn from Hirose & Creswell (2023) and Ishtiaq (2019). An ethnographic orientation was additionally adopted to conduct in-depth exploration of Indigenous knowledge systems and their associated mathematical structures, a choice supported by Almusaed et al. (2025). Ethnomodelling was used to connect emic, locally implicit knowledge with etic, formal mathematical representations, and the suitability of this approach is supported by findings of Umbara et al. (2021).

B. Participants

The study site for this research was the Passaungang Tau cultural heritage site, which was selected through purposive sampling. This site has a rich cultural foundation and holds research potential for uncovering embedded mathematical concepts. The study's participants were also selected via purposive sampling, to screen individuals familiar with the cultural practices of this heritage site. The participants included 1 traditional leader (KA1), 3 community members (M1, M2, M3), 2 teachers (G1, G2), and 1 student (S1). This sampling strategy allowed the inclusion of information-rich cases to deepen the research's analytical depth. The methodological support for this approach is drawn from study by Etikan et al. (2015).

C. Instrument

The core research instrument for this study was the researcher themself, supported by three tools commonly used in qualitative research: an observation guide, a semi-structured interview outline, and a recording form. Participatory observation was used to document cultural practices, spatial layouts, and contextual interactions; interviews were conducted to elicit interviewees' interpretations of cultural symbols and related content; and analysis of documents and cultural relics relied on photos, sketches, and object inspections to identify embedded mathematical rules including geometric principles, symmetry, and measurement logic.

D. Procedures

To ensure the depth of this qualitative ethnographic study and the effectiveness of triangulation, this research adopted a phased multi-source data collection plan. First, preliminary observation was conducted to become familiar with the research site and its cultural context. Second, through participant observation, naturally occurring cultural practices and spatial structures were recorded. Third, semi-structured in-depth interviews were carried out with selected participants to obtain in-depth understanding of the cultural meanings and practices at play. Fourth, literature and artifacts were analyzed to verify the observational and interview data collected in the earlier steps. The entire process spanned a long period, to meet the fundamental requirements of this type of research for long-term engagement and contextual comprehension.

E. Ethnomodelling Framework and Data Analysis

This study conducted data analysis using an integrated ethnomodelling framework. This framework incorporates thematic analysis to transform systems of cultural practice into formal mathematical representations, and the analysis in this study proceeded through three interconnected stages.

The first stage was the cultural exploration stage. We transcribed, organized, and coded three types of data collected from observations, interviews, and documentary records, and identified recurring themes related to cultural practices, spatial structures, symbolic meanings, and traditional measurement systems. This process followed the research protocol proposed by Braun & Clarke (2006). The second stage was the ethnomodelling analysis stage. We transformed four categories of ethnomathematical practices identified during fieldwork—spatial reasoning, geometric structures, measurement systems, and counting patterns—from an emic perspective into an etic mathematical framework. This translation method drew on the study by (Umbara et al. (2021), and through this process, we systematically generated formal mathematical models rooted in the local cultural context. The third and final stage was the instructional contextualization stage. We mapped the generated mathematical models onto potential classroom application scenarios, and developed contextualized mathematical tasks, conceptual learning trajectories, and instructional representations aligned with school mathematics curricula. This approach aligns with the view of culturally

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responsive contextualized mathematics learning, which emphasizes connecting mathematical concepts to learners' lived experiences. Supporting evidence for this view comes from study by Prahmana & D'Ambrosio (2020) and the study by Rosa & Orey (2021). This stage ensured that the outcomes of the ethnomodelling process had both theoretical significance and instructional applicability.

To ensure the credibility of this study, we adopted data source triangulation, long-term immersive participation, member checks for cultural validity verification, and reflexivity strategies throughout the entire research process. The theoretical basis for these methods draws on relevant studies by Lincoln et al. (2002), Nowell et al. (2017), and Tracy (2010).

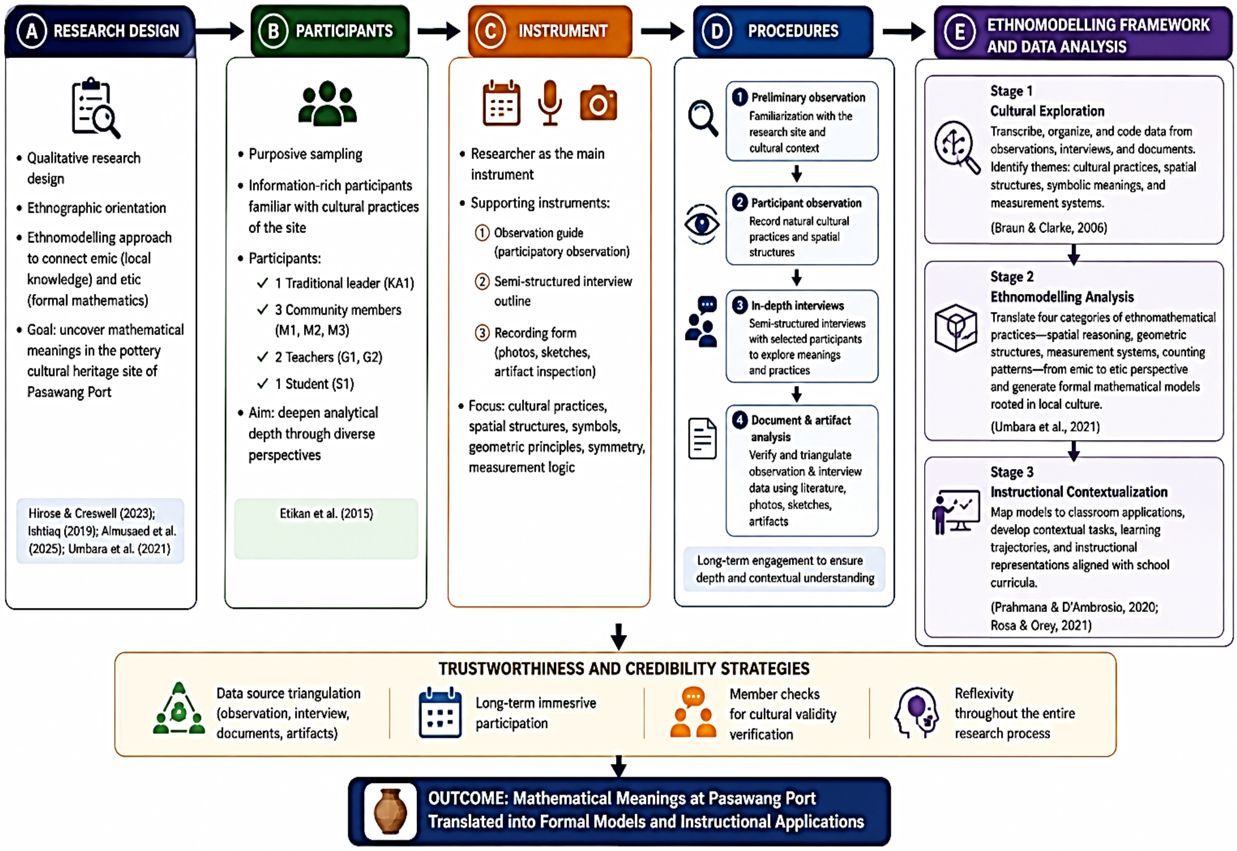

Fig 1. Research Method

3. RESULTS AND DISCUSSION

This study adopts thematic coding analysis to process three types of research data: interview data, observation data, and documentary data. Taking the Passaungang Tau site as its field research site for empirical investigation, the study identifies four core themes of ethnomathematics related to this site, which are: geometric expressions in cultural architecture, the traditional measurement system as an indigenous mathematical practice, the counting system embedded in cultural symbols and social activities, and the approach to transforming cultural practices into formal mathematical concepts through ethnographic modeling. This study clarifies the connection between the cultural practices of the Gantarang Keke community and the construction of situated mathematical knowledge, and defines the potential of integrating such knowledge into mathematics teaching. Figure 1 presents the physical conditions of the site, which serves as the empirical background for this study.

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Fig 2. Passaungang Tau Site in Gantarang Keke
(Source: Research Documentation, 2025)

Figure 1 shows the physical conditions of the Passaungang Tau archaeological site. As a cultural space, this site served as the carrier for the development of mathematical practices among the local community.

A. Theme 1: Geometry as a Representation of Cultural Structure

The physical structure of the site contains implicit geometric concepts. Based on field observations and interview results, the local community perceives the basic form of this site as an enclosed space that resembles a cuboid with specific dimensions.

Interviewee M2 explained that the site is like a large box with its own length, width, and depth. This indicates that in the local perception, it is not merely a flat area, but a three-dimensional space: "*Kalau dilihat dari bentuknya, ini seperti kotak besar… ada panjang, lebar, dan dalamnya juga. Jadi bukan hanya datar, tapi seperti ruang*." (Informant M2: "Just by its shape, this place is like a big crate... it has length, width, and depth. So it is not just a flat patch of land, but a real, tangible space.").

This statement shows that the local community had an intuitive understanding of three-dimensional concepts, but this understanding was never expressed in formal mathematical terms. This finding is also supported by the account of a local traditional leader (interview code KA1), who explained that when the site was built, the requirement for balance was fully considered: the left and right sides must be completely equal to ensure the structure was solid and orderly. He stated, "*Dulu dibuat dengan memperhatikan keseimbangan… kiri dan kanan harus sama, supaya kuat dan rapi*." (Informant KA1: "When we built things in the past, we always paid attention to balance... the left and right had to be the same, so that the structure would be firm and neat."). Table 1 organizes all implicit geometric concepts identified at the site, including cuboid shapes, symmetry, and the spatial dimensions related to area and volume.

Table 1. Identification of Geometric Concepts in Passaungang Tau

Cultural Aspect	Description	Mathematical Concept
Site structure	Bounded arena	Three-dimensional shape (cuboid)
Structure	Flat and balanced	Symmetry
Dimensions	Length, width, and depth	Volume and area

These findings confirm that geometric principles are in fact embedded in the local community's cultural construction practices. The concept of balance corresponds to the mathematical concepts of symmetry and proportion, while the orderly spatial layout reflects the community's capacity for intuitive geometric reasoning. The geometric understanding of the Passaungang Tau community is entirely derived from culturally embedded spatial practices, and the ideas of balance and order are put into practice as part of their daily life traditions.

This paper argues that the geometric understanding of the Passaungang Tau people is a product of local cultural practices, rather than the outcome of formal mathematics education. A study by Prahmana et al. (2021) points out that mathematical knowledge does not possess inherent symbolic properties; instead, it is embedded in cultural experiences. Combined with this ethnic group's embodied spatial reasoning about balance and symmetry, Mania & Alam (2021) proposed that geometry is a culturally constructed cognitive

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system. The geometry discussed here is precisely a structurally and value-laden construct that carries the social order of harmony.

B. Theme 2: Traditional Measurement as a Local Mathematical System

During the construction of Passaungang Tau, the local community used non-standard measurement systems such as the arm span (*depa*) and stride length. These systems are not merely practical measurement tools; they also embody the community's understanding of space and distance. Informant M3 explained that in the past, people did not use meters to measure, but instead used strides or arm spans, and would adjust these measurements according to actual needs: "*Dulu tidak pakai meter, ukurannya pakai langkah atau depa… disesuaikan saja dengan kebutuhan*." (Informant M3: "Back then, they didn't use meters; measurements were based on steps or arm spans, depending on what was needed.").

Informant G2, who works as a teacher, believes this system has educational potential. It can be used as an introductory scenario to let students compare traditional measurement units with standard units such as the meter, "*Ini bisa dijadikan awal pembelajaran. Siswa bisa membandingkan ukuran tradisional dengan meter*." (Informant G2: "This can serve as a starting point for learning. Students can compare traditional units with meters.").

The links between traditional units and mathematical concepts have been systematically sorted out in Table 2, which presents the forms of various measurement units, their corresponding descriptions, and the derivable mathematical transformation pathways.

Table 2. Traditional Measurement System

Traditional Unit	Description	Mathematical Transformation
Depa	Arm span	Unit of length
Footsteps	Walking distance	Length estimation
Approximation	Non-standard measurement	Ratio and comparison

These research findings show that the traditional measurement system contains implicit mathematical reasoning such as thinking related to estimation, comparison, and proportion. From an ethnomodelling perspective, these practices can be systematically transformed into formal mathematical concepts, building a bridge between indigenous cultural knowledge and school mathematics. Traditional measurement practices also indicate that mathematical reasoning is rooted in experience and functional needs. Under the ethnomodelling framework, these practices belong to emic mathematical structures that can be transformed into formal measurement concepts. This transformation is not a simple technical adjustment, but an epistemological reconstruction. Umbara et al. (2021) previously proposed the core logic of this transformation pathway, and Roza et al. (2020) had earlier pointed out the teaching potential of traditional measurement. This study advances relevant discussions into a implementable plan for the structured transformation of teaching content.

C. Theme 3: Numeration in Socio-Cultural Values and Structures

The concept of numbers within Passaungang Tau appears not only in quantitative forms, but also carries strong symbolic meanings within the community's social structure. Numbers such as 7, 14, and 15 possess particular significance in customary traditions.

KA1, a traditional community leader, explained that the consequences of violating customary rules can affect up to "14 generations," a detail that demonstrates the severity of sanctions within the traditional system. He stated in Indonesian: "*Kalau ada yang melanggar aturan, dampaknya bisa sampai 14 turunan… itu aturan yang sangat berat*." Another community member, M1, noted that 7 and 15 frequently appear in various customary activities, and local people believe these numbers carry unique symbolic implications. He stated in Indonesian: *"Angka 7 dan 15 sering dipakai dalam adat… dianggap punya makna tertentu."* The relationship between symbolic meanings and the mathematical functions of numbers in customary practices is systematically summarized in Table 3.

Table 3. Numerical Concepts in Culture

Number	Cultural Meaning	Mathematical Concept
7	Important customary number	Number
14	Generational sanction	Sequence / multiple
15	Cultural symbolism	Numeration

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The findings of this study show that counting systems have both quantitative and sociocultural attributes. The expression of "14 generations" is a symbolic form of quantification used to reinforce social norms and authority. Meanwhile, the repeated appearance of the numbers 7 and 15 reflects a fixed counting pattern formed in cultural practices. From an ethnomathematics perspective, this is exactly cultural counting that carries dual meanings of mathematics and philosophy. The use of counting in sociocultural contexts highlights the semiotic and normative dimensions of mathematics. As carriers of cultural meaning, the three numbers 7, 14, and 15 not only regulate social behavior but also encode core philosophical values. This finding challenges the reductionist view that counting is only a purely quantitative tool, and instead positions it as a symbolic system embedded in cultural discourse. Relevant supporting evidence can be found in the studies by Boaler (2019) as well as Pathuddin & Raehana (2019). In this sense, counting is a construct that operates at both the cognitive and sociocultural levels, which expands its role in the field of mathematics education.

Through ethnomodelling, these patterns can be converted into formal mathematical concepts such as digital patterns, relational logic, and situational counting systems for use in classroom teaching. On the whole, the cultural practices of Passaungang Tau themselves contain structured mathematical ideas that can be systematically transformed into formal mathematical content.

D. Theme 4: Ethnomodeling and Pedagogical Contextualization

The study finds that Passaungang Tau has sufficient potential to serve as a situational resource for mathematics learning, and both teachers and students have given positive feedback on integrating culture into mathematics teaching.

A participating student coded S1 stated that learning based on this site makes mathematical concepts easier to understand, because the related forms can be observed directly: *"Kalau belajar dari tempat ini, lebih mudah dipahami… karena bisa langsung lihat bentuknya."* ("If you learn from this place, it is easier to understand… because you can see the forms directly.").

Similarly, Teacher G1 explained that when mathematics teaching breaks free from the limitations of numbers written on blackboards and is integrated with historical and cultural contexts, it becomes more meaningful and engaging: *"Matematika jadi lebih hidup… tidak hanya angka di papan, tapi ada hubungannya dengan sejarah."* ("Mathematics becomes more vivid... it is no longer just numbers on a blackboard, but also connected to history.").

These findings show that learning rooted in real-world contexts can improve students' conceptual understanding by supporting concrete visualization and promoting the abstraction of mathematical ideas. From an ethnomathematics perspective, this is exactly the process through which cultural practices are transformed into formal mathematical concepts via ethnomodelling, which confirms that mathematics is inherently embedded in sociocultural life.

Figure 2 presents the integrated ethnomodelling framework developed in this study. It illustrates the complete pathway through which cultural practices are transformed into formal mathematical concepts through exploration and modelling, and then integrated into teaching scenarios. The framework clarifies that ethnomodelling serves as a bridge connecting local indigenous knowledge to school mathematics.

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Fig 3. Integrative Ethnomodeling Framework for Culturally Responsive Mathematics Education

This study organizes and presents the possibilities of integrating the above findings into mathematics learning, specifically using a table to show how cultural contexts map onto mathematical concepts and classroom activities.

Table 4. Potential Integration of Ethnomodelling in Mathematics Learning

Cultural Context	Mathematical Concepts	Learning Potential
Structure of the Passaungang Tau site	Spatial geometry, symmetry, and spatial reasoning	Identification of three-dimensional shapes and symmetry analysis
Measurement using *depa* and footsteps	Length units, estimation, ratios, and unit conversion	Comparison between non-standard and standard units
Symbolic numbers in customary traditions	Numeracy, number patterns, and numerical relations	Learning number patterns through cultural contexts

Overall study findings show that ethnomodelling not only supports learners' conceptual understanding, but also helps protect indigenous cultural knowledge in educational settings. From a broader perspective, the ethnomodelling used in this study acts as an epistemological bridge that connects indigenous knowledge systems and formal mathematics. It transforms cultural practice systems into structured mathematical representations, breaking the dominant narrative that mathematics is a universal, culturally neutral discipline. It highlights that mathematics is socially embedded knowledge shaped by historical and cultural contexts. This perspective advances discussions on the decolonization of mathematics education, recognizing indigenous knowledge as an equally valid cognitive resource (Garcia-Olp et al., 2022; Shultz et al., 2024).

It is important to highlight that integrating cultural contexts into mathematics learning can improve conceptual understanding when abstract ideas are grounded in learners' familiar sociocultural experiences. This aligns with culturally responsive and culturally sustaining pedagogical theories, which frame culture as a core component of knowledge construction rather than an add-on. Furthermore, ethnomodelling not only makes methodological contributions, but also can reshape the relationship between mathematics, culture, and learning.

E. Preliminary Pedagogical Exploration

To test the instructional applicability of the ethnomodelling framework, we carried out a small-scale learning activity for 8 middle school students at the Passaungang Tau Site. During the activity, students were asked to identify geometric shapes, use the traditional unit of measurement *depa*, and connect cultural practices with formal mathematical concepts. We also collected their feedback through reflective interviews.

The results of this study show that students have a high level of active participation, and are able to connect mathematical concepts with culturally meaningful representations. When concepts related to geometry and measurement are integrated with familiar cultural practices and the physical local environment, the difficulty of understanding these concepts decreases significantly. Students also hold positive attitudes toward the integration of local culture into mathematics learning, believing that this approach not only improves their conceptual understanding but also enhances their cultural awareness. As a preliminary exploration with limited scope, this study did not include quantitative validity measurements. The findings indicate that learning based on ethnomodelling can support culturally responsive teaching, and integrating mathematical concepts with students’ sociocultural context can strengthen their participation. Table 5 summarizes students’ feedback and their learning engagement.

Table 5. Students' Feedback and Learning Engagement in Preliminary Ethnomodelling Learning Activities

Activity	Student Response
Geometry identification	Students identified triangles, rectangles, and spatial patterns
Depa measurement	Students compared traditional and formal units
Reflection discussion	Students reported higher engagement and contextual understanding

The research findings show that integrating cultural heritage into mathematics learning can build a connection between abstract mathematical concepts and concrete life experiences; this approach not only supports learners' conceptual understanding, but also enhances their cultural perception and learning motivation. This study is exploratory, and its results provide preliminary empirical support for the teaching potential of mathematics learning rooted in local culture.

F. Pedagogical Implications and Global Relevance

The findings of this study have important reference value for mathematics teaching design and curriculum development. The mathematical elements identified in the Passaungang Tau cultural heritage site in this study can be transformed into learning materials, classroom activities, and situational assessment tasks. Developing teaching content based on cultural heritage allows students to access mathematics that aligns with their local context, which is consistent with the educational direction that emphasizes situational learning and the integration of local wisdom (Marshall, 2023; Nurhusain et al., 2025).

The small-scale teaching practice carried out in this study shows that cultural context is an effective entry point for introducing formal mathematical concepts. Cultural products and practices are by no means merely supplementary cases; instead, they can be systematically integrated into curriculum design to support students' exploration, discussion, and knowledge construction, while also connecting mathematical content with students' daily realities (Gresalfi & Hand, 2019; Kong et al., 2023; Marshall, 2023; Nolan & Xenofontos, 2023; Rosa & Orey, 2021). The positive outcomes of this practice have verified the suitability of the ethnomathematical modeling learning strategy, and all relevant conclusions are supported by existing research literature (Prahmana & D'Ambrosio, 2020; Supiyati et al., 2019).

Beyond its direct educational applications, this study also maps out directions for future research and innovation. By exploring the ethnomodelling framework built around Passaungang Tau, our work can be adapted for research on other cultural heritage scenarios, and can also support the development of curriculum resources, instructional media, and teacher professional development programs. Furthermore, this framework can serve as a research foundation to analyze how culturally rooted learning designs contribute to broader educational goals, including boosting student motivation and self-efficacy, and promoting formal education's recognition of diverse knowledge traditions. Relevant supporting evidence for this line of work can be found in a series of prior studies. This study also notes that collaboration between educational institutions and local cultural communities is a core condition for sustaining the applicability of culturally rooted mathematics education. The recording and interpretation of mathematical concepts embedded in cultural heritage requires the joint participation of community knowledge holders, educators, and researchers, to ensure the accurate presentation of local knowledge and the preservation of its cultural significance (Disnawati & Nahak, 2019; Garcia-Olp et al., 2022; Meaney & Trinick, 2020; Rosa & Orey, 2021; Shultz et al., 2024).

The findings of this study also indicate that greater attention must be paid to teacher preparation and professional development focused on culturally adaptive mathematics instruction. Most culture-rooted mathematical concepts fail to be implemented in classrooms, and the core reason for this is that teachers lack opportunities to identify, interpret, and integrate these concepts into formal learning settings. Strengthening teachers' ability to connect with local knowledge systems can support more diverse mathematical inquiries and classroom dialogues.

From a broader perspective, this study underscores the importance of expanding the knowledge base that shapes the content and perspectives drawn on in mathematics education. Treating cultural practices as a legitimate source of mathematical insights can foster more inclusive forms of cognition, support ongoing efforts to expand the participation of diverse stakeholders in mathematics education, and cultivate greater recognition of the knowledge contributions of local and Indigenous communities.

G. Limitations and Suggestions for Future Research

This study has several limitations. First, the research was conducted only within a single cultural context, which limits the generalizability of its conclusions. Second, the analysis relies on ethnographic interpretation; while every effort was made to ensure rigor, the potential for subjectivity remains. In addition, the teaching exploration was small in scale, exploratory in nature, and included only a small number of students, with no quantitative assessment of learning outcomes. This study also raises an important epistemological concern: converting Indigenous cultural practices into formal mathematical representations through cultural modeling may simplify the complex cultural connotations of those practices, or reframe their meanings through an academic lens. It may also romanticize Indigenous knowledge as static and universally applicable, even though cultural practices are inherently dynamic and context-dependent.

Future research needs to integrate multicultural contexts and carry out larger-scale classroom-based practical implementations to strengthen the reliability of empirical evidence. Further exploration is also required on how to balance the three core dimensions of cultural authenticity, epistemological integrity, and pedagogical transformation in ethnomathematics-based teaching.

4. CONCLUSION

This study aimed to fill the research gap between the identification of ethnomathematics and its pedagogical transformation. It investigated the mathematical meanings embedded within the Passaungang Tau cultural heritage site, and systematically interpreted these meanings through an ethnomodelling framework, which aligns with the objectives proposed in the introduction. The study found that mathematical concepts are deeply embedded in cultural practices, manifesting in three forms: geometric structures, traditional measurement systems, and symbolic counting. These cultural elements have been converted into formal mathematical representations and learning-oriented models, confirming that the study's objectives, methodological design, and empirical results are highly consistent with one another.

This study confirms that the local context of the Passaungang Tau in Gantarang Keke community has nurtured a socioculturally embedded system of mathematical knowledge. Within this system, geometric logic is rooted in indigenous spatial structures and concepts of balance; measurement relies on an embodied, non-standard system; and counting carries symbolic cultural meanings. When this knowledge is transformed into school mathematics content through ethnographic modeling, it can improve students' level of engagement, comprehension, and cultural awareness. This finding verifies that cultural practices are a legitimate epistemological source for formal mathematics education.

This study verified that the conceptual expectations laid out in the introduction are fully consistent with the empirical findings presented in the discussion section. The ethnomodelling framework proposed in this study not only connects ethnomathematics exploration with classroom practice, but also provides a transferable model for culturally responsive mathematics education. Future research can promote this framework in multicultural settings, carry out large-scale teaching experiments and quantitative evaluations, and meanwhile optimize the balance between cultural interpretation and mathematical formalization, to give simultaneous consideration to cultural authenticity and teaching applicability.

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