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Ethnomathematical Exploration of Two-Dimensional Geometric Shapes in *Mekongga* Traditional House Architecture

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Abstract

Geometry is a fundamental branch of mathematics, yet many students struggle to comprehend it as they often perceive the subject as disconnected from real-world applications. In reality, geometric concepts are deeply embedded in daily life, particularly evident in traditional architecture. The *Mekongga* tribe of Southeast Sulawesi, Indonesia, exemplifies this connection through their culturally rich architectural heritage. However, ethnomathematical research on the *Mekongga* remains limited, despite its significant potential for enhancing contextual mathematics education. This study aims to address this gap by examining geometric shapes in Mekongiga traditional houses. This investigation also highlights the properties of each two-dimensional geometric form discovered. Data collection involved field observations, semi-structured interviews with traditional house guards, and photographic documentation of existing structures. Data analysis was carried out by identifying two-dimensional geometric shapes, focusing on the walls, roofs and stairs which were then visualized using GeoGebra. The findings reveal specific geometric shapes integrated throughout the architectural elements: isosceles triangles and trapezoids are prominent in the roof structure, rectangular shapes dominate the walls designs, and parallelograms are distinctly present in the staircase construction. The formal properties inherent in mathematical principles correspond directly with each two-dimensional geometric shape discovered in the traditional *Mekongga* houses. This research contributes to the field of ethnomathematics by highlighting how traditional cultural practices incorporate mathematics and suggests applications to connect academic content with students' cultural heritage, providing teachers with authentic contexts for teaching geometric concepts.

Keywords: Ethnomathematics Exploration, Geometry, *Mekongga*, Traditional House, Mathematics

Introduction

Traditional heritage is often viewed as works of art, objects of historical study, or destinations for cultural tourism. While this perspective contributes to cultural preservation, it limits the broader and deeper utilization of local values, especially in the context of education. In fact, traditional heritage reflects mathematical principles that grow and develop naturally in local culture through their structure, pattern, symmetry, shape, and concept of measurement. As D'Ambrosio stated, mathematics is not a collection of absolute truths, but rather a socio- cultural production rooted in people's experiences and traditions. This approach proposes that all forms of mathematical knowledge should be viewed within a specific historical and cultural context so that the field of mathematics becomes more inclusive of cultural and local diversity. Other experts, such as Milton Rosa and Daniel Clark Orey, have further developed this idea, emphasizing the importance of integrating cultural values into the mathematics education process (Nasrum et al., 2025). This is a great opportunity to link culture with mathematics learning through an approach called ethnomathematics.

Ethnomathematics is the study of mathematical ideas and practices that emerge from diverse cultural contexts. It encompasses various numerical systems, mathematical reasoning, and approaches to multicultural mathematics education (Thomas & Jacob, 2021) .Within this framework, mathematical concepts are examined in the context of cultural practices. Indonesia, home to approximately 1,340 ethnic groups (Lidinillah et al., 2022), is a rich source of ethnomathematical exploration due to its cultural diversity. One such group is the Tolaki Mekongga tribe, an indigenous community in Southeast Sulawesi (Halil et al., 2024). The tribe maintains a wide range of cultural traditions, local wisdom, and historical artifacts that persist to this day. A prominent example is the traditional architecture of the Mekongga house. Its design features distinctive elements, such as roofs, stairs, windows, and doors, each of which reflects specific cultural meanings. These architectural components can be analyzed to reveal the underlying geometric concepts embedded within traditional construction practices.

There are many studies have investigated geometric shapes in various traditional houses, including the uma lengge and uma jompa of the Lambitu tribe (Mariamah et al., 2021), Balla Lompoa in South Sulawesi (Ja'faruddin & Naufal, 2023), and Segenter house in Bayan (L. M. Fauzi et al., 2021). These structures exhibit two-dimensional shapes such as squares, rectangles, triangles, circles, and trapezoids, as well as three-dimensional forms. Researchers have emphasized the potential of using these cultural elements as contextual teaching materials to enhance students' understanding of geometry concepts. Studies indicate that incorporating ethnomathematics into geometry education can enhance numeracy literacy and spatial abilities (Mahayani et al., 2024). Research has demonstrated that learning non-Euclidean geometry through ethnomathematics-based approaches positively impacts students' spatial abilities (Sukestiyarno et al., 2023). The integration of ethnomathematics in learning processes makes mathematics more relatable and enjoyable for students (Cahyadi et al., 2020). These studies collectively suggest that ethnomathematics can be a valuable solution for enhancing students' geometry skills and overall mathematical capabilities by connecting abstract concepts to familiar cultural contexts.

Based on previous research highlighting the significance of ethnomathematics in mathematics and geometry education, it is crucial to investigate the traditional house of the Mekongga tribe as potential learning resources. However, exploration in this area remains limited. There are only three significant studies about Mekongga traditional houses. Hidayati et al. (2025) concentrated exclusively on geometric transformations present in Mekongga architecture, providing valuable but narrowly focused insights. Jahring et al. (2025) explored several geometric shapes within these structures, while Wangsa et al. (2024) examined both geometric forms and their associated philosophical and historical values. While these contributions have established a preliminary foundation, previous studies have not adequately addressed the intrinsic properties of the two-dimensional shapes found throughout these structures. Furthermore, existing research has primarily adopted similar approaches, leaving unexplored alternative perspectives that might yield new insights.

The novelty of this proposed study lies in its examination of the properties of two-dimensional geometric shapes within these architectural structures, moving beyond simple identification to explore geometrical concepts. The findings will contribute to the preservation and appreciation of Mekongga cultural heritage and will provide educators with culturally relevant resources to enhance mathematics instruction. By combining traditional knowledge with modern education, this research promotes the development of a more culturally responsive approach to mathematical teaching.

Methods

This research is explorative research with an ethnographic approach. Ethnographic research, originally used in anthropology, has expanded to various fields including education and medicine (Reksiana, 2021). This approach involves immersing oneself in the participants' environment to understand their culture, challenges, and motivations (Arnout et al., 2020). Explorative research in this study is research that seeks to identify the two-dimensional geometry shapes of Mekongga traditional houses architecture in Kolaka District, Southeast Sulawesi. The ethnographic approach is used to understand the cultural context of the Mekongga traditional house. The research was conducted from July to November 2024 at the Mekongga Traditional House Museum in Kolaka District, Southeast Sulawesi.

There are two sources of data in this research, namely primary data and secondary data. Primary data is collected directly by researchers, while secondary data is obtained from existing sources. Primary data was obtained from directly from the field with observation and interview process. While secondary data comes from previous research such as journals, proceedings, and books (Mazhar, 2021). The main instrument in this research is the researcher themself while the auxiliary instruments are observation sheets and interview guidelines. Data collection techniques use principles in ethnography such as observation, interviews, documentation, and field notes with original ethnographic descriptions.

The data analysis techniques used are data reduction, data presentation, and conclusion drawing. Data reduction is the process of condensing and sorting data into conceptual units, categories, and themes (Rijali, 2019). The reduction stage is to classify the results of the exploration of the Mekongga to two-dimensional shapes category. Data presentation involves organizing reduced data into visual forms such as sketches, matrices, or synopses to facilitate understanding and interpretation (Mezmir, 2020). Data presentation in this research is to arrange the data clearly and then highlighting the geometric elements of the traditional house using GeoGebra. Conclusion drawing is the final steps in the analysis process (Rijali, 2019). Drawing conclusions is to conclude the concept of mathematical geometry that exists in the architecture of the Mekongga Traditional House Museum.

Results and Discussion

The Mekongga Traditional House (Figure 1) stands as a symbol of the rich cultural heritage of the Tolaki Mekongga tribe, filled with historical and philosophical meanings. Today, a replica of the Mekongga Traditional House can be found at the Mekongga Traditional House Museum, located on Dermaga Pelabuhan Ferry Street, Latambaga District, Kolaka Regency, Southeast Sulawesi. According to an interview with the museum guard and an official from the Department of Culture of Kolaka Regency, its history is linked to King Mekongga, Bokeo Latambaga, who ruled from 1906 to 1932. In the Mekongga dialect, Mekongga traditional house also named as "raha" means house, synonymous with "poiaha," which refers to a dwelling or residence. Apart from being an aesthetic feature of interior design, color can also represent a form. This traditional house is painted predominantly in red, yellow, and brown, with each color symbolizing a distinct cultural meaning. Brown is the colour of the traditional bird Kongga's wings, yellow is the colour of glory reserved for kings, and red is the colour of a king's courage. Red is also considered a bold colour that symbolises security (Franciska & Wardani, 2014).

Figure 1. *Mekongga* Traditional House

This traditional house features decorative motifs known in the local language as tabere. The tabere motif (Figure 2) resembling elongated fern leaves in yellow, black, and red, represents the beauty and honor of women in Mekongga culture. Spears (Figure 3) placed at the roof's edge offer protection from wild animals, while the triangular door ornament pointing upward (Figure 4) signifies divine power and also serves as decorative art.

Figure 2. *Tabere Motif*

Figure 3. Spears at the Roof of Mekongga Traditional House

Figure 4. Triangular Door Ornament

Several elements of the Mekongga traditional house exhibit distinct characteristics that are relevant for teaching mathematics. The components that focused to explore in this research are roof, walls and stair.

The Roof (*Powire*) of *Mekongga* Traditional House

The first part to be explored from this traditional house is the roof, presented in Figure 5. The roof covering of the Mekongga Traditional House is locally referred to as powire. Its triangular shape is regarded as a structure with strong stability, symbolizing firmness and balance. The pointed apex of the triangle facing upward represents a philosophical belief held by the community that there is something greater above, namely God. This design reflects a symbolic connection between humans living on Earth and the Creator who resides in a higher, spiritual dimension. Using the measurement feature provided by GeoGebra, the researchers identified the length and angle of the powire.

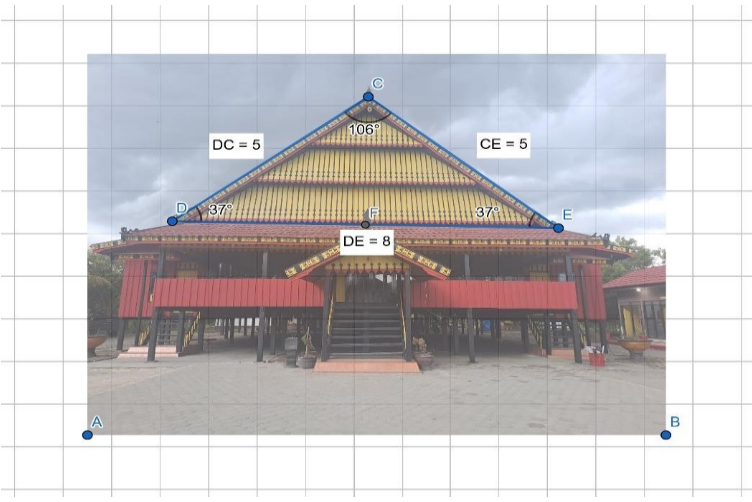


Figure 5. The Front Roof of *Mekongga* Traditional House

The results (Figure 5) showed that there are 3 vertices, let's say we give symbols C, D and E with 3 sides namely $\overline{CD}$, $\overline{CE}$ dan $\overline{DE}$. It also has 3 angles namely $\angle C$, $\angle D$, and $\angle E$. The powire has two sides of the same length, namely $|\overline{CD}| = |\overline{CE}| = 5$ and one other side $|\overline{DE}| = 8$. It is also found that the size of the angle formed is $\angle C = 106°$ and two angles of the same size $\angle D = \angle E = 37°$. The two-dimensional geometric shapes that fulfil these properties is an isosceles triangle. Thus, the geometry concept found on the powire is an isosceles triangle.

If we delve deeper into the powire, its structure is composed of three distinct layers as shown in Figure 6. This design carries a particular historical meaning: a powire with three layers signifies that the house belongs to a noble or royal family, whereas a powire without layers indicates that the house is owned by an ordinary citizen (Jahring et al., 2025).

Figure 6. *Powire* in Traditional Noble Houses

A closer examination of the powire in traditional noble houses reveals the presence of geometric forms in each of its structural components. The upper layer of powire (Figure 7) formed an isosceles triangle FGH. From the illustration results showed that triangle FGH has 3 sides: $\overline{FG}$, $\overline{FH}$, $\overline{GH}$ with 2 sides equals length $|\overline{FG}| = |\overline{FH}|$ and 3 interior angles $\angle F$, $\angle G$, $\angle H$ where 2 angles have the same measure $\angle G = \angle H$. One of the fundamental properties of any triangle relates to its interior angle specifically, that the sum of all three angles equals 180 degrees. This principle is clearly demonstrated in the isosceles triangle FGH identified in the Mekongga traditional house, where ∠F = 110°, ∠G = 35°, and ∠H = 35°. When these values are added together $\angle F + \angle G + \angle H$ = 110° + 20° + 80° = 180°.

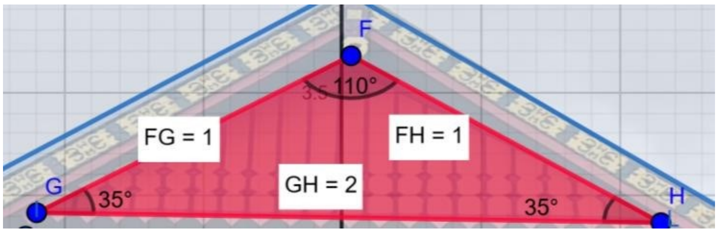


Figure 7. The Upper Layer of the *Powire*

In addition, another two-dimensional shape found in the powire is the trapezoid. According to Fraiverts et al. (2016), properties of a trapezoid are:

- It has a pair of parallel sides and a pair of equal length sides.
- The equal-length sides are called the legs of the trapezoid
- The angles adjacent to each non-parallel side are complementary
- The angles adjacent to each parallel side are congruent to each other

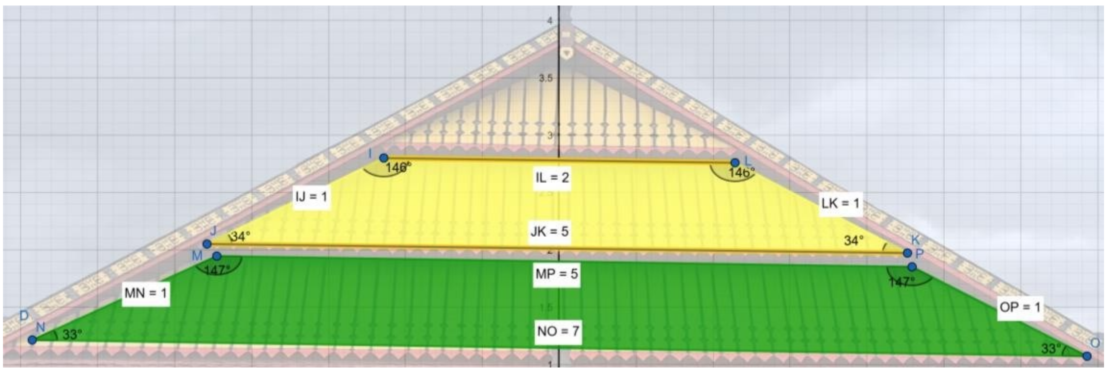


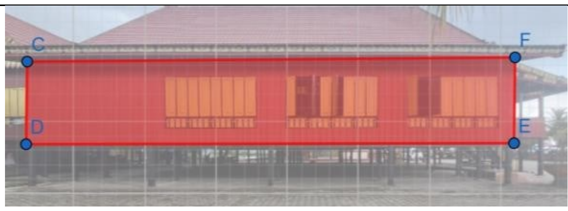
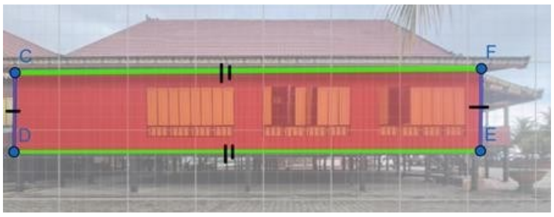
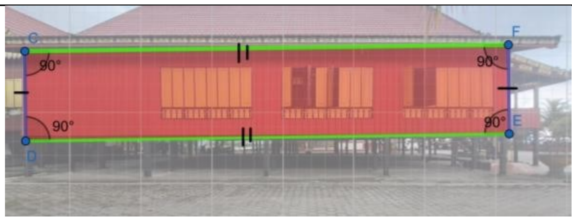
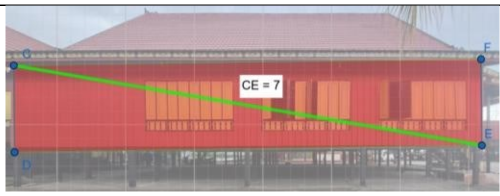
Figure 8. The Middle and Lower Layer of the *Powire*

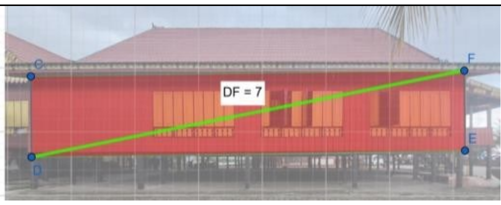
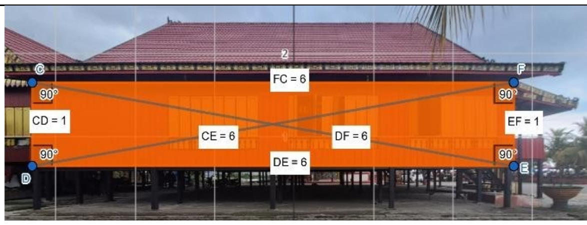
Based on the illustration in Figure 8, the shape IJKL from middle layer of powire (yellow section) has a pair of parallel sides $\overline{IL} \parallel \overline{JK}$. It also has a pair of equal length $|\overline{IJ}| = |\overline{KL}|$ as the legs of the trapezoid. Then $\angle I = \angle L$ and $\angle J = \angle K$ is a pair of adjacent angles on the same side. Besides that, angles adjacent to each non-parallel side that is $\angle I$ is complementary with $\angle J$ and $\angle K$ is complementary with $\angle L$, because $\angle I + \angle J = \angle K + \angle L = 146° + 34° = 180°$. Likewise, in the MNOP from the lower layer of powire (the green section), it has a pair of parallel side $\overline{MP} \parallel \overline{NO}$, a pair of equal length $|\overline{MN}| = |\overline{OP}|$ as the legs of trapezoid, and complementary angles: $\angle M + \angle N = \angle O + \angle P = 147° + 33° = 180°$.

The Walls (*Orini*) of Mekongga Traditional House

The next part to be explored is the wall, which is locally named as orini. Based on observations, the two-dimensional shapes formed on the walls of this traditional house both front, back and left and right walls is rectangular. The results of the exploration will be presented in Table 1.

Table 1. Geometric Concept Found in *Orini*

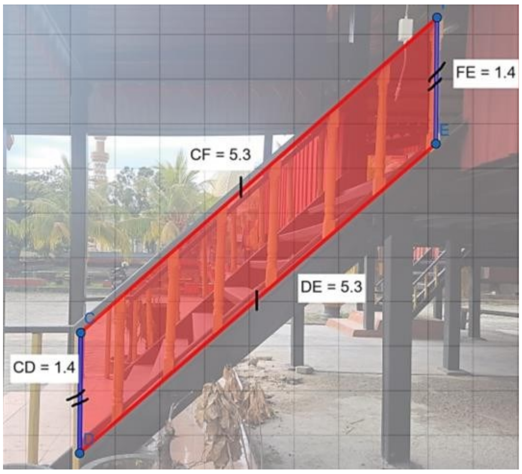
No	The Properties of Rectangular	Image	Explanation
1.	Rectangles have four sides		Based on visualization, *orini* have four sides: $\overline{CD}, \overline{DE}, \overline{EF}, \overline{FC}$
2.	The opposite sides are equal in length and parallel		The same length side of *orini:* $|\overline{CD}| = |\overline{EF}|$ $|\overline{CF}| = |\overline{DE}|$ The parallel side of *orini* $\overline{CD} \parallel \overline{EF}$ $\overline{CF} \parallel \overline{DE}$
3.	All four angles are equal and are right angles		*Orini* has four right angles: $\angle C = \angle D = \angle E = \angle F = 90°$
4.	Rectangular has two diagonals that are equal in length		*Orini* has two diagonals with same length $|\overline{CE}| = |\overline{DF}|$.

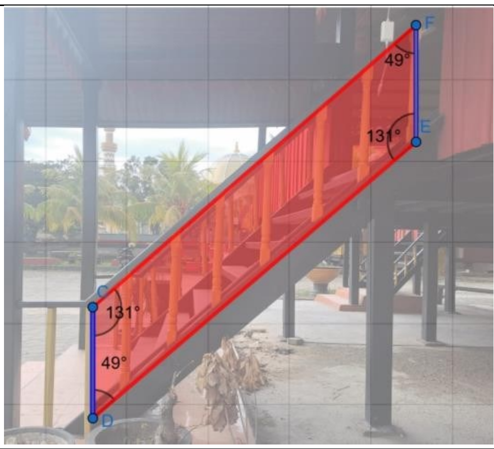
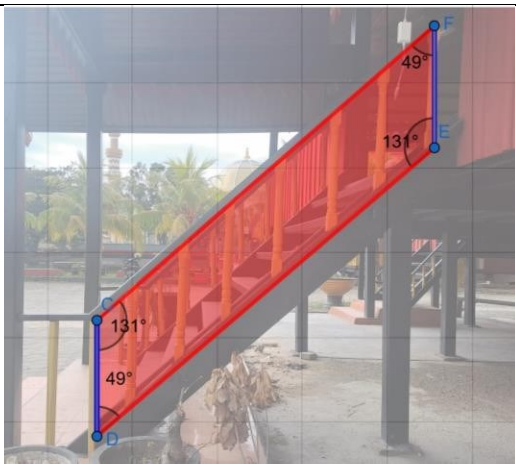
No	The Properties of Rectangular	Image	Explanation
			
5.	Sides are perpendicular to each other		Perpendicular lines occur whenever two lines meet at a 90° angle. These sides are: $\overline{CD} \perp \overline{DE}$ $\overline{DE} \perp \overline{EF}$ $\overline{EF} \perp \overline{FC}$ $\overline{CD} \perp \overline{FC}$

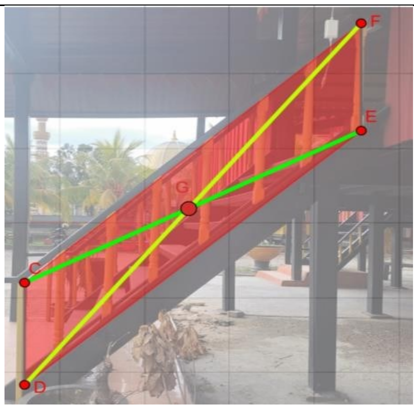
The Stair (*Lausa*) of Mekongga Traditional House

The staircase, known as lausa in the Mekongga language, was explored to identify its geometric shapes. The two-dimensional shape identified in this part is the parallelogram as presented in Table 2

Table 2. Geometric Concept Found in *Lausa*

The Properties of Parallelogram	Image	Explanation
Opposite sides are parallel and equal		• Opposite Sides of *Lausa* are Parallel: $CD \parallel EF$ and $DE \parallel CF$ • Opposite Sides of *Lausa* has same length $\lvert\overline{CD}\rvert = \lvert\overline{EF}\rvert$ and $\lvert\overline{DE}\rvert = \lvert\overline{CF}\rvert$

The Properties of Parallelogram	Image	Explanation
Opposite Angles are Equal		Opposite Angles are Equal: • $\angle CDE = \angle EFC = 49°$ • $\angle DCF = \angle FEC = 131°$
Consecutive Angles are Supplementary		$\angle CDE + \angle DCF$ $= 49° + 131°$ $= 180°$ $\angle EFC + \angle FEC$ $= 49° + 131°$ $= 180°$
Parallelogram has two diagonals		*Lausa* has two diagonals CE and DF

The Properties of Parallelogram	Image	Explanation
Symmetry		*Lausa* has point symmetry G about the intersection of its diagonals

Utilizing the Mekongga Traditional House as a Context for Learning

Exploring the roof, walls and stairs of the traditional Mekongga house revealed a variety of two-dimensional geometric shapes. This finding could be integrated into the learning process at various levels of education. At the elementary school level, identifying basic geometric shapes such as squares, rectangles, triangles, and trapezoids in the roof, walls, stairs, and doors of the Mekongga traditional house is highly relevant for introducing plane geometry. Students can learn to recognize geometric forms through culturally familiar contexts. For example, the isosceles triangle shape of the Mekongga house roof serves as a concrete example to introduce the concept of triangles and their properties, such as the internal angle sum of 180°.

In junior high school, exploration can be extended to more complex properties of geometric figures. This includes symmetry analysis in traditional house ornaments, calculations of area and perimeter, and the application of similarity and congruence in architectural elements. For instance, isosceles triangles in roof structures can be used to discuss angle theorems and triangle characteristics.

At the senior high school level, the focus can shift to more abstract geometry concepts such as geometric transformations (reflection, rotation, translation, and dilation), which appear in decorative patterns of traditional houses. Trigonometry can be applied to calculate roof height, stair slopes, and building proportions. Additionally, analysing the golden ratio potentially present in traditional architectural designs provides an engaging and culturally enriched learning opportunity.

The utilization of Mekongga traditional houses as a context for mathematics learning has enormous potential to improve students' understanding of geometry concepts while preserving and appreciating local wisdom. One of the primary benefits of ethnomathematics is its ability to contextualize mathematical concepts within the cultural practices of students. Incorporating ethnomathematics into the curriculum allows students to engage with mathematics through the lens of their own cultural experiences, thereby facilitating a more nuanced understanding of mathematical problem-solving (Zikir et al., 2024). This contextualization is crucial as it transforms abstract concepts into tangible knowledge that students can relate to their daily lives, as noted by

Ulya and Rahayu (2021), who found that local culture significantly improves students' mathematical abilities. Furthermore, the use of ethnomathematics has been linked to increased motivation and engagement among students, as it makes learning more relevant and enjoyable (Rosinansis et al., 2022). This is particularly important in mathematics education, where student motivation can significantly impact learning outcomes. This not only enhances their understanding of geometry but also encourages them to appreciate the mathematical principles behind the design and construction of traditional houses, blending culture with learning.

Conclusion

This study has uncovered the ethnomathematical elements embedded within the architectural design of Mekongga traditional houses. The findings reveal two-dimensional geometric forms including isosceles triangles, rectangles, squares, trapezoids, and parallelogram applied intuitively across structural components such as roofs, walls, and stairs. These shapes were not only identified but also analyzed in relation to formal mathematical properties, affirming the sophisticated mathematical that underlies indigenous Mekongga construction practices.

Importantly, this research highlights the potential of these cultural artifacts as educational resources. Ethnomathematical elements from Mekongga architecture provide context frameworks that can enhance mathematics learning at various educational levels, offering a bridge between cultural heritage and formal mathematical knowledge. However, several limitations were encountered, including a limited sample of preserved traditional houses, minor measurement constraints, and incomplete documentation of oral traditions due to the loss of cultural bearers. Additionally, the study primarily focused on two-dimensional geometry, leaving three-dimensional structures and more complex mathematical elements for future exploration.

This research addresses significant gaps in prior literature by offering an in-depth examination of the geometric properties present in traditional Mekongga architecture. Future research is encouraged to expand the architectural sample, investigate three-dimensional modeling, and develop educational interventions based on these findings. Interdisciplinary collaboration and digital preservation are also vital to safeguard and disseminate this valuable cultural-mathematical knowledge. Such efforts will not only enrich the field of ethnomathematics but also contribute to culturally responsive education and the preservation of indigenous wisdom.

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Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript. In addition, ethical issues, including plagiarism, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been covered completely by the authors.

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