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Ethnomathematical Analysis of Geometric Concepts in Balla Lompoa Bajeng Traditional Architecture in South Sulawesi, Indonesia

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abstract

Background: The integration of local culture into mathematics learning can enhance students' contextual understanding while supporting cultural preservation. However, many ethnomathematics studies remain limited to identifying mathematical forms without exploring their symbolic meanings and educational applications.
Aims: This study aims to identify and analyze the geometric concepts embedded in the architecture and heirlooms of the Balla Lompoa Bajeng Traditional House through an ethnomathematics perspective and to examine their potential contribution to mathematics learning.
Methods: This study employed a qualitative approach using an exploratory ethnomathematics design. Data were collected through direct observation, documentation, and literature review. The data were analyzed descriptively and analytically by identifying mathematical forms, structures, and patterns found in the traditional building and its cultural artifacts.
Results: The findings reveal that the architecture of Balla Lompoa Bajeng contains various geometric concepts, including plane figures such as rectangles and triangles, solid figures such as cubes and prisms, as well as the concepts of symmetry, similarity, and proportion. These results demonstrate that mathematical principles are implicitly embedded in the cultural practices and construction techniques of traditional architecture. Furthermore, the identified concepts have potential to be integrated into contextual geometry learning in schools.
Conclusions: The Balla Lompoa Bajeng Traditional House represents a valuable ethnomathematical resource that connects cultural heritage with formal mathematics learning and supports culturally responsive education. Theoretically, this study strengthens the role of ethnomathematics as a bridge between mathematical concepts and cultural contexts. Practically, the findings can serve as an alternative contextual learning resource for geometry instruction in schools.

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1. Introduction

Mathematics is a discipline that studies patterns, structures, relationships, and logical reasoning used to understand various phenomena in everyday life. In the context of education, mathematics not only functions to develop numeracy skills but also plays an important role in enhancing students' critical thinking, problem-solving, mathematical communication, and creativity. However, mathematics learning in schools is often perceived as abstract and disconnected from students' real-life experiences. This condition causes students to experience difficulties in understanding mathematical concepts deeply. Therefore, a learning approach is needed to connect mathematical concepts with real-life situations and local cultures that are closely related to students' environments. One relevant approach is ethnomathematics, which is defined as the study of mathematical practices embedded within a particular culture and used by communities in daily activities (Ashari & Alimuddin, 2024; Kastolani, 2021; Nur et al., 2020; Pathuddin et al., 2023; Yusran et al., 2022).

Ethnomathematics positions culture as a context for mathematics learning so that mathematical concepts can be understood more contextually and meaningfully. This approach emphasizes that mathematics develops from human activities within specific cultural settings, such as measuring, counting, designing buildings, creating patterns, and determining proportions. Previous studies have shown that ethnomathematics-based learning can improve students' learning motivation, mathematical communication skills, conceptual understanding, and problem-solving abilities because students learn through cultural objects familiar to their daily lives (Nur et al., 2020; Pathuddin et al., 2023; Rosmawati, 2018). In addition, ethnomathematics also plays an important role in preserving local cultural identity amid rapid globalization. Thus, integrating local culture into mathematics learning not only strengthens students' mathematical understanding but also supports the preservation of community cultural values.

South Sulawesi is one of the regions in Indonesia that possesses rich cultural heritage and traditional architecture with strong potential for ethnomathematical studies. Bugis-Makassar traditional houses, royal forts, traditional ornaments, and cultural heirlooms contain mathematical concepts integrated into their forms, patterns, measurements, and structures. Previous studies indicate that traditional houses in South Sulawesi contain geometric elements such as plane figures, solid figures, symmetry, patterns, and proportions that can serve as contextual mathematics learning resources (Ja'faruddin & Naufal, 2023; Kastolani, 2021; Yusran et al., 2022). An ethnomathematical study on Fort Rotterdam in Makassar, for example, identified the application of geometry, trigonometry, and spatial measurement concepts that can be utilized in culturally based mathematics learning (Ashari & Alimuddin, 2024). These findings suggest that traditional cultural buildings can function as authentic learning media that help students understand mathematical concepts more concretely.

One important cultural heritage in South Sulawesi is the Balla Lompoa traditional house, which symbolizes the greatness of the Bugis-Makassar community. Ja'faruddin and Naufal (2023) found that the Balla Lompoa traditional house in Gowa contains two-dimensional geometric concepts such as squares, rectangles, triangles, circles, and rhombuses that can be integrated into mathematics learning. Furthermore, Yusran et al. (2022) explained that Bugis traditional houses contain implicit mathematical knowledge developed through cultural

practices and traditional construction systems. Nevertheless, most ethnomathematics studies in South Sulawesi still focus on traditional houses in Gowa, Galesong, or other cultural objects such as Fort Rotterdam, while specific studies on the Balla Lompoa Bajeng Traditional House remain very limited. In fact, this traditional house is an important cultural heritage of the Bajeng community with strong historical, philosophical, and symbolic values.

The Balla Lompoa Bajeng Traditional House is a Bugis-Makassar stilt house constructed using teakwood and ironwood with a distinctive architectural structure consisting of the lower part, the main body, and the attic, representing the cosmological concepts of the Bugis-Makassar community concerning the underworld, middle world, and upper world. In addition to its architectural function, the house also preserves various royal heirlooms such as spears, keris, royal staffs, and the Jole-Jolea flag, all of which carry symbolic meanings for the Bajeng community (Ningrum et al., 2018; Taufik, 2022). From a mathematical perspective, the building structure and heirloom objects potentially contain geometric concepts such as triangles, trapezoids, cuboids, cylinders, similarity, symmetry, patterns, and proportions. However, these concepts have not been thoroughly examined through an ethnomathematical approach that connects geometric aspects with cultural values and mathematics learning implementation.

Based on this condition, there is a research gap in ethnomathematics studies on traditional houses in South Sulawesi, particularly regarding the exploration of geometric concepts in the Balla Lompoa Bajeng Traditional House and its heirlooms. Most previous studies focused mainly on identifying geometric forms in cultural objects without connecting them to philosophical meanings and pedagogical transformation in mathematics learning. Therefore, the novelty of this study lies in integrating geometric exploration, interpretation of Bajeng cultural values, and their utilization as local wisdom-based mathematics learning resources. This study is expected to enrich ethnomathematics research in Indonesia, particularly in South Sulawesi, while contributing to the development of more contextual, meaningful, and culturally responsive mathematics learning (Ashari & Alimuddin, 2024; Ningrum et al., 2018; Nur et al., 2020; Yusran et al., 2022).

Therefore, research on ethnomathematics in the Balla Lompoa Bajeng Traditional House is important to identify geometric concepts embedded in the building structure and heirloom objects, understand their symbolic meanings within Bajeng culture, and develop their potential implementation in contextual mathematics learning. This study not only contributes to mathematics education research but also supports the preservation of local cultural heritage as part of the identity of South Sulawesi society.

1.1 Ethnomathematics

Ethnomathematics is the study of mathematical practices that develop within particular cultural groups and are used by communities in everyday life. This approach emphasizes that mathematics is not only derived from formal concepts taught in schools, but also emerges from cultural activities, traditions, architecture, patterns, and local wisdom found within society (Andersson & Wagner, 2021; Ashari & Alimuddin, 2024; Yusran et al., 2022). Therefore, ethnomathematics connects mathematics with culture and students' real-life experiences, making learning more contextual and meaningful.

In mathematics education, ethnomathematics is used to relate mathematical concepts to students' local culture, such as shapes found in traditional houses, decorative patterns, traditional games, and community activities. This approach has been shown to improve students' learning motivation, conceptual understanding, mathematical communication skills, and problem-solving abilities because the learning materials are closely connected to their daily lives (Adiredja, 2020; Lidinillah et al., 2022; Nur et al., 2020; Sulistyowati & Mawardi, 2023). In addition, ethnomathematics-based learning also helps students recognize and preserve local culture through mathematics learning activities.

The implementation of ethnomathematics in mathematics learning can be carried out through the development of learning media, modules, worksheets, and contextual learning approaches such as Realistic Mathematics Education (RME) and Contextual Teaching and Learning (CTL). Various studies have shown that integrating local culture into mathematics learning positively affects student engagement and learning effectiveness, especially in geometry and solid geometry topics (Nugraha et al., 2020; Sunzuma & Maharaj, 2019; Yandani & Agustika, 2022). However, several challenges remain, including teachers' limited understanding of ethnomathematics, the lack of culture-based learning resources, and the need for professional training to integrate local culture effectively into mathematics learning (Hendriyanto et al., 2023; Maulina et al., 2023).

1.2 Geometry

Geometry is a branch of mathematics that studies shapes, sizes, positions, patterns, and spatial relationships of objects. Geometry plays an important role in mathematics learning because it helps students understand visual forms and spatial concepts found in everyday life (Lidinillah et al., 2022; Nur et al., 2020). In school mathematics, geometry includes concepts such as plane figures, solid figures, symmetry, similarity, transformation, measurement, and spatial reasoning.

In learning activities, geometry is often closely related to students' surrounding environments, including cultural artifacts, traditional architecture, ornaments, and local objects. Through ethnomathematics, geometric concepts can be identified in traditional houses, carvings, fabrics, and cultural symbols that contain mathematical values (Ashari & Alimuddin, 2024; Ja'faruddin & Naufal, 2023; Yusran et al., 2022). For example, traditional houses commonly contain geometric forms such as triangles, rectangles, rhombuses, trapezoids, cubes, and prisms, which can be used as contextual learning resources in geometry instruction.

Several studies show that contextual geometry learning based on culture can improve students' conceptual understanding, mathematical communication, spatial ability, and problem-solving skills because students learn through familiar and meaningful objects (Nur et al., 2020; Sulistyowati & Mawardi, 2023; Sunzuma & Maharaj, 2019). In addition, geometry learning integrated with local culture also supports cultural preservation by introducing students to the mathematical values embedded in traditional heritage.

However, the teaching of geometry still faces several challenges, such as students' difficulties in visualizing abstract objects, limited contextual learning resources, and teachers' lack of understanding in integrating culture into geometry instruction (Kyeremeh et al., 2025; Maulina et al., 2023). Therefore, the integration of ethnomathematics into geometry learning is

considered important to create more meaningful, contextual, and culturally responsive mathematics education.

1.3 Balla Lompoa Bajeng

Balla Lompoa Bajeng is a traditional house located in Bajeng District, Gowa Regency, South Sulawesi, Indonesia. In the Makassar language, balla means house and lompoa means big, so Balla Lompoa can be interpreted as the "great house" or royal house of the kingdom. Historically, this traditional house functioned as the center of government, a place for customary deliberation, and the residence of the Bajeng royal family (Ningrum et al., 2018). In addition to its governmental role, Balla Lompoa Bajeng also became the center of traditional ceremonies and the storage place for royal heirlooms known as gaukang.

Culturally, Balla Lompoa Bajeng has sacred value for the Bajeng community because it is closely connected to the history and identity of the local people. Inside the traditional house are various royal heirlooms such as spears, krises, royal staffs, and royal flags that have been passed down through generations. These heirlooms are believed to contain historical and symbolic values representing honor, bravery, and unity within the Bajeng community (Ningrum et al., 2018; Taufik, 2022). Therefore, the community continues to preserve and maintain the traditional house as part of their cultural heritage.

One of the traditional ceremonies that is still practiced today is the Gaukang Tu Bajeng Ceremony. This annual ritual is conducted to honor and cleanse the royal heirlooms. During the ceremony, the community performs several traditional activities, including the raising of the heirloom flag, the recitation of angngaru' (traditional oath or declaration), and processions carrying the heirlooms to sacred places (Ningrum et al., 2018). This tradition not only serves as a form of respect for ancestors but also strengthens social relationships and preserves the cultural identity of the Bajeng people.

Architecturally, Balla Lompoa Bajeng is a Bugis-Makassar stilt house made of wood with a strong and symmetrical structure. The house contains various geometric forms such as triangular roofs, rectangular walls and windows, and symmetrical patterns in the carvings and ornaments. These forms indicate the existence of mathematical concepts that developed naturally within the local culture (Ja'faruddin & Naufal, 2023; Yusran et al., 2022). Therefore, Balla Lompoa Bajeng has strong potential to be studied from an ethnomathematics perspective as a contextual mathematics learning resource based on local culture.

2. Methods

2.1 Research design

This research uses a qualitative approach with ethnographic methods. Ethnographic research aims to describe and analyze the cultural patterns of a community in depth based on direct observations and interactions in the field. This approach was used because this study seeks to explore and describe the application of geometric concepts found in the architecture and heirlooms of the Balla Lompoa Bajeng Traditional House within the cultural context of the Bajeng community.

2.2 Participants / informants

This research was conducted at the Balla Lompoa Bajeng Traditional House in Bajeng District, Gowa Regency, South Sulawesi Province, a historical relic from the Bajeng Kingdom. The focus of this research was on the architectural components of the traditional house, such as the roof shape, stairs, pillars, and ornaments, as well as on heirlooms such as the Jole-Jolea flag, spears, sticks, and keris (a type of keris) that contain geometric elements and philosophical values of the local community.

In this research, two informants were selected using purposive sampling, a deliberate selection of informants based on specific considerations consistent with the research objectives. This technique was used because ethnomathematics research requires informants with in-depth knowledge of local culture, the history of traditional houses, and the symbolic meaning of the objects being studied.

The informant selection criteria for this study included: (1) extensive knowledge of the history and culture of the Balla Lompoa Bajeng traditional house, (2) involvement or participation in local traditional activities, (3) understanding the symbolic meaning of architectural elements and heirlooms, (4) willingness to provide information openly, and (5) ability to explain information clearly and in-depth.

2.3 Data collection

Data collection was conducted through observation, interviews, and documentation. Observations were conducted to observe the form, pattern, and function of architectural elements and heirlooms related to geometric concepts. Interviews were conducted with traditional leaders and community leaders to obtain information about the history, symbolic meaning, and cultural value of each object studied. Documentation in the form of photographs, sketches, and field notes was used to corroborate the data.

2.4 Data analysis

Data analysis in this study was conducted using a qualitative ethnographic approach to explore and interpret the geometric concepts embedded in the architecture and heirloom tools of the Balla Lompoa Bajeng Traditional House. The analysis process was carried out through several systematic stages. First, data reduction was performed by selecting and focusing only on information relevant to the research objectives. Data documentation obtained from observations, interviews, and were reviewed carefully, while information unrelated to geometric concepts was excluded from further analysis.

Second, the selected data were organized and classified into several categories based on the mathematical concepts identified. The categories included plane figures, such as triangles, rectangles, and rhombuses, as well as solid figures with flat surfaces, such as cuboids found in the structural parts of the house. This categorization helps the researcher identify patterns and relationships between cultural artifacts and mathematical ideas.

Third, the data were described in detail by explaining the physical forms, positions, and functions of each geometric element found in the traditional house. For example, the roof structure was described as representing a triangular shape, while walls, doors, and windows

reflected rectangular shapes. Likewise, certain architectural components were interpreted as cuboid structures. This descriptive stage aims to present factual findings based on field data.

Fourth, interpretation was carried out by connecting the identified forms with formal geometric concepts in mathematics. At this stage, the researcher analyzed how local communities implicitly applied mathematical knowledge in designing buildings and heirloom tools. The interpretation also considered cultural values, practical functions, and construction wisdom reflected in the geometric forms.

Fifth, meaning-making was investigated by examining the significance of the findings in the context of mathematics education. The identified geometric concepts were considered as potential contextual learning resources, particularly for teaching plane and solid geometry in schools. These findings indicate that mathematics is closely related to local culture and daily life. Finally, to ensure the credibility of the findings, triangulation was applied by comparing data obtained from observations, interviews, and documentation.

3. Results

Data was obtained through three sources: observation, interviews, and documentation. Based on direct observation of the Balla Lompoa building, several geometric concepts were identified, including flat shapes and flat-sided geometric shapes. The identified geometric shapes included triangles and rhombuses on the roof, rectangles on heirlooms, and trapezoids on the house supports. Furthermore, flat-sided geometric shapes were found in the similar shapes of the stilt house pillars and curved-sided geometric shapes on heirlooms.

Based on interviews with informants, the triangular roof shape not only serves as a covering but is also designed to allow rainwater to drain easily and provide good air circulation within the house. Informants also explained that several geometric ornaments on the building have aesthetic value and cultural significance that have been passed down through generations. One informant stated:

> *"The shape of the roof was designed by our ancestors not only to protect the house from rain and wind, but also to symbolize balance and harmony in the family" (Informant 1)*.

Another informant explained:

> *"The ornaments on the house are not merely decorations. They contain cultural values and represent the identity of the Bajeng community" (Informant 2)*.

Meanwhile, based on documentation in the form of building photographs, archives, and written references, the findings from the observations and interviews are reinforced by visual evidence of geometric shapes in the traditional house structure. This documentation demonstrates that the geometric elements of the Balla Lompoa are still preserved and maintained as part of the local cultural identity. Thus, the three data sources complement each other in revealing the concept of ethnomathematics in the Balla Lompoa traditional house.

The Balla Lompoa Bajeng is a traditional building that has long been the center of the traditional, governmental, and spiritual life of the Bajeng Kingdom. Built in 1906 by Batang Banoa Limbung, this traditional house serves as both a royal palace and a place for deliberation, important decision-making, and various traditional ceremonies. Inside, various sacred heirlooms, known as Gaukang, are housed, including the Jole-Jolea royal flag, a war flag, a

sacred spear, a kris, a command staff, and even a royal hair garland. Considered so sacred, these heirlooms may only be touched by royal descendants, known as Paerang.

Entering the early days of independence, Balla Lompoa Bajeng served not only as a traditional center but also as a strategic hub for the Bajeng people in facing the threat of colonialism. In August 1945, this traditional house became a gathering place for youth and community leaders of Limbung to formulate resistance measures. It was here that Mr. Fukusima, a Japanese officer, requested permission to see the contents of the Gaukang box, thus opening the heirlooms for the first time. Another important moment occurred on August 14, 1945, when the Jole-Jolea flag and the war flag were raised in the courtyard of Balla Lompoa Bajeng as a symbol of the Bajeng people's readiness to defend independence, even three days before the Indonesian Proclamation was read.

Since then, Balla Lompoa Bajeng has not only served as the center of traditional government, but has also become a symbol of the Bajeng people's struggle, identity, and honor. To this day, every August 14th, the community holds the Gaukang Tu Bajeng Ceremony, a major ritual featuring the raising of the heirloom flag, the recitation of the angngaru', and the release of Gaukang objects from their boxes. Every two years, some of these heirlooms are also paraded to Bungung Barania, a sacred well where ancient warriors sought courage. Although some of the heirlooms have been lost and community awareness has begun to wane, Balla Lompoa Bajeng remains a cultural heritage that connects the present generation with their ancestors. The Balla Lompoa Bajeng traditional house, seen from the front and back, can be seen in Figure 1 below.

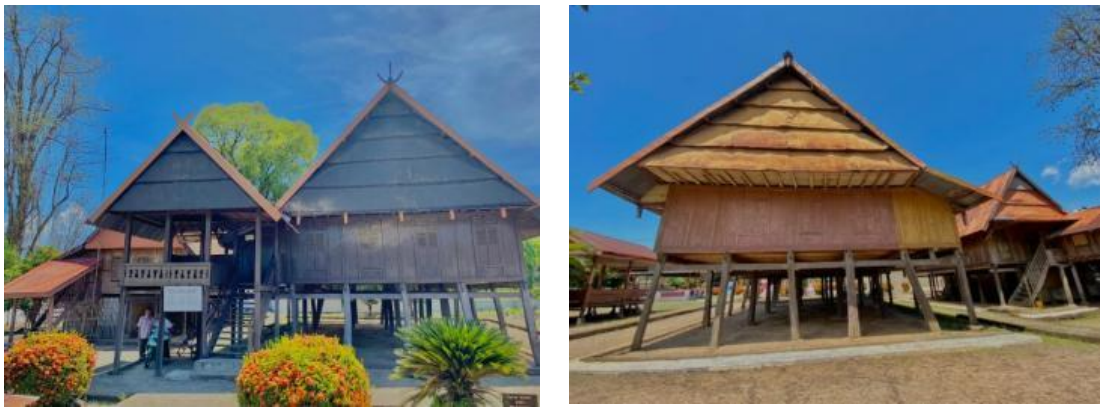


Figure 1. (a) Front yard of the Balla Lompoa Bajeng traditional house (b) Back yard of the Balla Lompoa Bajeng traditional house

In the overall structure of the building and its heirlooms, Balla Lompoa Bajeng contains various geometric concepts that are clearly visible in the architectural parts and in each inherited heirloom object. The application of geometry is not only seen in the basic shape of the stilt house, but is more detailed in the roof of the house which forms an isosceles triangle, the roof frame supports that follow the contour of a trapezoid, the house pillars that are shaped like blocks, and the lasugi motif on the roof fascia that is arranged in a rhombus pattern. In its heirlooms, geometric shapes are also seen in the Poke' Bonrangang which resembles an isosceles triangle, the Poke' Tamannyala handle which is rectangular, the Poke' Tubarani sheath which is shaped like a tube or block, and the Jole-Jolea Flag which is square. Thus, all these findings show that geometric elements are an integral part of the construction, symbols, and

cultural functions of Balla Lompoa Bajeng, thereby strengthening the historical value and identity of the Bajeng people. According to the informants, the geometric forms found in the traditional house and heirlooms were inherited from previous generations as part of local wisdom in construction and cultural preservation.

> *"The forms used in the house and heirlooms have been maintained for generations because they represent the traditions and identity of the Bajeng people" (Informant 1).*

3.1 Balla Lompoa architecture

3.1.1 Front roof of Balla Lompoa Bajeng

The front roof of the Balla Lompoa Bajeng Traditional House forms an isosceles triangle when viewed from the front or rear side. This geometric form is one of the characteristics of traditional Bugis-Makassar architecture. Geometrically, the triangular form is created by two sloping sides that meet at a single peak point and one base side at the bottom.

Based on the observations, the triangular roof not only creates a symmetrical and aesthetic appearance but also functions structurally to accelerate rainwater flow and maintain proper air circulation inside the house. One informant explained:

> *"The pointed roof allows rainwater to flow down quickly so the house does not easily leak" (Informant 1).*

Another informant stated that the triangular roof also has symbolic meaning for the Bajeng community.

> *"The triangular roof symbolizes balance and harmony in family life" (Informant 2).*

From an ethnomathematical perspective, the roof demonstrates the application of the isosceles triangle concept intuitively used by traditional communities to create buildings that are strong, balanced, and environmentally adaptive.

Figure 2. Roof of Balla Lompoa Bajeng

Figure 3. Illustration of the Triangular Roof of Balla Lompoa Bajeng

In the first section of the Balla Lompoa Bajeng traditional house, the roof shape looks like an isosceles triangle when viewed from the front or rear. This geometric shape is a characteristic of traditional Bugis-Makassar architecture. The front roof of the Balla Lompoa Bajeng is an isosceles triangle formed by two inclined planes that meet at a single ridge point at the peak. This shape not only gives a symmetrical and aesthetic impression, but also functions structurally to accelerate the flow of rainwater, keep the roof dry, and increase the strength of

the stilt house construction to be more resistant to wind. From a cultural perspective, this triangle symbolizes balance, harmony, and family dignity, while ethnomathematically it can be explained as a flat shape with two sides of equal length and a base as the basis of the structure.

3.1.2 Supporter of the Balla Lompoa Bajeng traditional house

Inside the traditional house, there are supporting structures extending above the main pillars that function as roof reinforcements. Based on observations, these structures form trapezoidal patterns following the slope of the roof. According to the informants, the support structures were designed to maintain the stability of the building and ensure its durability over time.

> *"The supporting beams were designed to follow the roof shape so the house remains strong and stable" (Informant 1).*

From an ethnomathematical perspective, the trapezoidal form of the supports reflects the application of geometric concepts related to balance and load distribution in traditional architecture.

Figure 4. Traditional House Supports

Figure 5. Illustration of a Trapezoidal Traditional House

Inside the Balla Lompoa Bajeng traditional house, the supporting structure extending above the main pillars serves as a reinforcing beam that binds all the pillars together to maintain stability and support the weight of the roof frame. This beam not only functions as a structural element, but also reflects the distinctive ethno-architectural form of the Bajeng traditional house, namely the trapezoidal roof frame. This trapezoidal shape creates a sloping position on the left and right sides of the roof, so that the supporting beams that follow the lines of the roof frame also form a trapezoidal contour that is clearly visible in the interior of the house. The combination of the supporting beams and the trapezoidal roof shape allows the building to remain strong, balanced, and durable while maintaining the traditional character of the Balla Lompoa Bajeng as a symbol of the glory and wisdom of the Bajeng people's construction.

3.1.3 Pillar

The house pillars are the main structural components supporting the entire Balla Lompoa Bajeng Traditional House. Based on observations, the pillars resemble cuboids with rectangular cross-sections arranged in regular patterns. An informant explained that the spacing between pillars was intentionally designed equally to maintain the stability of the building.

> *"The pillars are placed at equal distances so the building remains sturdy and balanced" (Informant 2).*

From an ethnomathematical perspective, the arrangement of the pillars demonstrates the application of geometric concepts such as cuboids, repetition patterns, symmetry, and balance in traditional house construction.

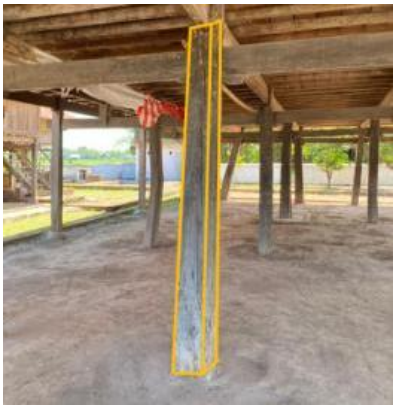


Figure 6. Traditional house pillars

Figure 7. Illustration of traditional house pillars in the shape of a beam

The pillars in traditional houses, as shown in the picture, are the main structural components that support the entire load of the stilt building, from the floor and walls to the roof frame, ensuring the house remains sturdy and stable. From an ethnomathematical perspective, the shape of these pillars resembles a vertical beam with a square or rectangular cross-section, demonstrating the application of traditional geometric concepts in the construction of the Bajeng people. The beam shape of the pillars allows for even vertical load distribution, while the regularly spaced arrangement of the pillars reflects an intuitive understanding of symmetry, balance, and repeating patterns. Although some pillars appear to be leaning due to age and the natural characteristics of the wood, their position and arrangement still demonstrate the application of mathematical principles passed down through generations in the construction of traditional houses.

3.1.4 Lasugi

Lasugi is a traditional Makassar ornament located on the roof edges and fascia boards of the Balla Lompoa Bajeng Traditional House. Based on observations, the lasugi motif forms repeated rhombus patterns arranged systematically. An informant explained that the lasugi ornament not only serves as decoration but also contains cultural meaning.

"Lasugi symbolizes orderliness and the beauty of life in the Bajeng community" (Informant 1)

From an ethnomathematical perspective, the lasugi ornament reflects geometric concepts such as rhombuses, symmetry, repetition, and patterns.

Figure 8. Lasugi on the roof of a traditional house

Figure 9. Illustration of a rhombus-shaped lasugi

The lasugi motif on the roof of the Balla Lompoa Bajeng traditional house is a typical Makassar ornament that enhances the building's appearance and emphasizes the cultural identity of the Bajeng people. On the roof, lasugi provides a strong visual accent through its repeating carved patterns located on the eaves and eaves, making the house's structure appear more defined, neat, and distinctive. From an ethnomathematics perspective, the lasugi motif features a sequential rhombus shape, reflecting geometric concepts such as symmetry, pattern, and order. Beyond its aesthetic value, this rhombus motif also carries a philosophical meaning about the steadfastness and orderliness of life. Therefore, its presence on the roof not only enhances the artistic element but also maintains the authenticity and cultural significance of traditional Balla Lompoa Bajeng architecture.

3.2 Heirloom tool balla lompoa bajeng

3.2.1 Poke' Bonrangang

Poke' Bonrangang is a sacred spear heirloom with a spearhead shape resembling an isosceles triangle. Based on observations, the spearhead appears symmetrical with two sloping sides and one base side. An informant explained that the spear symbolizes courage and firmness among the Bajeng warriors.

"The sharp spear shape symbolizes courage and strength" (Informant 2).

From an ethnomathematical perspective, the spear demonstrates the application of the isosceles triangle concept in traditional weapons.

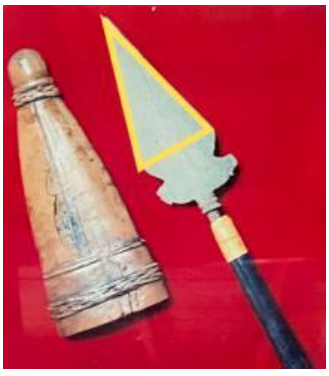


Figure 10. Poke' bonrangang heirloom tool

Figure 11. Illustration of poke' triangular bonrangang

Poke' Bonrangang is a type of heirloom weapon from the Balla Lompoa Bajeng family, characterized by its wider spearhead than other Poke' types. The geometric shape of the spearhead resembles an isosceles triangle, with two symmetrical slanted sides and a shorter base as the base of the blade. The sheath or cover is made of wood wrapped in brass, giving it a sturdy appearance and traditional aesthetic value. During the Bajeng kingdom, Poke' Bonrangang was known as a sacred weapon symbolizing strength and authority, while its triangular shape reflects the firmness of direction, sharpness, and stability of the traditional weapon's construction.

3.2.2 Poke' tamannyala

Poke' Tamannyala is considered one of the most sacred heirlooms in Bajeng culture. The handle or sheath of this spear forms a rectangular shape. According to the informants, this heirloom is believed to possess spiritual power, and therefore not everyone is allowed to touch it.

"Only certain people are allowed to clean the Poke' Tamannyala" (Informant 1).

The rectangular form of the spear handle reflects the geometric concept of rectangles with parallel and equal opposite sides.

Figure 12. The poke' tamannyala heirloom tool

Figure 13. Illustration of a rectangular poke' tamannyala

The Poke' Tamannyala is one of the most sacred heirlooms in the Balla Lompoa Bajeng tradition. This spear is made of copper and is believed to possess supernatural powers, making it the most powerful spear compared to other types of poke'. Its sacredness is so high that during the process of cleansing the heirloom, people dare not approach it unless a special person is tasked with cleaning it. Geometrically, the sheath or handle of the Poke' Tamannyala is rectangular, characterized by two pairs of parallel, equal-length opposite sides. This rectangular shape provides a straight, stable, and easy-to-grip structure, reflecting the ethnomathematical principle that even traditional objects contain plane geometric elements that can be learned in basic geometry.

3.2.3 Poke' tubarania

Poke' Tubarani is a traditional iron weapon equipped with a sheath resembling a cylinder or cuboid. Based on the interviews, the sheath was designed to facilitate storage and ensure the safety of the weapon.

"The sheath was designed to be straight and strong so the spear can be safely stored" (Informant 2).

From an ethnomathematical perspective, the sheath demonstrates the application of three-dimensional geometric concepts in Bajeng culture.

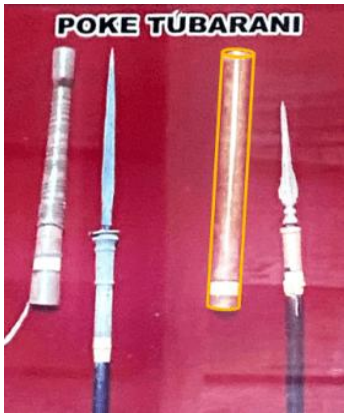


Figure 14. Poke' tubarani heirloom tool

Figure 15. Poke' tubarani heirloom tool in the shape of a tube

The Poke' Tubarani is a traditional weapon of the Bajeng Kingdom made of iron with a sharpened tip. It comes in two types: a longer, very sharp one and a slightly shorter one. Each type of weapon is equipped with a bamboo sheath, resembling a block with straight sides and a flat surface. From an ethnomathematics perspective, the block-shaped sheath reflects the intuitive application of three-dimensional geometric concepts used by ancient societies, particularly in creating strong, sturdy, and proportional objects. Furthermore, the block-shaped sheath facilitates storage, ensures the safety of the sharpened iron tip, and emphasizes that mathematical concepts such as shape, volume, and flatness are naturally applied in Bajeng culture. Thus, the Poke' Tubarani not only holds historical value as a powerful weapon, but also contains mathematical values in its accompanying cultural elements.

3.2.4 Jole-Jolea Flag

The Jole-Jolea flag is a royal red flag with white ornaments forming a square shape. The square shape symbolizes order, firmness, and stability within the Bajeng kingdom. An informant explained that the raising of the flag carries an important meaning for the community.

> *"When the Jole-Jolea flag is raised, it means the community must unite in facing an important situation" (Informant 1).*

Geometrically, the square shape of the flag reflects the concept of four equal sides and four right angles, symbolizing balance and strength.

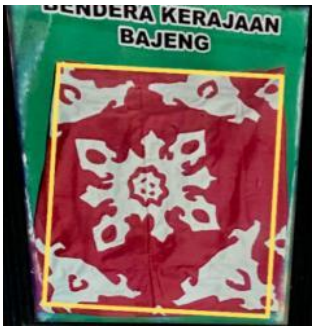


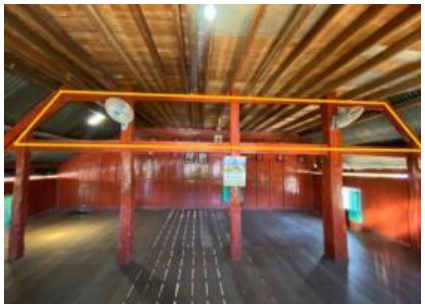
Figure 18. The jole-jolea flag heirloom

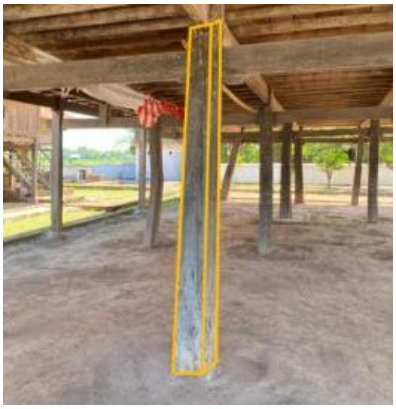
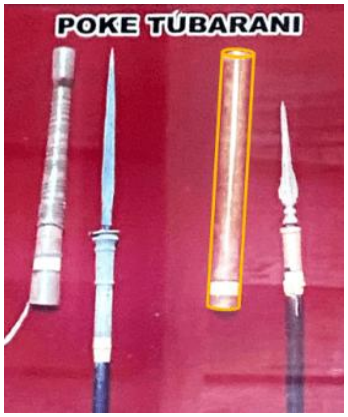
Figure 19. Illustration of the square-shaped jole-jolea flag

The jole-jolea flag, a red flag with white ornamentation, is square in shape, representing the firmness, order, and solidity of the government structure at that time. The square shape of this flag reflects the geometric concept of four equal sides and four right angles, signifying balance and stability, which symbolized the kingdom's authority. When the jole-jolea flag was flown alongside the plain red flag, the community understood that Bajeng was in a critical situation or state of emergency, as described by local historical sources.

Observational findings indicate that the building structures and heirlooms at balla lompoa Bajeng contain various geometric elements arranged in a regular manner and serving a cultural function. The presence of these shapes demonstrates the application of mathematical concepts in the traditional community's daily lives. The following are the findings of the traditional Balla Lompoa house.

Table 1. The findings of the traditional Balla Lompoa house

In the Balla Lompoa Traditional House	in Geometry	Application in Learning
 The Poke' Tamannyala heirloom tool		Can be used to introduce quadrilaterals, including their elements, properties, area, perimeter, and other related concepts.
 Balla Lompoa Bajeng roof		Can be used to teach triangles, including area, perimeter, related problem solving, Pythagorean theorem, similarity, composite plane figures, and other related concepts.
 Traditional house support		Can be used to teach triangles, including area, perimeter, related problem solving, and Pythagorean theorem and other related concepts.

In the Balla Lompoa Traditional House	in Geometry	Application in Learning
 Lasugi on the roof of a traditional house		Can be used in teaching combined plane shapes (plane shapes within plane shapes) using a contextual approach, or other appropriate approaches to determine the number of plane shapes within a plane shape.
 Traditional house pillars		It can be used to introduce flat-sided geometric shapes because they are shapes that students see quite often, making them a relevant example. Cylinder-shaped shapes can be used to teach geometric concepts, including surface area, volume, nets, and other related concepts.
 Poke' Tubarani heirloom tool		Can be used to teach curved-sided geometric shapes, particularly cylinders. Learning can be done by showing other similar geometric shapes and teaching the concept of geometric shapes.

Based on these findings, the following discussion will provide a more in-depth analysis of the application of these geometric elements through an ethnomathematics perspective.

4. Discussion

The findings of this study demonstrate that the architecture and heirloom objects of the Balla Lompoa Bajeng Traditional House contain various geometric concepts integrated into the cultural practices of the Bajeng community. The identified concepts include plane figures such as triangles, rectangles, rhombuses, and trapezoids, as well as solid figures such as cuboids and

cylinders. These findings indicate that mathematical ideas have long been implicitly applied in traditional construction systems and cultural artifact designs, even though local communities may not formally express them using mathematical terminology. Therefore, this study answers the research problem regarding how geometric concepts are represented within the architecture and heirlooms of Balla Lompoa Bajeng through an ethnomathematical perspective.

One of the main findings of this study is the integration of geometric concepts with structural and symbolic functions within the traditional house architecture. The triangular roof of Balla Lompoa Bajeng not only reflects architectural adaptation to environmental conditions but also symbolizes balance and harmony in the social life of the Bajeng community. Structurally, the triangular roof facilitates rainwater drainage and improves the stability of the building. This finding is consistent with the study conducted by Kurino et al. (2022), which explains that triangular roof structures in Indonesian traditional houses are generally designed to maintain symmetry and structural stability. Similarly, Kadir et al (2022) reported that the sloping roof structures of Buton traditional houses reflect local knowledge related to load distribution and weather adaptation.

The trapezoidal supports and cuboid-shaped pillars identified in this study further demonstrate the intuitive geometric reasoning possessed by the Bajeng community. The trapezoidal supports function to maintain roof balance and structural strength, while the cuboid pillars distribute vertical loads evenly throughout the building. These findings support Islamiati (2024), who argued that traditional Indonesian architecture reflects empirical mathematical reasoning inherited through generations of construction practices. Although traditional builders may not formally use modern mathematical formulas, they apply proportional reasoning and spatial understanding based on local wisdom and practical experience.

Another important finding is the rhombus-shaped lasugi ornament located on the roof fascia of the traditional house. The repetitive rhombus pattern demonstrates the application of symmetry, repetition, and geometric patterns within traditional decorative art. In ethnomathematics, ornaments are not merely decorative elements but also representations of mathematical thinking embedded in culture. This finding aligns with Ridha and Komalasari (2024), who found that repetitive rhombus patterns in Pontianak Malay traditional houses symbolize order and balance while representing geometric pattern concepts. Likewise, Nurhasanah and Puspitasari (2022) explained that geometric ornaments in Kampung Pulo traditional houses function as expressions of cultural identity while containing mathematical values applicable in mathematics learning.

The results of this study also reveal that geometric concepts are embedded not only in the architecture of Balla Lompoa Bajeng but also in its heirloom objects. The isosceles triangular form of Poke' Bonrangang, the rectangular shape of Poke' Tamannyala, and the cylindrical or cuboid forms of Poke' Tubarani indicate that mathematical concepts were applied in the creation of traditional weapons and sacred objects. These findings support Wahyuni et al. (2023), who stated that triangular forms in traditional artifacts often symbolize strength, courage, and stability. Furthermore, Wijayanti & Ratnaningsih (2026), emphasized that traditional societies frequently applied geometric reasoning in designing tools and cultural objects requiring proportional balance and durability.

An important contribution of this research is its ability to address the gap identified in previous ethnomathematics studies. Most previous studies focused primarily on identifying mathematical forms in cultural objects without connecting these forms to symbolic meanings and educational transformation. In contrast, this study demonstrates that the geometric concepts found in Balla Lompoa Bajeng are closely related to cultural values, philosophical meanings, and mathematics learning potential. For example, the triangular roof symbolizes harmony and balance, while the rhombus-shaped lasugi ornament represents social order and aesthetic values within the Bajeng community. Therefore, the novelty of this study lies in integrating geometric exploration, symbolic interpretation, and pedagogical transformation within a single ethnomathematical framework.

The findings of this study also strengthen the ethnomathematics theory proposed by Ubiratan D'Ambrosio, which states that mathematical knowledge develops through cultural practices and daily human activities. The Bajeng community demonstrates mathematical thinking through house construction, ornament design, and heirloom creation even without formal mathematical notation. This finding confirms that mathematics is not merely an abstract academic discipline but also a cultural product developed through social interaction and local wisdom. Consequently, ethnomathematics serves as a bridge connecting formal mathematics with indigenous cultural knowledge.

Another important implication of this study lies in mathematics education. The ethnomathematical elements identified in the Balla Lompoa Bajeng Traditional House can be transformed into contextual mathematics learning resources. Geometric concepts found in the traditional house architecture, such as triangles, trapezoids, rhombuses, cuboids, and cylinders, can be integrated into geometry learning materials and problem-solving activities in schools. For example, the triangular roof structure can be used to introduce concepts of similarity, perimeter, area, and the Pythagorean theorem, while the rhombus patterns in the lasugi ornament can be applied in learning about symmetry, tessellation, and plane geometry.

In addition, contextualizing mathematical concepts through local cultural objects enables students to connect abstract mathematical ideas with real-life experiences. This learning approach not only improves conceptual understanding but also strengthens students' appreciation of local culture and cultural identity. These findings support Rahmawati and Muchlian (2019), who found that culturally contextualized mathematics learning enhances students' conceptual understanding and engagement. Similarly, Riswati et al. (2021) reported that ethnomathematics-based learning improves students' problem-solving abilities because students can relate mathematical concepts to familiar cultural experiences. Moreover, Nuryadi et al. (2023) explained that culture-based learning creates positive learning experiences, while Turmuzi et al. (2023) found that contextual learning improves students' memory retention.

Despite its contributions, this study has several limitations that should be acknowledged. First, the research focused mainly on geometric concepts related to plane and solid figures, while other mathematical concepts such as transformations, ratios, measurement systems, and spatial reasoning were not explored comprehensively. Second, the identification and interpretation of geometric forms in cultural artifacts involve subjective analysis, which may lead to different interpretations among researchers. Third, this study focused only on one traditional house, meaning the findings cannot automatically be generalized to all traditional

architectures in Indonesia, as each region possesses unique cultural forms and construction principles.

Nevertheless, this study provides important implications for future ethnomathematics research. Future studies are recommended to explore broader mathematical concepts embedded in local cultures, including transformations, proportional reasoning, traditional measurement systems, and statistics. Comparative ethnomathematical studies between Balla Lompoa Bajeng and other Indonesian traditional houses may also reveal similarities and unique mathematical knowledge across different ethnic groups. In addition, future researchers are encouraged to develop ethnomathematics-based teaching materials, contextual learning modules, and culturally responsive instructional media derived from local cultural heritage.

Overall, this study confirms that geometry is deeply embedded within the architecture and heirloom objects of the Balla Lompoa Bajeng Traditional House. The findings demonstrate that the Bajeng community has long applied mathematical reasoning through local wisdom, traditional construction practices, and cultural symbolism passed down through generations. By integrating cultural meaning with geometric analysis, this study contributes to the development of ethnomathematics research while supporting culturally responsive and contextual mathematics education.

5. Limitations and future research

This study has several limitations. First, the research focused only on geometric concepts found in the architecture and heirlooms of Balla Lompoa Bajeng, limiting the exploration of other possible mathematical concepts within Bajeng culture. Second, the study used a qualitative descriptive approach without empirically examining the impact of ethnomathematics-based learning on students' mathematical achievement. Third, the data sources were limited to selected cultural artifacts and local informants, which may not fully represent the entire cultural knowledge of the Bajeng community. Future research is recommended to explore broader mathematical concepts embedded in local cultures and to develop ethnomathematics-based learning materials derived from Balla Lompoa Bajeng culture. Further studies should also examine the effectiveness of these materials in improving students' mathematical understanding, cultural awareness, and learning engagement through experimental or longitudinal research designs, while integrating digital technology to support cultural preservation and contextual mathematics learning.

6. Conclusion

This research has successfully revealed that the architecture and heirlooms of Balla Lompoa Bajeng contain various geometric concepts reflected through the forms, patterns, and symmetry used structurally and symbolically by the Bajeng people. The isosceles triangular roof, trapezoidal supports, block-shaped pillars, and rhombus-shaped lasugi motifs demonstrate the application of plane and spatial concepts in traditional construction, while heirlooms such as Poke' Bonrangang, Poke' Tamannyala, Poke' Tubarani, and the Jole-Jolea Flag demonstrate the use of geometric shapes functionally and philosophically. These findings demonstrate that mathematical knowledge has been internalized in Bajeng culture through architectural practices and heirloom making, although not expressed in formal terms. Thus, this research not only explains the application of geometry in a cultural context, but also provides a basis for the

development of local wisdom-based mathematics learning and enriches ethnomathematics studies in Indonesia while supporting cultural preservation through a contextual scientific approach.

Author Contributions

Muhammad Ihyaul Afif Shidiq: Conceptualization, methodology, formal analysis, writing—original draft preparation. Rezki Ayu Ramadhani: Conceptualization, validation, supervision. Inriati: Conceptualization, formal analysis, investigation, writing—original draft preparation. Andi Dian Angriani: Validation, data analysis, project administration. Fitriani Nur: Methodology, investigation, data curation, visualization. Nurul Ainun Fajriah: Writing—review and editing, visualization, funding acquisition.

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