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Exploring ethnomathematics in Malay architecture and traditional hall in *Penyengat* Island and connecting it to geometry in elementary schools

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Abstract

Malay ethnomathematics is culture-based learning that is very important in 21st-century life. The progress of globalization has led to many technological advances, which have resulted in many cultures being abandoned or even extinct. Ethnomathematics research can be a solution for preserving culture, because it integrates culture and learning materials in schools. This study aims to explore Malay ethnomathematics in the architecture of the Indra Perkasa Traditional Hall on *Penyengat* Island as a resource for teaching mathematics on geometry and measurement in elementary schools. The method used was an ethnographic study, which is part of a qualitative research method. Data collection techniques included observation, interviews, documentation, and other sources, such as books and journals. This study shows some aspects of Malay ethnomathematics related to geometry and measurement materials in elementary schools, including flat shapes, spatial shapes, and length measurements. This study indicates the potential for the integration of Malay ethnomathematics into the architecture of the Indra Perkasa Traditional Hall on *Penyengat* Island as a mathematics learning resource for geometry and measurement in elementary schools in Indonesia.

Keywords: elementary school; geometry; Indra Perkasa traditional hall; Malay ethnomathematics; measurement; *Penyengat* Island

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Introduction

Indonesia's legal system, more precisely in Law of the Republic of Indonesia Number 20 of 2003 concerning the National Education System, Article 37, states that mathematics is a mandatory subject to be taught at primary and secondary school levels. Additionally, mathematics is a scientific field studied from childhood into adulthood, which makes it familiar to human activity (Chevallard, 2006; Freudenthal, 1991).

In the era of Industrial Revolution 4.0 and Society 5.0, many human activities are closely related to the field of mathematics. "Mathematics is an inseparable part of a person's life" (Atmaja, 2014). Mathematics is born from the results of thinking and all activities carried out by humans in their daily lives. Bishop (1997) as confirmed that mathematics is a form of culture and has been integrated with all aspects of people's lives wherever they are. The relationship between culture and mathematics in certain social groups has a vital role in mathematics learning at various levels of education, especially at the elementary school level. This is because the study of ethnomathematics can connect students' learning experiences with formal mathematics at school through the integration of culture and tradition in mathematics learning (Hardiani & Putrawangsa, 2019).

Ethnomathematics was first discovered and introduced by a Brazilian researcher, namely D'Ambrosio, in 1985 (D'Ambrosio, 1985). Ethnomathematics is seen as a response to demographic dynamics and socioeconomic imbalance in both impoverished and prosperous civilizations, especially in Europe and the USA. Sociologically, it is true that ethnomathematics seeks to value and encourage the knowledge production of people who are the "losers" in the protracted process of globalization (D'Ambrosio & Borba, 2010). D'Ambrosio (1989) said that this was because bridging culture and mathematics was an essential step in recognizing different ways of thinking that could lead to various forms of mathematics. This is the essence of what is then called ethnomathematics (D'Ambrosio, 1989). Another opinion says that ethnomathematics can be defined as mathematics practiced by specific cultural groups, such as urban and rural communities, labour groups, children of various age groups, and Indigenous communities (Anriana et al., 2023). Ethnomathematics borderlines between the history of mathematics and cultural anthropology. It examines scientific and technical phenomena in connection to their social, economic, and cultural contexts (D'Ambrosio, 1995). There are unresolved issues in the literature on culture and mathematics, particularly in the use of the word ethnomathematics (Barton, 1996).

Ethnomathematics consists of three syllables, which consists of three syllables: ethno, mathema, and tics. The prefix ethno refers to or is directly related to the culture of a particular community group. Mathema is related to all mathematical activities such as explaining, calculating, measuring, classifying, ordering, and modeling patterns/problems that arise in certain communities in detail, while tics means art or is more related to techniques/methods. The definition of ethnomathematics according to D'Ambrosio (1985) is as follows: In contrast to this we will call "ethnomathematics" the mathematics which is practiced among identifiable cultural groups, such as national-tribal societies, labor groups, children of a certain age bracket, professional classes (D'Ambrosio, 1989). Ethnomathematics aims to provide an account of how

mathematics is constructed, understood and conveyed that is congruent with sociological and anthropological accounts of how mathematics is propagated and used (Barton, 1999).

Ethnomathematics is a learning activity that combines mathematics and culture in everyday life (Khairunnisa et al., 2022). It is an alternative approach that can make mathematics learning more meaningful and contextual, which is very closely related to the culture of a particular group (Fajriyah, 2018). Mathematics learning will be more interesting and meaningful for students when the learning process itself can be linked or connected directly to the culture in the environment around the students because students can learn directly from the local culture in the place/area where they live (Fendrik et al., 2020). Ethnomathematics is mathematics learning directly linked to a particular community group's wisdom. It is a form of recognition that various ways of teaching mathematics can be used so that learning can be more innovative and enjoyable for students (Anriana et al., 2023).

Malay ethnomathematics is a collaboration between mathematics and culture in the Riau Malay community. Malay ethnomathematics activities can be found in several fields of art, including literary arts, Malay fashion, carving, and games (Hasanuddin, 2017). Malay ethnomathematics is a practice that was born and developed in the Malay community, which can be used as student learning both at school and outside of school in everyday life (Nuh & Dardiri, 2016). Learning that is directly linked to the Malay culture around students can instill a character of love for local culture. According to Putri et al. (2023), Malay ethnomathematics learning must be adjusted to students' socio-cultural context in elementary schools, which can continuously instill character-building values that improve the quality of education. Thus, Malay ethnomathematics is an integration of mathematics and Malay culture that explores how mathematical concepts in everyday life can be used as a form of learning taught to students in schools.

There is information from several relevant studies, including research conducted by Tyas et al. (2022) entitled "Ethnomathematics Study of the Building Structure of the Traditional House of Riau of *Selaso Jatuh Kembar*." This research is qualitative descriptive research with an ethnographic approach. The aim is to describe the mathematical elements in the *Selaso Jatuh Kembar* Traditional House. The data collection techniques used were literature study, observation, and documentation. In this research, it was found that there were mathematical elements and concepts in the *Selaso Jatuh Kembar* Traditional House. In further research, it was found that most of the ornaments and decorative patterns in this traditional house contain the concept of geometry, which consists of squares, rhombuses, rectangles, circles, and triangles. Thus, ethnomathematics is a form of mathematics learning that is directly related to a particular culture, such as games, traditional houses, and customs, and containing knowledge, elements, and mathematical concepts that can be used as mathematics learning.

The Malay tribe is one of the largest ethnic groups and a community widely spread throughout almost all of Indonesia, with a diverse set of cultures and traditions (Anriana et al., 2023). Cultural diversity can be found in the forms of customs, language, religion, and architecture/historical buildings. Historical buildings have unique architectures, one of which is in the Riau Islands Province, specifically on Penyengat Island, Tanjungpinang City.

Penyengat Island is one a historical and cultural tourism destination (Prayuda et al., 2022). It is famous for its heritage, which offers unique Malay culture in various objects. The island has three types of tourism: historical, cultural, and religious. On the other hand, there are still many objects on this island whose potential can be explored and can be used as learning resources because there are still very few people who can visit the island; one of the reasons is that access to the island must be reached by boat. Therefore, the present study is interested in exploring ethnomathematics in one of the famous architectures and buildings on Penyegat island, called the Indra Perkasa Traditional Hall.

The Indra Perkasa Traditional Hall on Penyengat Island is a style of Malay traditional architecture located in Tanjung Pinang City, Riau Islands Province. It is one of the Malay Archipelago traditional houses, usually a kind of house on stilts with a large room and functions to welcome guests or hold banquets for important people. Malay architecture is part of Indonesian traditional architecture, which is a work in the form of buildings and environments, where the form, function, ornaments, and methods of manufacture are passed down from generation to generation to accommodate human activities according to their needs. A Malay traditional building is used as a family residence. Additionally, it is also usually used as a place for deliberation, procreation, and shelter for anyone who needs it. Riau has a traditional hall, a distinctive feature of Malay culture. Traditional halls are a defining feature of Riau Malay culture. The Traditional Hall is an important venue for traditional festivities for the Malay population. Additionally, the figures of customs and society use the traditional hall as a venue for reflection (Zaini, 2017). Thus, this study is driven by the following questions:

1. What mathematical forms are related to geometry in different contexts in the Indra Perkasa Traditional Hall on Penyengat Island?
2. To what extent can mathematical forms related to geometry and measurement be integrated in learning mathematics in elementary school?

Methods

The research method used by researchers in this study is an ethnographic method included in one of the qualitative research methods used by (Creswell & Poth, 2016). Qualitative research produces descriptive data in speech, writing, and people's everyday behavior, which have been previously observed. Ethnographic research is research that focuses on tradition or culture. Ethnography aims to seek an understanding of a tradition or culture in a particular community group (Anriana et al., 2023). Therefore, this research requires researchers to spend quite a long time going directly to the field or even living with the local community to understand the culture of the community group they are researching.

First, the primary researcher is assigned to be the leading researcher responsible for collecting data directly in the field. Apart from that, the researcher is also a native of the Tanjungpinang City area. Hence, he knows a lot about the Malay culture there, and he was assisted by two supervisors who provided advice to the first researcher in conducting this study. Researchers first made direct observations on Penyengat Island to find out firsthand what the architectural form of the Indra Perkasa Traditional Hall Building on Penyengat Island was, as

well as measurements made by the people of Penyengat Island in ancient times by interacting directly with the people on Penyengat Island. Apart from that, to get more information, the researchers also involved four experts who already understand their fields, such as humanists, LAM administrators, building guards, and employees of the Tanjungpinang City culture and tourism office.

The interview technique was a considerable problem in this study. To lighten the mood, researchers must exercise caution and be adept at managing words and questions. The capacity to comfort each source might also impact the final interview findings. In addition to serving as direct observers and interviewers, researchers must review the technical aspects of the observation procedure and interview questions with supervisors on campus. This research uses a variety of data sources, including interviews, field notes, documentation, and other supporting materials. The interviews done for this study are semi-structured, meaning the questions might evolve and grow based on the circumstances and settings in the field.

The data analysis technique in this research uses the Miles and Huberman data analysis model (Miles et al., 2018), which is carried out interactively and continuously until completion to ensure the data will be saturated. The activities in data analysis are data reduction, data presentation, and data verification (Sugiyono, 2019). In general, the research procedure carried out by researchers uses the following steps: a) determine the social situation in the form of places, activities, and informants to be researched; b) prepare interview guidelines that researchers will use to find out what things they want to know about the research object; c) collect data on informants through the data collection techniques used; d) carry out data analysis in the form of data reduction to obtain data that is more focused on the research title; e) present data containing a description of the research being carried out; f) draw conclusions from the results of data reduction and data presentation whose contents provide answers to the problems studied, namely ethnomathematics studies in the Indra Perkasa Traditional Hall Building on geometry material in elementary schools.

Table 1. List of resource information

Name (Pseudonym)	Age Range	Field of Position/Occupation
Raja Malik	55-65	Cultural practitioner/ Member of Malay Customary Institute (LAM)
Raja Suzana	50-60	Cultural practitioner/ Employee of the Riau Islands Province BPSDM Service Office
Wimmy Hidayat	50-60	Member of Malay Customary Institute (LAM)/Tanjungpinang City Tourism and Culture Office Employee
Wawan	60-65	Site caretaker of Indra Perkasa Traditional Hall Penyengat Island

Results

The results of this study are presented in several subsections. First, we provide stories from everyday geometric contexts at the Indra Perkasa Traditional Hall on Penyengat Island. Then,

we look at the formal school context of geometry in elementary school. Finally, we evaluate and differentiate between the concepts of geometry in everyday life and school mathematics.

History of the Indra Perkasa Traditional Hall building on Penyengat Island

The Indra Perkasa Traditional Hall building on Penyengat Island is one of the historical buildings on Penyengat Island. This building is also a replica of a traditional Malay building. This building was built in 1985 and was used as a meeting hall for the people of Penyengat Island. This building is located in Ladi Village, Penyengat Island. This type of building is included in the traditional Malay buildings of *Selaso Jatuh Kembar*. The geographical location and condition of the Riau Archipelago Province is a group of islands spread across the waters of the Melaka Strait and the South China Sea. The conditions of these islands are hilly, with sloping and steep beaches in some places. The general village pattern is a village of fishermen and coconut farmers, so many houses are built above the sea using poles (houses on stilts) along the coastline. The house on the beach has some of its pillars in the water.

Before the birth of many other Kingdoms in Indonesia, on the Island of Sumatra, the Sriwijaya kingdom was born, which controlled the Malay Peninsula, Sumatra Island, Riau Islands, Nicobar Island, Sunda Land, West Kalimantan and the South China Sea. The source of prosperity of this kingdom was trade routes, which were supported by an adequate sea transportation system. The most important trade route at that time was the waters of the Strait of Malacca. Therefore, the Riau Islands Province has become a stopover place for traders on a national and international scale. After the power of the Sriwijaya Kingdom began to fade and disintegrate, the small kingdoms that had previously been under the authority of the Sriwijaya Kingdom finally let go and formed their own kingdoms. Among them is the Kingdom of Bintan in the Riau Islands Province

The Bintan Kingdom was founded around 1100 AD by Asyar Aya; at the beginning of the 14th century, the Bintan Kingdom was at the peak of its glory during the reign of Sang Nila Utama, or what was known as Sri Tri Buana, who became the forerunner of the Malay kings of Riau. After Sang Nila Utama moved to Tumasik (Singapore), the Bintan Kingdom was led by a young king named Tun Telanai. Since then, the glory of the Bintan Kingdom slowly began to decline, and finally, Singapore took control of the government. In the following period, when Singapura held power, the kingdom was finally defeated by Mojopahit. The king went to Malacca and later built the country's civilization to become the center of the Malay empire until the Portuguese finally conquered it in 1511 AD. Sultan Mahmud Syah, the last King of Malacca, went into the interior of the Tanah Peninsula, finally to Bintan Island and Pekan Tua Kampar.

Sultan Mahmud Syah's son returned to Bintan Island to establish the Malay empire in Johor. For approximately two centuries, Johor regained control as Malaka's successor. In 1699, Johor experienced chaos with the murder of Sultan Mahmud Syah II by Admiral Megat Sri Rama. Datuk Bendahara Tun Hebab ruled this kingdom with the title Abdul Jalil Syah IV, whom Raja Kecil defeated from Siak. Raja Kecil became King of Johor with the title Abdul Jalil Rakhmad Syah. Then, a new dispute arose with King Sulaiman's brother-in-law, the son of Abdul Jalil Syah IV, resulting in a civil war. As a result of this war, Raja Kecil resigned and returned to his native area, namely Siak, because Sulaiman wanted to rule in Johor with the

help of the Bugis people, then with the title Sultan Sulaiman Badrul Alam Syah. The kingdom's center was moved to Bintan Island and then to Lingga, known as the Malay kingdom of Riau Lingga.

With a very long historical background, it can be seen how this area has had its ups and downs during its glory days and the culture inherited, namely Malay culture, from successive kingdoms. Over the following centuries, many other ethnic groups came and even settled in this area, both ethnic groups in the Archipelago and from different countries. With the large number of arrivals of various tribes, it cannot be denied that it has influenced and impacted Malay culture as its parent. This culture is still inherited by the residents of this area, which is rich in various styles and varieties.

One example of fine art is carving. The carved motifs depict types of flora, fauna, natural surroundings, and religion. The carvings are flat, and the structures and containers are generally wood and metal. These carvings are placed on residential buildings, such as stairs, beams, doors, windows, walls, pillars, rooftops, planks, fins, attics, household equipment, etcetera. In everyday life, carvings on someone's house or objects are often used to measure the owner's social status. The more carvings on a house and its belongings, the higher its prestige.

Geometric concept in Indra Perkasa Traditional Hall on Penyengat Island

Three-dimensional shapes

1. Cuboids

Cuboids are a form of spatial structure found in the Indra Perkasa Traditional Hall Building on Penyengat Island (Figure 1). Researchers discovered this through observations, interviews, and direct documentation in the field. Cuboids can be found on the pillars supporting the building. This can be seen from the same opinion from several sources, one of which was explained by Mr. Wawan, who stated:

> "In terms of parts and shape, it is the same as Malay houses in general, namely rectangular in shape, and many parts of the building are found in the form of cuboids."

The same opinion is also expressed in the book Riau Regional Traditional Architecture, pages 13, 14, and 20, which states that:

> "The art of building in this area can be seen in several forms, most of which are residential houses. In the past, there were many other buildings, such as the "Traditional Hall," the Palace of the Kings, and the Tomb Dome; because almost all the buildings were made of wood, many of them have become extinct. The house is built on a pole whose average height is between 1.50 to 2.40 m. Therefore, it is commonly called the Stagehouse type. "Meanwhile, according to the plan of 1 main house, the typology includes cuboids/rectangular buildings."

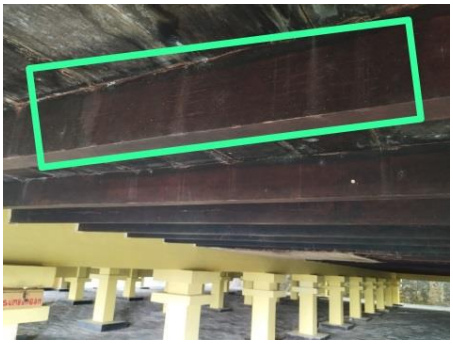


Figure 1. Cuboids in the Indra Perkasa Traditional Hall building on Penyengat Island

A cuboid is a three-dimensional shape with six sides, 12 edges, and eight vertices. This object is found in the characteristics of traditional Malay houses, which are generally found in many 3D shapes in the building. The philosophy contained in this section is that there is a general philosophy in Malay buildings, namely stilt buildings, which symbolize the typical characteristics of Malay houses. It means that they act as a buffer so that they are protected from disturbance by wild animals and so that they are not exposed to seawater because usually many Malay traditional house buildings are located on the edge, sea, or river. This is what causes Malay buildings to be made higher from the ground by using support poles made of very strong wood so that they can withstand various conditions for a long time. The cuboids are also rectangular, so they contain four cardinal directions, meaning that good fortune can come to the house from every corner of the building. The colour philosophy includes yellow, symbolizing power during the kings' time.

2. Pyramid

The pyramid is a spatial object in the Indra Perkasa Traditional Hall Building on Penyengat Island (Figure 2). Researchers discovered this through observations, interviews, and direct documentation in the field. The shape of the pyramid room can be found in the ornaments or decorations on the side pillars of the stairs of the Traditional Hall. This can be seen from the same opinion from several sources, one of which was explained by Mrs. Raja Suzana, who stated:

> "The patterns and ornaments on the building stairs are shaped like a pyramid/triangle."

The same opinion is also expressed in the book Riau Regional Traditional Architecture, pages 18 and 19, which states that:

> "On either side of the stairs, there are sometimes ladder arms installed parallel to the stair posts, and they are always decorated with latticework (lathes) or cane boards (translucent boards)."

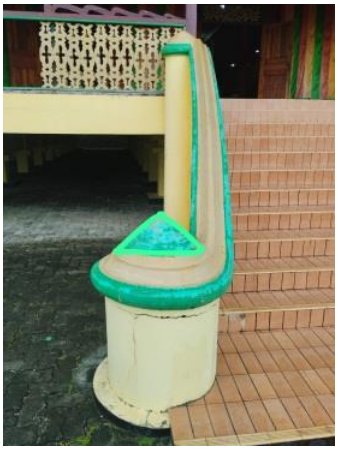


Figure 2. A pyramid shape in the Indra Perkasa Traditional Hall building on Penyengat Island

A pyramid is a three-dimensional shape bounded by an n-shaped base (triangle) and triangular upright sides. Pyramids are divided into four types, namely triangular pyramids, rectangular pyramids (squares), pentagonal pyramids (pentagons), and hexagonal pyramids (hexagons). There is no philosophy regarding the shape of the hand of the ladder, and the number of steps is not determined. However, it has a colour philosophy, including yellow, which symbolizes power during the time of kings, and green, which symbolizes prosperity/fertility.

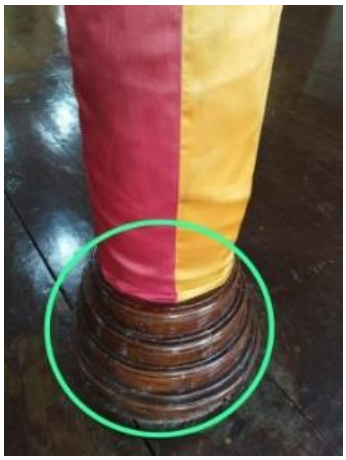
3. Tube

The tube is a spatial object in the Indra Perkasa Traditional Hall Building on Penyengat Island (Figure 3). Researchers discovered this through observations, interviews, and direct documentation in the field. The structure of the tube room can be found in the Traditional Hall building, precisely in the shape of the building's pillars. This can be seen from the same opinion from several sources, one of which was explained by Mr Wimmy Hidayat, who stated that:

"Then there are six pillars in the tube-shaped building."

The same opinion is also expressed in the book Riau Regional Traditional Architecture, pages 18 and 20, which states that:

> “The poles are round or faceted. The maximum and minimum size of a pole is not specified. This size depends a lot on how big or small the house is. The bigger the house, the bigger the pillars.”



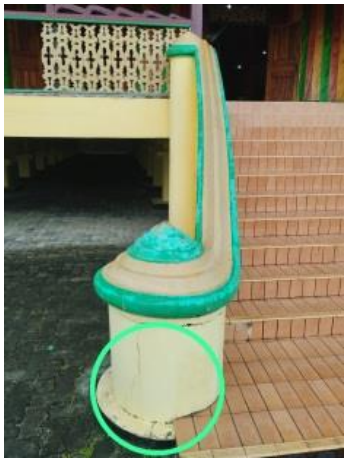


Figure 3. Tube in the Indra Perkasa Traditional Hall building

A tube is a three-dimensional shape formed from two parallel identical circles and a rectangle that surrounds the two circles. The philosophy is found in the number of pillars in the building support, which are six, which holds the connotation of practicing the pillars of faith in the Islamic religion. The color philosophy includes yellow, which symbolizes power during the time of kings, and green, which symbolizes prosperity/fertility.

Two-dimensional figure

1. Square

The square is one of the rectangular flat shapes found in the Indra Perkasa Traditional Hall Building on Penyengat Island (Figure 4). Researchers discovered this through observations, interviews, and direct documentation in the field. The square flat structure can be found at the pillar's base supporting the main building. This can be seen from the same opinion from several sources, one of which was explained by Mr. Raja Malik, who stated:

> "Just like other Malay houses, other Malay houses are generally square or rectangular in shape, and if we look at the building, the house is on stilts."

The same opinion is also expressed in the book Riau Regional Traditional Architecture, pages 13 and 14, which states that:

> "The art of building in this area can be seen in several forms, most of which are residential houses. Previously, there were many other buildings, such as the "Traditional Hall", the Palace of the Kings and the Tomb Dome; because almost all the buildings were made of wood, many of them have become extinct. The house is built on a pole whose average height is between 1.50 to 2.40 m. Therefore, it is commonly called the Stagehouse type. "Meanwhile, according to the plan of 1 main house, the typology includes square and rectangular buildings."

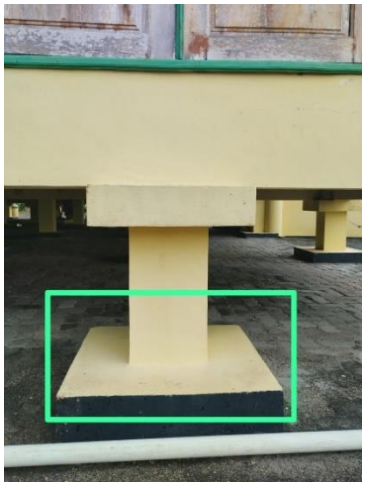


Figure 4. A square on the Indra Perkasa Traditional Hall building on Penyengat Island

The finding of the square object is based on the characteristics of traditional Malay houses, which generally have flat square and rectangular shapes. A square is a flat rectangular shape that has four pairs of equal sides. This section's philosophy is that Malay buildings, particularly those with stilts, have a broad philosophy that represents the usual qualities of a Malay house. Because Malay traditional houses are typically built on the edge of a sea or river, the stilts serve as a buffer, protecting the dwelling from being disturbed by wild animals and exposure to seawater. In addition, the house's square or rectangular design represents the cardinal directions, implying that good fortune can come from any direction. The philosophy of the color yellow symbolizes the power of the Malay Kingdom during the time of the kings.

2. Rectangle

The rectangle is one of the rectangular flat shapes found in the Indra Perkasa Traditional Hall Building on Penyengat Island (Figure 5). Researchers discovered this through observations, interviews, and direct documentation in the field. Rectangular flat shapes can be found in several parts of the traditional hall, such as doors, windows, floors, etcetera. This can be seen from the same opinion from several sources, one of which was explained by Mr Wimmy Hidayat, who stated that:

> "If you look at the general shape of the architecture, it is rectangular. "Within it, there is a large room for meeting rooms, and on the left and right sides, there is a kind of resting place; then, in front of it, on the terrace, there are stairs."

The same opinion is also expressed in the book Riau Regional Traditional Architecture, pages 13 and 14, which states that:

> "The art of building in this area can be seen in several forms, most of which are residential houses. In the past, there were many other buildings, such as the "Traditional Hall", the Palace of the Kings, and the Tomb Dome; because almost all the buildings were made of wood, many of them have become extinct. The house is built on a pole whose average height is between 1.50 to 2.40 m. Therefore, it is commonly called the Stagehouse type. "Meanwhile, according to the plan of 1 main house, the typology includes a rectangular building."

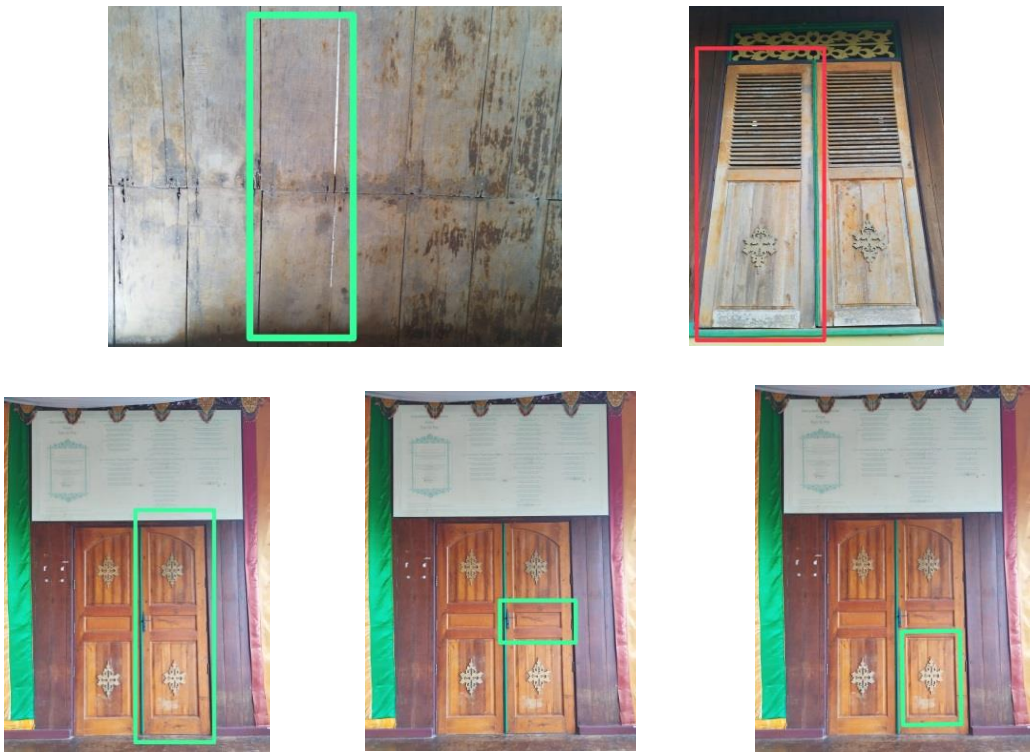


Figure 5. Rectangular shapes on the Indra Perkasa Traditional Hall building on Penyengat Island

A rectangle is flat with two parallel sides and four right angles. The finding of this rectangular object is based on the characteristics of traditional Malay houses, which generally have a flat, rectangular shape. The philosophy is contained in the shape of the window/casement; the height of the window is adjusted to the height of the building floor, and some are also related to customs. Windows made as high as an adult symbolize people who understand customs/traditions. In contrast, slightly lower windows symbolize friendly people who always receive guests sincerely and openly. The color philosophy includes yellow, which symbolizes power during the time of kings.

3. Trapezoid

The trapezoid is a flat-shaped object found in the Indra Perkasa Traditional Hall Building on Penyengat Island (Figure 6). Researchers discovered this through observations, interviews, and direct documentation in the field. The flat trapezoidal shape can be found in several parts of the Traditional Hall, such as the shape of the roof when viewed from the side, which is an isosceles trapezoid, and on the carved doors of the Traditional Hall building, which is a right-angled trapezoid. This can be seen from the same opinion from several sources, one of which was explained by Mrs. Raja Suzana, who stated:

> "And the shape of the roof is straight upwards, like a triangle or trapezoid when viewed from the side."

The same opinion is also expressed in the book Riau Regional Traditional Architecture, pages 14 and 15, which states that:

> "A house with a steep roof is called a Folding Pandan House (Figure 1); if the roof is slightly flat, it is called a Folding Kajang House (Figure 2); if the roof is added to the bottom (leg of the roof) with another roof, then it is called a Screen Roof House or Ampar Labu House (Figure 3). A house made with its roof shingles parallel to the main road where the house is located is called a "Long Perabung House" (Figure 4), whereas if the house has its roof shingles not parallel to the main road where the house is facing, it is called a "Melintang Perabung House" (Figure 5)."

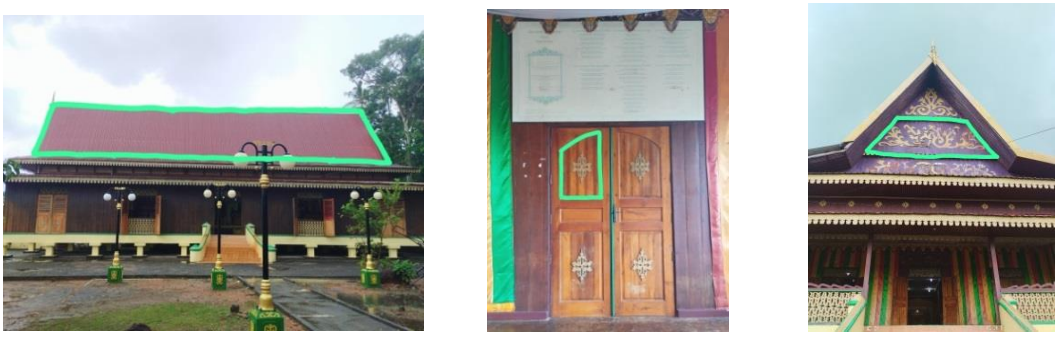


Figure 6. Trapezoid shapes on the Indra Perkasa Traditional Hall building on Penyengat Island

A trapezoid is a flat rectangular shape that has a pair of parallel opposite sides. Trapezoids are divided into three types: isosceles trapezoids, right-angled trapezoids and arbitrary trapezoids. The general philosophy regarding the shape of the roof, when viewed in general, is a straight line from the front, which looks like a triangle and from the side, it looks like a trapezoid, which has the function and meaning of facilitating the flow of water when it rains. The color philosophy includes yellow, which symbolizes power during the time of kings, and red, which symbolizes brotherhood or courage.

4. Triangle

The triangle is one of the flat objects found in the Indra Perkasa Traditional Hall Building on Penyengat Island (Figure 7). Researchers discovered this through observations, interviews, and direct documentation in the field. The flat triangular shape can be found in the Traditional Hall building, precisely in the architecture and shape of the roof of the building. This can be seen from the same opinion from several sources, one of which was explained by Mr Wawan, who stated that:

> "With the roof straight up, it forms a triangle when we look at it from the front."

The same opinion is also expressed in the book Riau Regional Traditional Architecture, pages 14, 15, and 42, which states that:

> "A house with a steep roof is called a Folding Pandan House (Figure 1); if the roof is slightly flat, it is called a Folding Kajang House (Figure 2); if the roof is added to the bottom (leg of the roof) with another roof, then it is called a Screen Roof House or Ampar Labu House

(Figure 3). A house made with its roof shingles parallel to the main road where the house is located is called a "Long Perabung House" (Figure 4), whereas if the house has its roof shingles not parallel to the main road where the house is facing, it is called a "Melintang Perabung House" (Figure 5).”

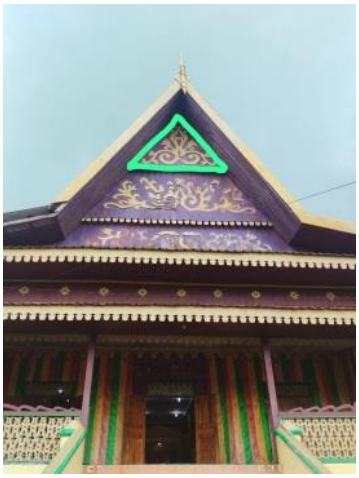


Figure 7. A triangular shape on the Indra Perkasa Traditional Hall building on Penyengat Island

A triangle is a flat shape bounded by three line segments whose two ends coincide. Triangles are divided into three types, namely isosceles triangles, equilateral triangles, and arbitrary triangles. The general philosophy is that the shape of the roof has a wooden decoration standing upwards at the top, called *Tunjung Langit*, which contains the meaning of recognition of God Almighty. The color philosophy includes yellow, which symbolizes power during the time of kings; green, which symbolizes prosperity/fertility; and red, which symbolizes brotherhood and courage.

5. Circle

Circles are one of the flat objects found in the patterns and ornaments of the Indra Perkasa Traditional Hall Building on Penyengat Island (Figure 8). Researchers discovered this through observations, interviews, and direct documentation in the field. This can be seen from the same opinion from several sources, one of which was explained by Mr. Wawan, who stated:

"If you look at the architecture of the building, there are several parts that have patterns and ornaments such as circular shapes."

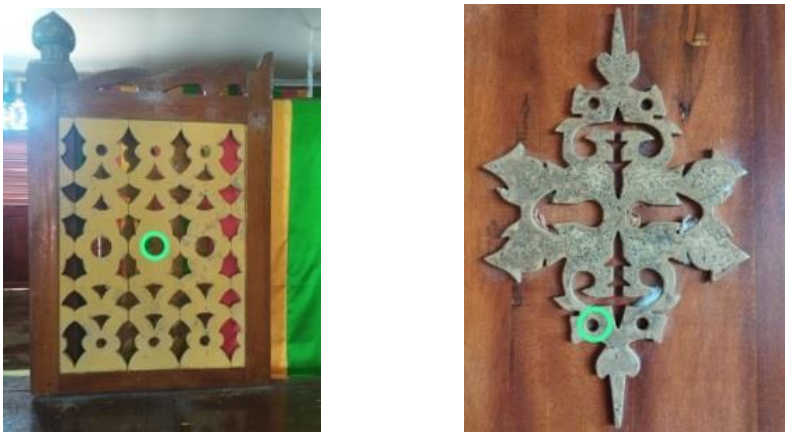


Figure 8. Circles on the Indra Perkasa Traditional Hall building on Penyengat Island

A circle is a flat shape formed from a collection of points the same distance from a specific center point. The philosophy of the decoration on the building includes bamboo shoots and grass stalks symbolizing fertility/happiness, curling ferns symbolizing prosperity, and hanging bees taken from behang nests, which contain the meaning of bringing happiness to their owners. The color philosophy includes yellow, which symbolizes power during the time of kings, and green, which symbolizes prosperity/fertility.

Discussion

Based on the analysis of the Malay ethnomathematics study carried out in the previous sub-chapter, there are several ethnomathematics practices regarding geometric material in the Indra Perkasa Traditional Hall Building on Penyengat Island. According to Batiibwe (2024) ethnomathematics can be applied as a teaching, learning, or evaluation strategy for mathematics instruction in classrooms. Ethnomathematics studies play a significant role in mathematics learning in schools because they can connect students' mathematical understanding directly with culture-based mathematics that develops near where the students live or, more precisely, in the community environment. Fajriyah (2018) explains that culture-based mathematics learning, or what is better known as ethnomathematics studies, is an alternative that can be carried out and can make the mathematics learning process more meaningful and contextual, which is closely related to a cultural group. Furthermore, Fendrik et al. (2020) stated that through ethnomathematics, mathematics learning is expected to be more meaningful and cultural and can increase the feeling of love for the homeland. According to the study Sunzuma and Maharaj (2022) the application of geometry in daily life depends on knowledge construction and conceptual understanding.

Various geometric objects in each part of the Indra Perkasa Traditional Hall Building on Penyengat Island show that the Malay people of Penyengat Island have implemented multiple customs and cultures since ancient times (Table 2). From the findings of several geometric aspects of the Indra Perkasa Traditional Hall Building, it can be seen that different meanings are contained in each architecture and pattern created by the people on Penyengat Island. The

shape of the building is not made haphazardly but based on traditions and rules that have existed and developed since ancient times in society. This also aligns with teachers' geometry material, especially in elementary schools in Phase B. Each geometric shape, namely flat and spatial, has different properties and characteristics.

Table 2. Elements of ethnomathematics in the Indra Perkasa Traditional Hall Building on Penyengat Island in geometry material in elementary schools.

Geometry material in Elementary School Phase B	Geometric objects found in the Indra Perkasa Traditional Hall on Penyengat Island
Two-Dimensional Shapes	Square Rectangle Triangle Trapezoid Circle
Three-Dimensional Shapes	Cuboid Pyramid Tube

The flat shapes include squares, rectangles, triangles, circles, and trapezoids. There were also findings on spatial objects including cuboids, pyramids, and tubes, and the relationship between these two objects and learning materials in elementary schools. Two- and three-dimensional objects are elementary school learning materials in phase B (grade 3). These two objects can be used as tangible examples of the initial understanding teachers give to their students before entering the core learning material. It can attract students' interest in studying the material and make learning less monotonous. Many studies also emphasize the importance of students' conceptual understanding in understanding and interpreting the meaning of measurement activities (Hardiani & Putrawangsa, 2019). The cultural, social, and practical aspects of ethnomathematics were used to categorize the teachers' perspectives on geometry. The teachers' opinions affect how they instruct geometry (Sunzuma & Maharaj, 2022).

Apart from that, there are also findings of philosophy or meaning contained both in the form of the building and in the architecture and style of the Traditional Hall building. This philosophy was obtained from interviews, observations, documentation, and other sources. Firstly, the general philosophy of Malay buildings includes buildings on stilts, which symbolize the characteristics of Malay houses, facing towards the sea, which symbolizes the sea is the source of life for the Malay people, pointing to the sky symbolizes that the Malay tribe upholds the teachings of religious knowledge, namely Islam.

The two decorative philosophies on buildings include stacked leaves, which symbolize love and family harmony; a single leaf symbolizes a strong personality; a ringgit leaf, which symbolizes social life; fern roots symbolize that life will return to the Almighty God; rattan roots symbolize that life must be able to develop. *Tunjang* roots symbolize a place to stand, jasmine and *melur* flowers symbolize purity, gourd flowers symbolize fortitude in life, clove flowers and mangosteen fruit symbolize splendor, Chinese flowers symbolize sincerity, forest flowers symbolize the diversity of life, shoots of bamboo shoots and Sulo lalang symbolize

fertility/happiness, Curly ferns symbolize prosperity, ants in a row symbolize harmony and cooperation, ducks coming home in the evening or *Itik Sekawan* symbolizes harmony and order, fish symbolize fertility and prosperity, snakes symbolize ingenuity and power. Lastly is the colour philosophy, including yellow, which symbolizes power during the time of kings, green which symbolizes prosperity/fertility, blue which symbolizes might in the sea, red which symbolizes brotherhood and courage, white which symbolizes purity, gold which symbolizes glory, and black which symbolizes might. Several theories and supporting sources exist of the three philosophies found above, including the results of interviews with sources in the field and the book "Traditional Architecture of the Riau Region" published in 1983/1984 (Wahyuningsih & Abu, 1986).

Ethnomathematics studies in a particular community group can link students' learning experiences with formal mathematics at school by integrating culture and tradition in mathematics learning (Hardiani & Putrawangsa, 2019). The practice of ethnomathematics in the Malay tribe tradition on Penyengat Island shows that several principles in mathematics are studied in schools, especially elementary schools, such as the geometric concept of plane shapes and space shapes, as well as measuring length. This can be evidence that the traditions and culture of a community group can be used as sources and learning materials and play a vital role in the mathematics learning process in schools, especially in elementary schools. This is also in line with the results of Tyas et al. (2022), which described and identified the existence of mathematics learning in the Selaso Far Twin traditional house, which shows that in this traditional house, there are mathematical activities and applications of Malay ethnomathematics related to mathematics learning in the material, geometry, and measurement. This is also proven by the shape of the Malay buildings in Riau and the Riau Islands, which are similar and almost identical. Apart from that, before separating into the Riau Islands Province, this Province was also part of Riau Province. So, until now, the two provinces have very similar Malay ethnic backgrounds and histories.

In this study, there are several findings, both similarities and differences. Several relevant studies found similarities, namely in terms of the material used, namely geometry. However, in this study, there are several differences, namely the discovery of several ancient cultural concepts in the construction process of the building, which still uses old methods or calculation methods. In addition, Penyengat Island is also a special island because, in every corner, there are many historical relics that we can still see today. Additionally, prior to being constructed and renovated into a new structure, this building was a part of a cultural heritage site.

Conclusion

Several ethnomathematics studies in the Indra Perkasa Traditional Hall building on Penyengat Island relate to geometry and measurement material in elementary schools. The results of the research are in the form of ethnomathematics practice, namely 2 and 3D shapes in the style and architecture of the Indra Perkasa Traditional Hall Building on Penyengat Island, and Malay measurements related to geometry and measurement material in Phase B elementary schools (classes III and IV). These include (1) the existence of geometric objects of flat shapes and

spatial shapes found in the Indra Perkasa Traditional Hall Building, (2) the existence of units of measurement and instruments for measuring cubits, rafter numbers, and boom numbers in the length measurement material. Additionally, (3) there is a philosophical meaning in the parts and the style or architecture of the Indra Perkasa Traditional Hall Building on Penyengat Island.

From ethnomathematics studies, several flat shapes have been found, including squares, rectangles, circles, and spatial shapes such as blocks, pyramids, and tubes. However, in measurement practice, these traditional measurements, which were once and very often used by society, have now been abandoned and are no longer used due to advances in time and technology. From several ethnomathematics studies conducted by the Malay community on Penyengat Island, it is clear that the local community is familiar with several basic principles in mathematics that are studied at the school level, especially in elementary school. Aside from that, Penyengat Island is also a place with a wealth of ancient Malay culture, some of which have been preserved as cultural heritage sites Indonesia.

This research is expected to provide an understanding that mathematics and culture are important parts of human life. They cannot be separated and can be used as a medium or source of learning materials for teachers and students so that they can provide benefits to advance the world of education in Indonesia. This study also provides information about the study of ethnomathematics in the Indra Perkasa Traditional Hall, Penyengat Island on geometry material that can be applied in the learning process in elementary schools. In addition, it can also be a source and reference for other researchers who want to conduct research in the same field.

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Conflicts of Interest

The authors declare no conflict of interest regarding the publication of this manuscript.

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Author Contributions

Rizki Rahmali Fadhillah: Conceptualization, writing-original draft, visualization, editing, formal analysis, and methodology; **Zetra Hainul Putra**: validation, monitoring, review, and editing; **Zufriady**: validation and monitoring; **Jismulatif**: review and editing; **Ayman Aljarrah**: validation and review.

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