p-ISSN: 2086-4280
e-ISSN: 2527-8827

Ethnomathematics: Exploration of Geometry from Karang Bayan Ancient Mosque in Elementary School Mathematics Learning

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Article received: 08-03-2023, revised: 18-07-2023, published: 31-07-2023

Abstrak

Penelitian ini dilakukan dengan tujuan untuk mengeksplorasi filosofis mengenai bangunan serta mengungkap etnomatematika konsep geometri pada Masjid Kuno Karang Bayan, Nusa Tenggara Barat. Penelitian ini menggunakan pendekatan kualitatif dengan rancangan penelitian etnografi yang akan menjelaskan salah satu bangunaan bersejarah islam di Lombok dengan teknik pengumpulan data observasi dan wawancara secara mendalam. Subjek penelitian yaitu dua narasumber yang merupakan penghulu desa dan juru kunci/pemelihara masjid yang paham terhadap aspek sejarah filosofi serta stuktur pada bangunan masjid kuno. Hasil penelitian menunjukkan bahwa terdapat makna filosofi dan unsur-unsur matematika berupa bangun datar dan bangun ruang pada bagian-bagian masjid. Konsep geometri yang ditemukan pada arsitektur Masjid Kuno Karang Bayan antara lain: konsep bangun ruang prisma pada atap masjid, konsep balok ditemukan pada bagian lampen jejait masjid dan bagian tunjeng atap masjid, konsep persegi panjang ditemukan pada pintu masjid.
Kata Kunci: Etnomatematika; geometri; Masjid Kuno Karang Bayan.

Abstract

This study was carried out to uncover the geometric concepts used in an old mosque in Karang Bayan, West Nusa Tenggara, and to explore philosophical ideas about architecture. This qualitative study discussed one of the old Islamic structures in Lombok using an ethnographic research design. Data collecting strategies were observation and in-depth interviews. The research topic involved two resources: the village chiefs and mosque keepers/maintainers who were knowledgeable about the philosophical and architectural history of the mosque. Findings demonstrated the presence of philophosis and mathematical features in the mosque's structural components as flat shapes and building spaces. The Geometry Concepts found in the architecture of the ancient Mosque of Karang Bayan included: 1) Prismal Concepts on the Roof of the Mosque; 2) the concept of the beam was found by the mosque lampen and the mosque roof section; 3) The rectangular concept was found at the mosque door.
Keywords: Ethnomatematics; geometry; Karang Bayan ancient mosque.

I. INTRODUCTION

Mathematics is one lesson content that is closely related to culture. Mathematics is not alone but is influenced by history, social environment, geography, and culture (Sutarto, Hastuti, & Supiyati, 2021; Diniyati et al., 2022). Mathematics is one of the subject contents that is the pillar of educational progress. Mathematics is a subject that positively impacts people's lives by contributing to the humanization of Indonesian society in general (Kholisa, 2021; Nuqthy, Nityana, & Navia, 2023). Mathematics is still a complicated subject that children or students rarely enjoy because the lessons taught at school are usually focused on rigid material and force children or students to think abstractly.

According to Dwi Purnama et al. (Putri, Somakim, Negara, & Sumatra, 2020), it is stated that children's mathematics at the elementary school level still uses the lecture method, which only presents an explanation of the material and focuses more on memorizing than making concepts. This is because teachers who are still less creative in utilizing learning resources make the learning process less enjoyable, and students have difficulty understanding concepts in mathematics learning (Surat, 2018; Meilina, Mariana, & Rahmawati, 2023). The availability of innovation in the math learning process is needed so that math learning becomes more enjoyable (Dewita, Mujib, & Siregar, 2019; Hartono & Putra, 2022). One of the innovations in mathematics learning is the science that explores the relationship between mathematics and culture, also known as ethnomathematics. Mathematics learning needs to be related to the culture or daily life of students because, basically, mathematics cannot stand alone and is strongly influenced by aspects of history, geography, and social environment, and learning designed with ethnomathematics can increase students' enthusiasm for learning and start to be stimulated to think logically in elementary school (Sutarto et al., 2021; Situmorang, 2020). According to D'Ambrosio (Prabawati & Muslim, 2022), ethnomathematics is a mathematical practice carried out by cultural groups or communities.

The implementation of mathematics in the culture of society is an important thing to explore so that it is easy to learn so that students understand directly apply mathematics in their lives. Cultural context can stimulate students' knowledge to be easily remembered and connect directly to their daily lives (Yudianto, Febriyanti, Sunardi, Sugiarti, & Mutrofin, 2021). Following the opinion of Ulum (Nurhidayah & Budiyono, 2022), it is stated that the 2013 Curriculum learning in elementary schools currently emphasizes increasing students' cultural abilities (Kim, Raza, & Seidman, 2019; Solikhah & Budiharso, 2020). It is hoped that by applying ethnomathematics, students can better understand mathematics and their local culture.

The primary purpose of ethnomathematics studies is that students can easily understand mathematical concepts through cultural applications (Maryati & Prahmana; 2019; Pitaloka & Susanti, 2022). In general, ethnomathematics is mathematics practiced in cultural groups such as national societies, tribes, labor groups,

p-ISSN: 2086-4280
e-ISSN: 2527-8827

children of specific age groups, and professional classes (Hastuti, Mariyati, Sutarto, & Supiyati, 2022).

Ethnomathematics in geometry includes illustrating mathematical concepts from drawing sketches, visualizing authentic images, or building forms that can be seen concretely in everyday life (Sunzuma & Maharaj, 2020; Rofiq, Damayanti, Janan, Sitaresmi, & Nuryami, 2022; Iqrima, Zulkarnain, & Kamaliyah, 2023). Mathematical concepts sometimes arise naturally through activities in which there is a process of abstraction from actual experiences in everyday life. According to Zayyadi (Bahagia et al., 2022), Mathematics with ethnomathematics nuances plays a considerable role and support in constructing concepts in mathematics learning.

This research is supported by previous research using ethnomathematics that has been widely studied, such as the research of Sulaiman and Nasir (2020), which found mathematical concepts on flat planes, lines, and series; ethnomathematics in the Sundanese tribe has three activities, namely measuring, estimating, and making patterns (Muhtadi, Sukirwan, Warsito, & Prahmana, 2017); Exploration of ethnomathematics in the traditions and traditional clothing of the Dayak tribe contains mathematical concepts (Dimpudus & Ding, 2019); found mathematical objects in cultural products in the form of flat and spatial shapes (Kusaeri & Pardi, 2019).

Further research (Lakapu et al., 2021) has found the concept of geometry and arithmetic in buna woven fabric motifs; then ethnomathematics at Waringin Lawang Temple has found the concept of geometry in the form of flat shapes (Nurhidayah & Budiyono 2022), the study of fraction patterns and geometry from various weaving motifs or other objects in the form of traditional cake shapes as abstractions of mathematical concepts (Laurens, Ngilawayan, & Pattiasina, n.d.); Research by (Putra, Wijayanto, & Widodo, 2020) has explored the ethnomathematics of the 2D geometry field at the Soko Tunggal Mosque. These studies were conducted to explore the mathematical concepts implied in a culture.

Several previous researchers have researched the exploration of ethnomathematics in mosque buildings. One of them is the exploration of the ethnomathematics of the Jami' Al-Baitul Amien Jember Mosque (Yudianto et al., 2021). As a renewal effort, this research is aimed at digging deeper into the philosophy of the building and revealing the ethnomathematics of the geometry concept at the Karang Bayan Ancient Mosque because no researchers have studied the philosophy and revealed ethnomathematics at the Ancient Mosque in Karang Bayan, West Nusa Tenggara. The Karang Bayan Ancient Mosque is one of the historical objects of the people of Lombok. The Karang Bayan Ancient Mosque is evidence of the historical heritage of Islamic propagation and maintains its cultural purity and a unique religious object typical of traditional Lombok. The unique shape and architecture of the Karang Bayan Ancient Mosque need to be explored to find ethnomathematical values in it. The

reason for choosing the Karang Bayan Ancient Mosque's architecture is because the ancient mosque's shape can be found in some real examples of geometric objects. Karang Bayan Ancient Mosque can be used as an alternative learning source for mathematics that is more realistic and meaningful because of its geometric shape and architecture so that the teacher can facilitate students in naturally recognizing the concept of geometry of flat and spatial shapes. Another reason is that the Karang Bayan Ancient Mosque is unique in the history of Lombok and is still used and built by the community. Therefore, this research aims to explore geometric elements of spatial and flat shapes in the Karang Bayan Ancient Mosque building to be used as a learning resource facility and increase elementary school students learning motivation.

II. METHOD

This study is a qualitative approach with an ethnographic research design and follows the stages of the Spradley cycle (1980). The informants of this research consisted of two people, namely one Village Penghulu/Tetua Adat and one caretaker/manager of the mosque. Both informants understand culture and history well and know the structure of the ancient mosque of Karang Bayan.

Table 1.
Research Stages

No	Stages/Steps of Research	Activities
1	Ethnographic project selection	a. Site selection b. Selecting and determining key informants (village headman & mosque caretaker), c. Selection of activities/culture
2	Asking ethnographic questions	a. identify what will be explored and what data to collect b. What mathematics materials can be explored with an ethnomathematics approach
3	Ethnographic data collection	a. Field observation b. Participant observation c. In-depth interviews using interview guidelines and standardized open-ended interviews d. Data collection
4	Making ethnographic notes	Take field notes and collect documentation
5	Analyzing the ethnographic data	Make field notes and collect documentation
6	Menulis etnografi	Writing results in the form of report

Source: Spradley (1980)

Data collection techniques were conducted through participant observation and in-depth interviews over four months. In participant observation, the researcher observes what is done and is involved in the activities of the research subject.

The researcher observes what is done and is involved in the activities of the research subject. In-depth interviews are unstructured so that research subjects are more accessible and naturally provide the information needed. Data analysis consists

p-ISSN: 2086-4280
e-ISSN: 2527-8827

of three stages, namely 1) preparing and organizing data, 2) describing, clarifying, and interpreting data into codes and themes, and 3) finally presenting data.

III. RESULT AND DISCUSSION

Based on data collection from observations and interviews with both informants, the results obtained on the object of this research show that various ethnomathematics and philosophical elements in several parts of the Karang Bayan Ancient Mosque building can be implemented into mathematics learning.

Karang Bayan Ancient Mosque is one of the traditional mosques of the Sasak Tribe located in Karang Bayan Village, Lingsar District, West Lombok Regency, West Nusa Tenggara. The building was built around ± 600 years ago, calculated from the Trah / Nasab, and found fossils that are evidence of the existence of Karang Bayan village. The community commonly refers to the ancient mosque of Karang Bayan as Langgar. Mosque architecture is one part of the design that is a traditional icon of Lombok and has a long history, and there are several functions of mosques or ancient mosques to become a center of civilization (Supiyati, Hanum, & Jailani, 2019).

Figure 1. Karang Bayan Ancient Mosque Building

Based on the results of the exploration, the model used in the mosque building, namely the jejait (sewn) building model with a mound foundation, low pillars and walls, and a towering roof extending downwards as if almost touching the ground, requiring everyone to duck to enter the mosque because there is a philosophy of meaning about civilized procedures when entering people's territory so as not to be arrogant/arrogant, and there are stairs leading to the door of the mosque with a total of 3 steps that have a fiolosi, namely the time telu da'wah method which is divided into two philosophies, namely: 1.) Time telu on three specifications of how to learn nature classified in breeding material such as: a.) by breeding; b.) by laying eggs c.) by growing alone. And 2.) Time telu on da'wah methods that go into beliefs such as: a.) the first ladder, which is the initial journey when the human is still in the spirit of the mother's womb before being born into the world; b.) the second ladder is after humans are born and live life in the world; and c.) the third ladder which is human life after death. Every living being with a life that enters these three natural studies has a period of life or death.

The roof of the Karang Bayan Ancient Mosque is made of thatch to maintain the local wisdom and authenticity of the building. The roofing material is made of twisted thatch in the sense that Islamic law is tied in a knot that describes the three ties on the corpse. The knot is likened to the creed with the intention of how we tie the creed of faith in God Almighty. The roof is 6 m high, 9 m long and 8 m wide.

The following is an excerpt from the interview with the subject. (P: Researcher, S1: Village Penghulu/Customary elder)

P: *Why is the mosque's roof made to look like that, sir?*

S1: *This mosque is the result of the legacy of the ancients who fought against the Dutch around ± 600 years seen from the research results that have found human bone fossils calculated from the Trah / Nasab.*

So actually, the concept of this mosque building was built like a boarding school which we maintain as its initial form even though we are continuing to renovate and the original building materials are still maintained, namely the original stone and wood materials left by the ancestors during the Datu's time. The concept of building an ancient mosque is like a boarding school that functions as a place of worship and religious learning where the separation between men and women has been applied. (P: Researcher, S2: Mosque caretaker)

P: *Is there a philosophical meaning in the shape of this mosque building, sir?*

S: *So, the mosque building has a towering roof and extends downward as if it is almost touching the ground. If we enter the mosque, our position must be bowed down, which has a philosophical meaning about civilized procedures when entering people's territory to avoid being arrogant.*

Three stairs go to the main room of the mosque. The philosophy is about belief in the form of the time telu da'wah method, with the first staircase which means the initial journey when the human is still in the spirit of the mother's womb before being born into the world, the second staircase means that after humans are born, and live life in the world, and the third staircase means the life of the world after death. The purpose of this philosophy is to remind us always to fear God Almighty to be a provision for life in the afterlife.

P: *Are there any special provisions in the mosque's construction, or is it made freely?*

S2: *As in the original question, this mosque has been around since + 600 years ago.*

So, the construction has been around for a long time, so we are continuing what our ancestors have built but still maintaining the authenticity and durability of the mosque.

P: *What is the roof size of this ancient mosque, sir?*

S1: *For the size of this mosque, we use the size of the arm, commonly called the Sasak sedepa. The size of this sedpa is according to the size of the arm of the person measuring; for my arm size sedepa means 1.5 meters.*

The mosque roof is 6 fathoms long, 3.5 fathoms in width, and 4 fathoms in height.

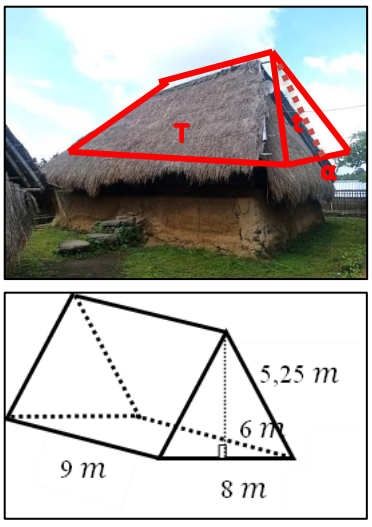

Figure 2. Mosque Roof and Sketch

After observing in terms of geometry, the ethnomathematical form on the roof of the ancient mosque represents a type of space in the form of a triangular prism. Triangular prisms generally follow the shape of the base with two congruent

p-ISSN: 2086-4280
e-ISSN: 2527-8827

triangular tops and lids with three rectangular sides, six corner points, and nine ribs (Mubarok, 2019). Fioiaini (2019) Triangle area formula = triangle perimeter (S3) x prism height (t), prism volume formula = base area ($\frac{1}{2}$.a.t) x height (T), and surface area = triangle perimeter (s3) x T prism (t) + 2 triangle area (at), (Mubarok, 2019) with the following solution;

$V_{prism} = (\frac{1}{2} \text{ x a x t}) \text{ x T}$

$= (\frac{1}{2} \text{ x } 8m \text{ x } 6\ m) \text{ x } 9m$

$= 24\ m \text{ x } 9\ m$

$= 216\ m^3$

$L_{Surface} = (K_a \text{ x } t_{prism}) + (2 \text{ x La})$

$= (8\ m + 6\ m + 5{,}25\ m) \text{ x } 9\ m) + (2 \text{ x } \frac{1}{2} \text{ x } 8\ m \text{ x } 6\ m)$

$= (19{,}25\ m \text{ x } 9\ m) + (2 \text{ x } 24\ m)$

$= 173{,}25\ m + 48\ m$

$= 221{,}25\ m^2$

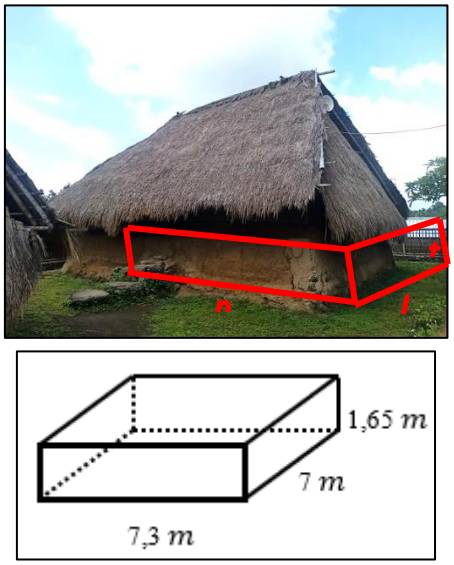

Figure 3. Mosque surface and sketch

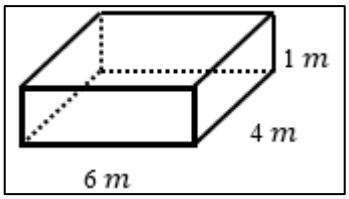

Figure 4. Lampen Jejait and Sketches

Visible from Figure (3) and Figure (4) can represent the shape of the building space in the form of blocks. In Figure (3), the mosque's surface is 7.3 meters, with a width of 7 meters and a height of 1.65 meters. The philosophy contained in the surface of the ground that is made higher shows the virtues of the mosque in the world to be one of the places of worship and praying mustajab granted prayers.

This part of the lampen jejait, the central part of the mosque, is straightforward and made of bamboo pieces. Lampen jejait in ancient mosques has a length of 6 m, a width of 4 m, and a height of 1 m. The beam area formula (L) = 2pl + 2pt + 2lt, and the beam volume formula = p x l x t (Mubarok, 2019).

Completion of the beam in volume and area formulas on the surface of the mosque;

$V_{beam} = \text{P x L x t}$

$= 7{,}3m \text{ x } 7m \text{ x } 1{,}65m$

$= 84{,}315\ m^3$

$L_{beam} = 2 \text{ x } (PL + Pt + Lt)$

$= 2 \text{ x } (51{,}1m + 12{,}04m + 11{,}55\ m)$

$= 2 \text{ x } 74{,}69\ m$

= 149,38 m^2

Completion of blocks in volume and area formulas in lampen jejait;

V_{beam} = P x l x t
= 6 m x 4 m x 1 m
= 24 m^3

L_{beam} = 2 x (*PL* + *Pt* + *Lt*)
= 2 x (24m + 6m + 4m)
= 2 x 34 m
= 68 m^2

The following is an excerpt from the interview with the participant;

P: *Why is the mosque building made more in such a form, sir?*

S: *The mosque building here is made on the surface using the remaining volcanic ash soil from the ancestors' time, and the core room is made of bamboo using jejait to make it stronger and maintain the authenticity of the mosque building materials.*

P: *Is there any meaning in making a high surface, sir?*

S: *So, the meaning in the surface of the mosque, which is higher than the mosque in general, is that it shows the virtue of the mosque in the world to be one of the places of worship and praying mustajab granted prayers.*

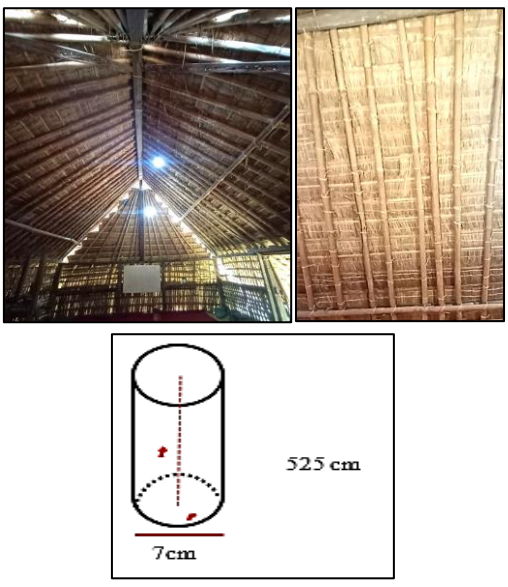

Figure 5. Mosque roof and sketches

Figure 5 shows that the ancient mosque also has a roof arranged in parallel to support the roof made of thatch. The roof of the Karang Bayan Ancient Mosque has a shape like a space, namely a tube. The shape of the tube was chosen because it follows the shape of the material, namely bamboo, which forms a circle resembling a tube. Made of bamboo because, at that time, the construction of houses and mosques still used bamboo and was still used to maintain the cultural value of the ancient mosque. Each roof vine pole has a height of about 5 m and a circumference of 7 cm. Tube surface area formula = $2\pi r$ T + $2\pi r^2$ and the formula volume = base area (πr^2) x height (T), where r denotes the radius of the base or lid of the tube (Lumbatoruan, 2019; Mubarok, 2019).

Here is an excerpt of the interview with the participant:

P: *Why is the roof made like that, sir?*

S1: *The roof is made of bamboo, so the formation is like a circle and cut into lengths to hold the thatched roof somewhat tighter and more resistant to supporting the roof.*

P: *How many usuk are installed, sir?*

S1: *The number of roof rafters installed from the side and front differs. There are 12 usuk from the side and 32 usuk from the front.*

P: *Is there a philosophical meaning of the roof of this mosque, sir?*

S1: *the philosophical meaning of the roof rafters is seen from the number, from the number of 12 rafters interpreted as 12 Islamic months and 32 the number of other roof rafters with the meaning of the 32nd chapter of the Qur'an, namely As-Sajdha with the meaning of prostration.*

Completion of the tube with volume and area formulas on the roof vine:

V_{tube} = La x t

p-ISSN: 2086-4280
e-ISSN: 2527-8827

$= \pi \, x \, r^2$ x t
= 3,14 x $(3{,}5)^2$ x 5,25
= 3,14 x 12,25 x 5,25
= 201,9 m^3

L_{tube} = 2 π r (r + t)
= 2 x 3,14 x 3,5 (3,5 + 525)
= 21,98 (8,75)
= 192,3 m^2

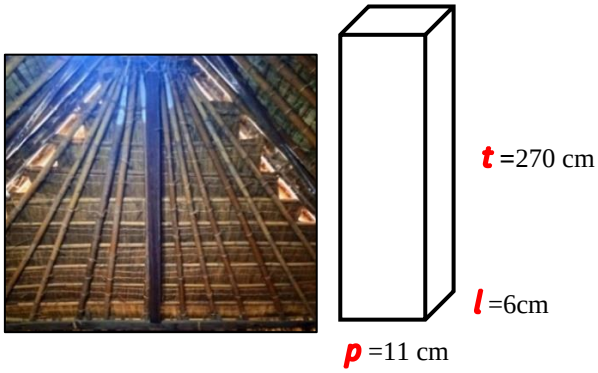

Figure 6. Roof Tunjeng and Sketches

Other than the roof usuk, there is also a roof tunjeng as a support for the roof of the ancient mosque, which is made of sentul tree wood because sentul wood is a sturdy material for building materials. In terms of geometry, the roof tunjeng stands upright, extending upwards, having a spatial shape in the form of a block with a length of 11cm, a width of 6cm, and 2.7. A beam is a space that has four rectangular sides, the same side, and four equal ribs. The six wooden roof pillars have a meaning: the six pillars of faith in Islam. The formula for the surface area of a beam (L) is L = 2 x (p x l + p x t + l x t), and the volume of a beam (V) is V = p x l x t with p representing the length of the beam, l representing the width of the beam and t the height of the beam (Lumbatoruan, 2019; Mubarok, 2019).

Expects of the interview with the participant follow:

P: Why is the tunjeng roof made using wood in this shape, sir?

S2: Back again, the tujeng roof is indeed from our ancestors in the form of a box and long made of sentul wood taken from the Karang bayan forest.

P: How many tunjeng roofs are there in this mosque, sir?

S2: For the number of tunjeng roofs here, six wood planks are installed as roof supports to make it stronger.

P: Is there a philosophical meaning of this roof tunjeng, sir?

S2: Indeed, there is, for the philosophy is interpreted from the number of tunjeng roofs which are the pillars of Muslim belief, namely six numbers of the pillars of faith. Completion of beams with volume and area formulas for rooftops as follows;

V_{beam} = P x L x t
= 11cm x 6cm x 270cm
= 17.820 cm^2
= 178,2 m^3

L_{beam} = 2 x (*PL* + *Pt* + *Lt*)
= 2 x (66 + 2.970 + 1.620)
= 2 x 4656
= 9.312 cm^2
= 93,12 m^2

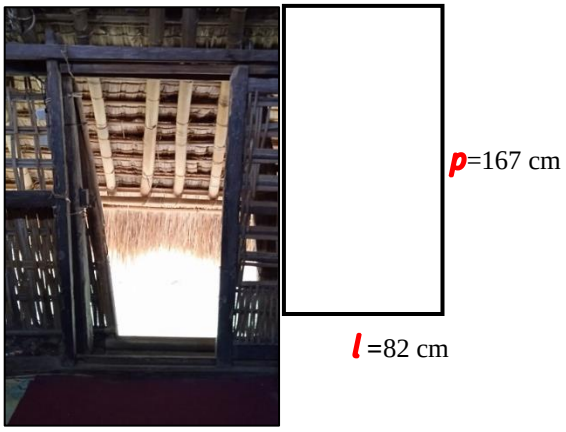

Figure 7. Mosque Door and Sketch

The results of observations in Figure (7) of the mosque door observed in terms of geometry can be found in flat rectangular shapes. Rectangles have properties such as parallel sides of equal length and all angles being right angles, the diagonals being equal in length and bisecting equal in length, and the diagonals intersecting (Fioanini, 2019). The mosque's door is made short because when entering the mosque, duck with the philosophical meaning, namely civilized procedures when entering people's territory so as not to be arrogant. The door of this mosque has a length of 167 cm and a width of 82 cm. Rectangular area formula (L) = length (p) x width (l) and rectangular perimeter formula (K) = 2 x (p + l) (Lumbatoruan, 2019).

Excerpts of interviews with participants follow:

P: *What is the size of the door on the door of the ancient mosque, sir?*

S2: *The door of this mosque has a length of approximately 167 cm with a width of 82cm, according to the measurements that have been taken.*

Completion of the rectangle with the formula for the perimeter and area of the mosque door as follows;

L = P x L
= 1,67 x 0,82
= 1,37 m^2
K = 2 (P + L)
= 2 (1,67 + 0,82)
= 2 (2,49)
= 4,98 m^2

Based on the results of exploring the Karang Bayan Ancient Mosque can be implemented into classroom learning practices to understand the properties and elements of building spaces and flat planes. The ethnomathematics-based learning design can be seen in the following Table 2:

Table 2.
Ethnomathematics-based Learning Design

Material focus	Spatial and plane geometry
Indicators of Learning	1. Identify the characteristics of various geometric shapes (triangular prism, block, tube, rectangle). 2. Solve problems on the concepts of area, volume, and perimeter of various shapes (triangular prisms, blocks, tubes, rectangles)
Learning Achievement	1. Students can identify various shapes (triangular prism, block, tube, rectangle). 2. Students can solve problems on the perimeter, volume, and surface area of various shapes (triangular prism, beam, tube, rectangle).
Explorations of Ethnomathematics	1. Calculate the mosque roof area, mosque surface area, lampen jejait surface area, roof tunjeng area, roof usuk area, and rectangular area. 2. Calculate the volume of the mosque roof prism, the volume of the mosque surface, the volume of the lampen jejait, the volume of the roof tunjeng, the volume of the roof usuk, and the perimeter of the rectangle.

Through this, the use of cultural heritage such as the Karang Bayan Ancient Mosque, which is one of the historical relics of Islam in Lombok, can provide benefits to Learners in ethnomathematics learning because the Ancient Mosque can be found in its shape and architecture, which looks geometry in the form of spaces and flat shapes. Another benefit is that students can easily understand geometry concept material and take cultural and historical values. Agree with (Ilyyana & Rochmad, 2018; Kurnia, Dewi, & Dwidayati, 2019; Mukeriyanto, Mastur, & Mulyono, 2020;

p-ISSN: 2086-4280
e-ISSN: 2527-8827

Rahmawati, Zaenuri, & Hidayah, 2023), which explain that ethnomathematics learning can develop mathematical problem-solving skills and the character of cultural love.

IV. CONCLUSION

The importance of education and culture, especially in learning mathematics, is through ethnomathematics studies. The results of exploring ethnomathematics in the Karang Bayan Ancient Mosque Building can be implemented into classroom learning which contains geometry concepts, namely space and flat buildings. The geometry concepts found in the architecture of the Karang Bayan Ancient Mosque include the concept of prism found on the roof of the mosque; the concept of beam found on the lampen jejait mosque and the tunjeng part of the mosque roof; the concept of the tube on the mosque roof; the concept of rectangle found on the mosque door. Based on the results of this study, future researchers should add the object of research so that there can be more mathematical values and modules made so that students are more familiar with and love math and culture. Moreover, it can be followed up to apply to schools as a source of learning mathematics students.

ACKNOWLEDGEMENT

We would like to thank all those who have supported the completion of this scientific article, especially the participants who have provided information about the ancient mosque in Karang Bayan.

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