Ethnomathematical Expolarization of The Portibi Temple Building in North Padang Lawas Regency

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ABSTRACT

This study explores ethnomathematics in the architecture of the Portibi Temple in North Padang Lawas Regency to reveal the relationship between geometric concepts and the symbolic meaning of Hindu-Buddhist culture. A qualitative approach using observation, interviews, and documentation was used to identify mathematical elements in the temple structure. The results show the presence of a cube-shaped solid on the main body of the temple, symbolizing the stability of human life and the connection between the earth and the sky; a cylinder on the roof representing the continuity of life; beams on the stairs and the base of the temple as symbols of sturdiness; and a rectangular pyramid in the interior, reflecting the relationship between humans and the spiritual world. In addition, the rectangular and trapezoidal solid shapes emphasise the principles of proportionality and balance. These findings demonstrate that the geometric forms in the temple serve not only structural functions but are also rich in philosophical values. The implication is that Portibi Temple can be used as an ethnomathematics-based learning resource that links abstract concepts with the local cultural context, thereby making mathematics learning more concrete, meaningful, and fostering students' appreciation of cultural heritage.

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1. INTRODUCTION

Indonesia is known as a pluralistic country, and its cultural diversity is caused by its status as an archipelagic country with many tribes, cultures, and customs. According to Nugraha and Novaliyosi [1], one of the efforts to preserve Indonesian culture is through integrating culture into each lesson at school to introduce culture to students. Therefore, it is necessary to innovate mathematics learning from various parties in direct contact with culture. Culture and education are two inseparable aspects of daily life. The two have a very close relationship, and the relationship between culture and mathematics [2]. According to

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Yuningsih [3], culture is the creation of human opinions in the form of works, and culture contains the meaning that humans can use their intellect and thoughts to slow down daily life. Thus, culture is a community tradition inherited from generation to generation, so it becomes a characteristic of each region.

Mathematics is one of the subjects that students learn from elementary school to high school and even in college. This proves that mathematics is one of the subjects that plays an important role in daily life. Mathematics requires mentality in the learning process because mathematics is an abstract concept systematically arranged in a structure based on logical reasoning [4]. Learning math is very important, but some students say that learning math is complicated [5]. Students often experience obstacles when learning mathematics because learning does not provide concrete examples of abstract mathematical objects [6]. Mathematics learning is not only a learning that emphasises knowledge, but also an education that can foster understanding, critical thinking, and analytical skills so that students can solve mathematics-related problems in daily life. Mathematics is an important part that cannot be separated from daily life, although most people do not realise that they often apply mathematical concepts and principles in their daily activities [7].

According to Kristial [8], mathematics education requires a tool that can compare mathematics education in schools with mathematics education used by students worldwide in their daily lives, namely, ethnomathematics education. Meanwhile, according to Turmuzi [9], in his article, mathematics education in schools aims to help students understand the basics of subjects by relating math to their everyday experiences through everyday activities. Learning mathematics associated with cultural elements will make students more interested and able to relate the material learned to their everyday experiences. This approach not only helps in strengthening the understanding of concepts but also plays a role in increasing students' motivation and interest in learning [10]. Mathematics related to culture is commonly called ethnomathematics. Ethnomathematics looks at how mathematics is used in activities or people's lives that associate it with culture [11]. In line with that, students or teachers must also be familiar with ethnomathematics, there needs to be an ethnomathematics approach as an approach in mathematics learning, because without realizing that ethnomathematics originates and develops from culture and without realizing that mathematics has been used in human activities and is a form of application of mathematics in real life [12].

Ethnomathematics is a mathematical concept found in several cultures and mathematical foundations that will significantly impact mathematics education [13]. Ethnomathematics serves as a method to combine, collect, and understand the relationship between socio-cultural aspects and existing science and technology. The purpose of ethnomathematics-based education is to concentrate on subjects related to the culture of the area where students are studying, as well as, according to Sinaga in his article, the purpose of culture-based learning is to provide students with information, organise, and discover mathematical concepts that can be applied in daily life [14]. Many residents do not understand the meaning of characteristics in the local environment, especially those based on mathematics [15]. In line with his research, Yusnizar concluded that ethnomathematics studies how traditional societies use mathematics in many ways, such as in their art and culture [16]. According to Ilham [17], in his article, he explained that ethnomathematics is a learning approach that helps children understand mathematical material better. One way to learn mathematics better is by using the templates in ethnomathematics studies.

Temple buildings as historical relics have high value and reflect the region's culture. A mathematical concept can be found easily when constructing the temple [18]. There are many temple buildings in the Padang Lawas Regency, such as Portibi Temple, Sipamutung Temple, and Tandihat Temple [19]. Research by Nursahadah [20]. This research contributes to introducing the relationship between local culture and mathematics. This study found the concept of geometry in the Portibi Temple, but it was still limited to a general description of the shape without presenting an analysis of the drawings of what mathematical concepts were found, and the lack of discussion of the discovery. Therefore, further in-depth research is needed to use the concept in contextually culture-based mathematics learning. Several previous studies have discussed the use of temple sites in education, one of which is the book by Barus and Suratno [21] discussing the use of the Bahal temple as an outdoor learning medium for various subjects, emphasising contextual learning, hands-on experience, and student involvement. However, this study does not examine the relationship between temple architecture and mathematical or ethnomathematical concepts. The discussion is still general, without focusing on integrating certain materials. Zulkarnain's research [22] discusses the development of Bahal Tourism Village from the perspective of development anthropology, highlighting the community's social, cultural, and economic potential. However, this study has not examined the use of temple sites for education, especially mathematics or ethnomathematics, and does not discuss the details of geometric architecture, the development of culture-based learning media, or the evaluation of its educational impact.

In previous studies, no studies have been found that have studied the architecture of Portibi Temple in depth with the concept of mathematics in the context of ethnomathematics. Nursahadah [20] only describes geometric shapes in general without detailed analysis and application in learning, and Barus and Suratno [21] discuss the use of temples as an open-air learning medium without focusing on mathematical aspects. In contrast, Zulkarnain [22] focuses on developing tourist villages without discussing the educational potential of temples. Therefore, this research presents a novelty by analysing geometric shapes such as cubes, blocks, tubes, rectangles, and trapezoids along with their cultural meanings, then integrating them in contextual and relevant local culture-based mathematics learning to foster appreciation for cultural heritage.

2. METHOD

This type of research is qualitative research using an ethnographic approach. Qualitative research focuses on information research by examining the consequences of respondents' perception and exposure to the information. In general, qualitative research is exploratory research that can play a role in understanding the social environment observed and displaying the actual data results [23]. Meanwhile, the approach used is a research approach in terms of mathematical ethnography, or ethnomathematics. The ethnomathematical approach means an approach that relates mathematical concepts in a local culture, intending to make it easier for students to understand the mathematical material presented [24].

The object of this research is the Portibi Temple, located in Bahal Village, Padang Bolak District, North Padang Lawas Regency, North Sumatra Province. This research was conducted at three temple sites, each approximately $300 - 500\ m$ apart: Bahal I, Bahal II, and Bahal III. This research focuses on identifying the geometric concepts of spatial and plane shapes found in the structure and ornamentation of the Portibi Temple. Before conducting the research, the researcher obtained permission from the village head and was then recommended to conduct interviews with the Portibi Temple management. The interview process was conducted by requesting the informants' consent and ensuring voluntary participation. The informants' identities are only listed upon their consent. The researcher used data collection techniques through direct observation, interviews with the temple management, and photographic documentation. This study analysed data using the Miles and Huberman [25] method, which outlines the steps of data reduction, data presentation, and conclusion drawing. In this study, the researcher played a direct role in data collection. Data reduction is the initial step in data analysis to facilitate understanding of the data obtained. The researcher then selects which data are relevant and which are not to the research objectives. The data presentation uses descriptive text analysis. This analysis is based on the idea that every new piece of data will always be linked to other data. Concluding is the final step in data analysis, where researchers formulate meaning or interpretation from the data that has been reduced and presented.

In the Portibi Temple research, data from observations, interviews, and documentation were reduced by focusing on relevant information on geometric shapes, while data that did not support the objectives were ignored. The findings were then presented descriptively by grouping them based on the type of geometric and plane shapes, supplemented by documentary photographs and supporting information linking the field findings to ethnomathematics theory. The research conclusions indicate that the architecture of the Portibi Temple contains geometric concepts that have structural functions and symbolic meanings in Hindu-Buddhist culture. These geometric shapes also have the potential to be used as contextual learning media that connect mathematics with local culture, while supporting the preservation of historical sites as meaningful learning resources.

3. RESULTS AND DISCUSSION

North Padang Lawas Regency, located in the province of North Sumatra, has a rich and diverse history and reflects the influence of Hindu-Buddhist civilisation from the cultural heritage of the ancient Batak people. This area is known for various historical sites, including the Portibi Temple, which was built between the 11th and 14th centuries AD. It is one of the largest temples after Sipamutung Temple, which is located in Padang Lawas Regency, North Sumatra [26]. Portibi Temple, commonly known as Bahal Temple, which is located in Bahal Village, Padang Bolak District, North Padang Lawas Regency, North Sumatra Province, is about 3 hours away from the city of Padang Sidempuan, or about 400 km from Medan City, and is one of the historical sites that store beauty and high cultural value. This complex includes three temples, namely Bahal I Temple, as shown in Figure .1, regarding the parts of Portibi Temple, namely (a) Bahal I Temple, (b) Bahal II Temple, and (c) Bahal III Temple, each of which is separated by a distance of about 500 meters. In this complex, the main building of the Bahal I Temple, with a courtyard area of about 3,000 m^2, is the largest compared to the main buildings of the Bahal II and Bahal III Temples. These three temples are made of red brick except for the statues, which are made of hard stone. Each of these temple complexes is surrounded by a fence that is 1 meter high, thick, and red brick.

Figure 1. Parts of the Portibi Temple for (a) Bahal I, (b) Bahal II, (c) Bahal III

Based on the results of observations, documentation, and interviews conducted by researchers at Portibi Temple in Bahal Village, Padang Bolak District, North Padang Lawas Regency, North Sumatra Province, it can be concluded that in the architecture of Portibi Temple, there is the application of mathematical aspects, especially in the concepts of spatial geometry and flat geometry. This can be seen in the shape, size, and layout of the temple parts following geometric principles. Data was obtained through direct observation at the location, interviews with 2 temple managers, and visual documentation in photos and field notes. This analysis process is carried out by processing data collected through interviews, observations, and documentation following ethnomathematical characteristics during research activities. Data analysis uses the Miles and Huberman model, which includes three stages, namely data reduction (selecting and focusing relevant data), data presentation (organising data in the form of descriptive narratives and visual documentation), and drawing conclusions (formulating the meaning and interpretation of data to answer research objectives). The following researchers present the three analyses.

3.1 Results of the analysis of interview data conducted by the researcher with the manager of the portibi temple, namely Mr. Arbin Harahap and Mr. Marhan Nasution.

a. Geometry in the temple

Researcher	*:*	*What do you think can be seen directly from this portibi temple?*
Speaker 1	*:*	*If we see this portibi temple for the first time, the first thing that immediately catches our eyes is the shape of the cube found on*

the main body of the temple. Then, we will see the beam part of the staircase.

Speaker 2 : *In my opinion, the first thing that is immediately visible is the temple roof, which is shaped like a tube, and the part of the temple body that we can see in the shape of a cube.*

(a) (b (c)

Figure 2. Several Parts of the Temple with Geometric Shapes for (a) Cube, (b) Cylinder, (c) Block

b. The ornaments of the Portibi Temple

Researcher : *Is there a symmetrical pattern or repetition in this ornament of the Portibi Temple?*

Speaker 1 : *In my opinion, Portibi Temple has a neat and balanced pattern. In the Bahal I Temple, the left and right sides of the courtyard are similar, and the main temple fits right in the middle, so it looks symmetrical and balanced. The decorations at the foot of the temple are also repeated, such as carvings of animal figures and dancing people. In my own opinion, the symmetrical and repetitive pattern is indeed a characteristic of the decoration of the Portibi Temple.*

Speaker 2 : *In my opinion, apart from what has been conveyed, the ornaments of the Portibi Temple have a symmetrical and repetitive pattern and are characteristic of Hindu-Buddhist architecture, even though they are not as complicated as the decorations of Borobudur or Prambanan Temples. At the Bahal III temple, some motifs are often used in batik or fabric.*

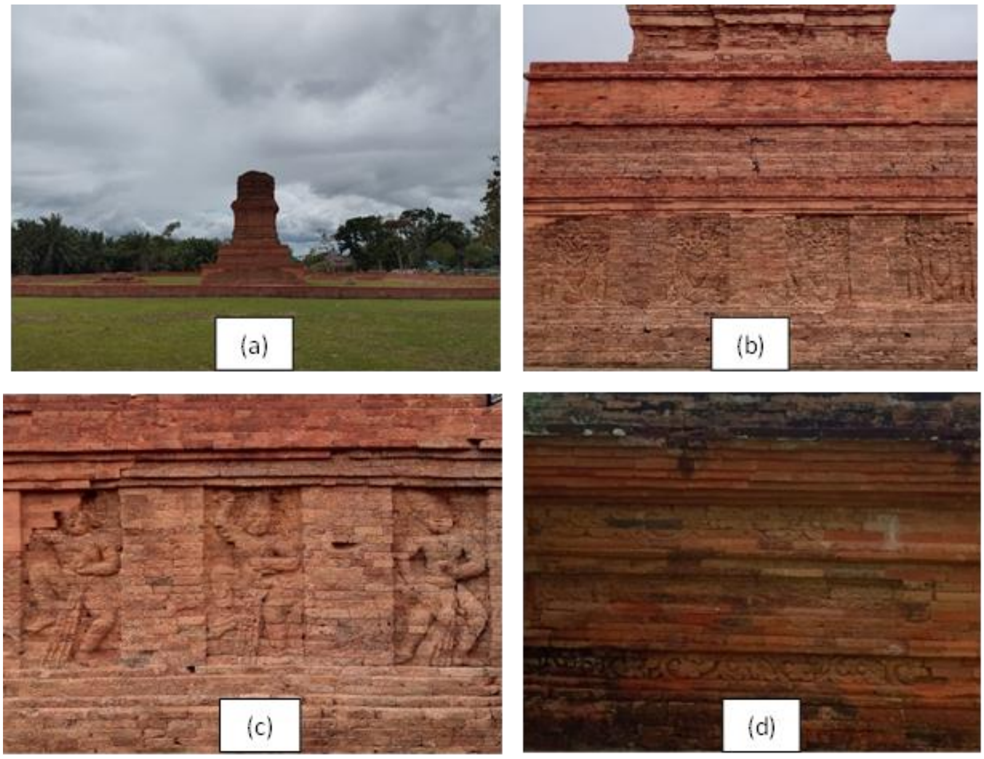

Figure 3. Several symmetrical or repetitive patterns in the ornaments of the portibi temple for (a) the right & left sides of the temple which are balanced, (b) carvings of animal figures on the walls of the temple, (c) carvings of dancing people on the walls of the temple, (d) symmetrical patterns on the foot of the temple

Interviews show that the ornaments of the Portibi Temple exhibit symmetrical and repetitive patterns, clearly visible in the building's layout and decoration. Symmetry is evident in the position of the main temple, which sits directly in the centre of the courtyard, with the left and right sides having similar shapes, creating a sense of balance and harmony. Repeating patterns are evident in the carvings at the temple's base, such as motifs of animal figures and dancing figures, which are characteristic of the ornaments at the Portibi Temple. This symmetry and repetition are aesthetic elements and part of the geometric principles often found in Hindu-Buddhist architecture [2], [27].

c. The meaning of the building form at Portibi Temple

Researcher	:	*Is there a meaning in the building forms in the Portibi Temple? Why does the body's shape have to be a cube?*
Speaker 1	:	*In my opinion, each form of the building has its meaning, and in the Portibi Temple, it must have its meaning and is not made carelessly. For example, the cube-shaped part of his body symbolises the human world or the natural world we live in. The shape of the cube was chosen because it is considered sturdy, stable, and balanced, so it is suitable as the main part of the sacred building.*

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Speaker 2 : *In my opinion, even though the shape is simpler than the big temples in Java, it is possible that the philosophy of the shape of the cube on the temple body can be interpreted so that the building looks sturdy, stable, and becomes the center of attention as well as a symbol of a place to live or an object of worship.*

Based on the interview results, the cube-like shape of the Portibi Temple has a philosophical meaning closely related to cultural beliefs and symbolism. The interviewees revealed that the cube shape symbolises the human world or natural habitat, chosen because of its sturdy, stable, and balanced nature, making it suitable as the main part of a sacred building. Furthermore, the cube shape is also seen as a symbol of the centre of attention and a place of residence or object of worship. This is in line with the findings of Jayanti & Puspasari [27] that every geometric shape in traditional architecture generally has a symbolic meaning rooted in the cultural and spiritual values of the local community.

3.2 Analysis of observation and documentation that

Based on the results of observations carried out by researchers, mathematical concepts found in the Portibi Temple include:

a. Cube

A cube is a three-dimensional geometric figure bounded by six congruent square faces. All edges of a cube are the same length. At the Portibi temple, researchers discovered several sections of the Bahal I, Bahal II, and Bahal III temples embody the mathematical concept of a cube, specifically within the main body of the main temple.

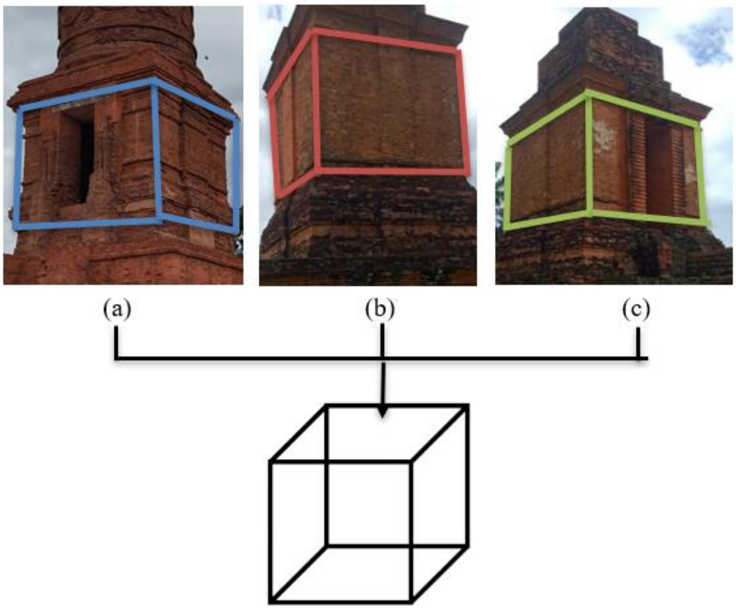

Figure 4. The mathematical concept of the cube space is found in the Bahal I, II, and III temples for (a), (b), and (c).

The images (a, b, c) above show the main body of the Portibi Temple, which resembles a cube, a geometric shape with six equal square sides, twelve equal edges, and eight corner points. This shape allows for precise geometric calculations such as surface area ($L = 6 \times s^2$) and volume ($V = s^3$). The sturdy, symmetrical, and balanced cube shape symbolizes the stability of human life on earth and is a link between the earth (base) and the sky or realm of the gods (top of the temple). This is in line with studies on Borobudur Temple, which also explain that the base, body, and peak represent a translation of cosmological concepts into the physical form of the building [28], [29], [30]. Within this framework, the cube at the temple's base is not merely a structural element but also has a symbolic meaning, as it symbolizes the stability of human life on earth and the starting point of the spiritual journey to a higher realm. Thus, the cube shape of the Portibi Temple embodies the fusion of spatial geometry, structural function, and cultural symbolism, all fused into a single architectural unit.

b. Tube/Cylinder

A cylinder is a three-dimensional geometric shape with two identical circles: a base and a top, and a rectangular covering covering both circles. A cylinder has three sides (two circles and one covering) and two edges (the circumference of the circles).

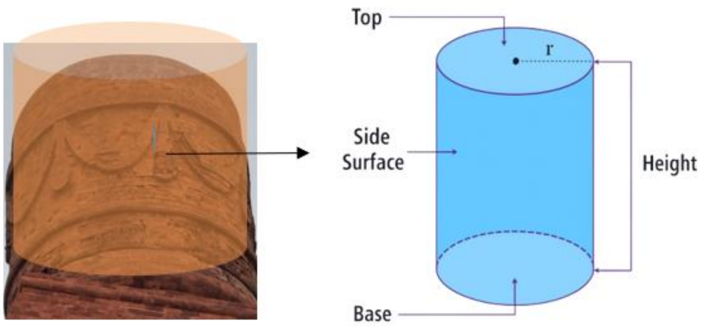

Figure 5. The mathematical concept of the cylindrical geometric shape is found in the Bahal I temple

In addition to the cube shape on the main body of the temple, the Portibi Temple also has other geometric elements that resemble a tube or cylinder, namely those found on the roof of the Bahal I temple, as in Figure 5. From a mathematical perspective, a tube/cylinder is a geometric shape with two parallel and congruent circular sides, and one curved side that connects the two. The mathematical calculation related to the cylinder is the surface area $L = (2\pi^2 + 2\pi rh)$ and volume $V = (\pi r^2 h)$ where r is the radius of the base and h is the height. Symbolically, the cylindrical shape of temples, especially stupas, represents a sacred vessel or virtues (Utami, 2021). The cylinder is also considered an embodiment of continuity and eternity due to its circular shape without corners, reflecting the life cycle in Hindu-Buddhist cosmology [31].

c. Rectangle and Trapezoid

A trapezoid is a two-dimensional plane figure belonging to the quadrilateral type. Its main characteristic is that it has exactly one pair of parallel sides. These parallel sides are called the bases of the trapezoid, while the other two sides are called the legs. Conversely, a

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rectangle is a two-dimensional plane figure with two pairs of parallel sides of equal length and four right angles (90 degrees). The longer side is called the length, and the shorter side is called the width. These rectangular and trapezoidal shapes are found on the main body of the temple, including the Bahal I, Bahal II, and Bahal III temples, as shown in images a, b, and c below.

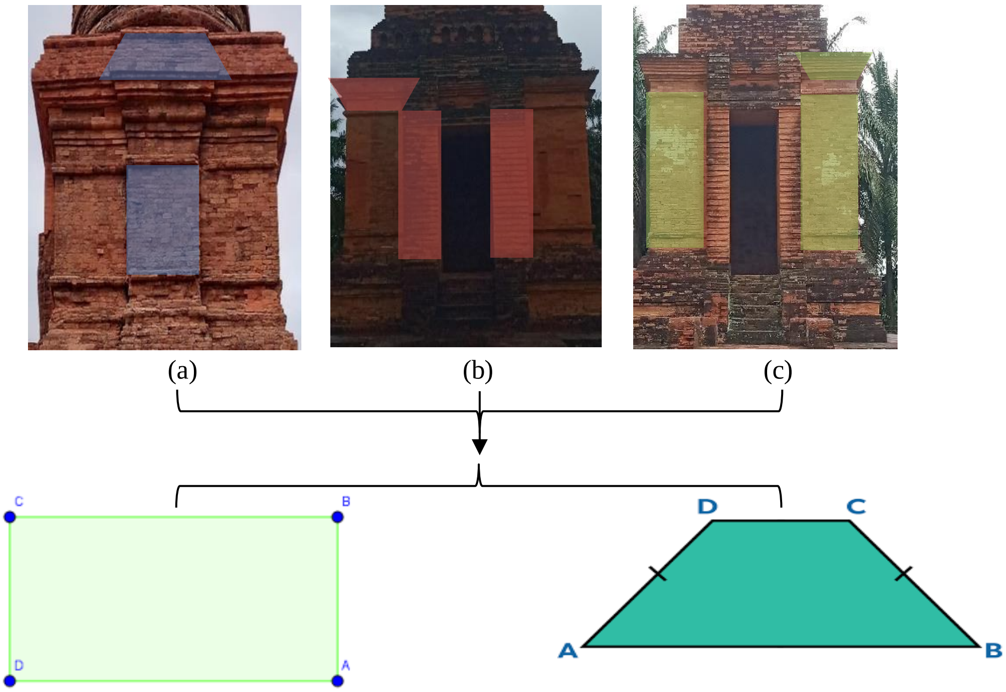

Figure 6.1. The geometric mathematical concept of the rectangle in Bahal Temples I, II, and III for (a), (b), and (c)

Figure 6.2. The geometric mathematical concept of the trapezoid in Bahal Temples I, II, and III for (a), (b), and (c)

According to Utami [32], the rectangular shape reflects the principles of proportionality and cosmological order. Meanwhile, in temple construction, the trapezoidal shape creates the optical illusion of stability. The wider lower part of the structure gives a solid impression, while the tapered upper part directs the view toward the summit.

d. Block

A cuboid is a three-dimensional geometric shape with three pairs of opposite sides in a rectangle, eight vertices, and twelve edges. At the Portibi Temple, the cuboid shape can be found in several parts of the building structure, namely the stairs leading to the temple monastery in both Bahal I, Bahal II, and Bahal III temples, and at the base or body of the temple in all three temples, which have an elongated shape with sharp corners. This structure usually supports the upper part of the temple to keep it stable. The following researchers show in images (a) and (b) that the Bahal I temple and the Bahal II and Bahal III temples also have the same shape as the image below.

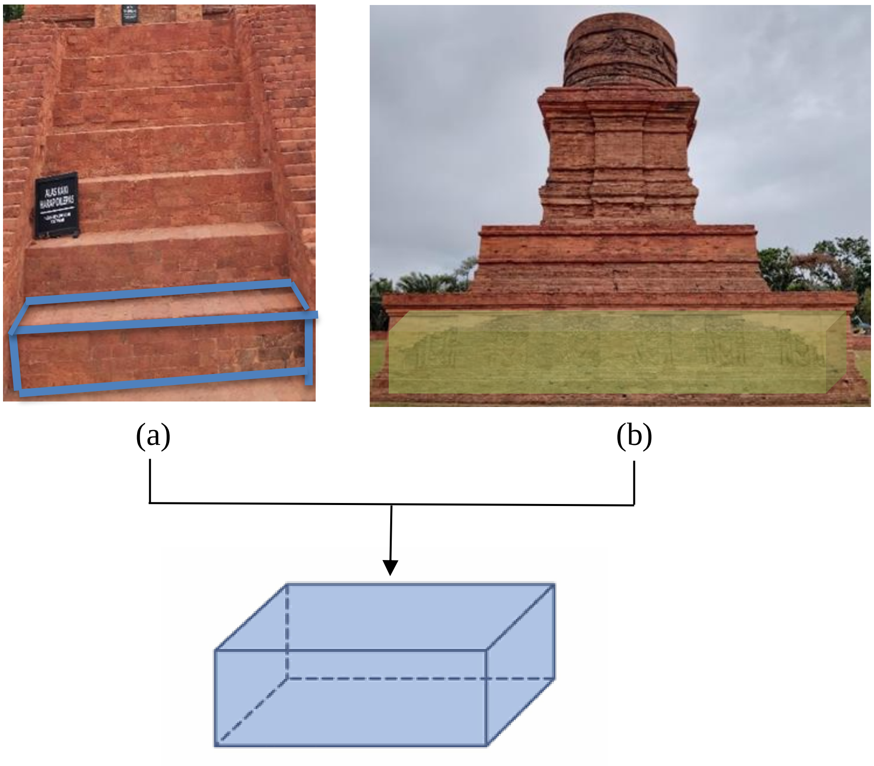

Figure 7. Mathematical concept of the cube geometry in the Bahal I, II, and III temples for (a) and (b)

The block shape of the temple body means that the concept of flat-sided spatial construction is used not only for structural functions but also contains symbols of strength and stability in the cultural views of the community in its construction [33].

e. Square Pyramid

A rectangular pyramid is a three-dimensional geometric shape that has a square or rectangular base and four triangular sides that meet at a point. This shape has 5 sides, 8 edges, and 5 corner points. At the Portibi Temple, the rectangular pyramid shape can be found inside the temple room, which, when seen from the entrance, looks like a cube, but if we go inside, we can see that the actual shape inside the temple room is a rectangular pyramid, as shown in Figure 8 below. This shape is also commonly found on the roof or peak of the temple; this part is usually made to taper upwards as a symbol of the connection between the human world and the spiritual world, which is a characteristic of temple architecture in Indonesia. A study on the Untoroyono Temple by Issabella and Hadiprasetyo [34] revealed the presence of a "pyramid" shape, which in this context can be interpreted as a rectangular pyramid, showing similarities in architectural patterns across regions. Furthermore, research by Ramadhiyani and Mariana [35] on the Dermo Temple also confirmed the presence of rectangular pyramids alongside cuboids, cylinders, and triangular prisms. These facts reinforce the understanding that the presence of rectangular pyramids in the temple is not simply a choice of shape, but rather part of the application of geometric principles with structural, aesthetic, and symbolic value relevant to ethnomathematics-based learning.

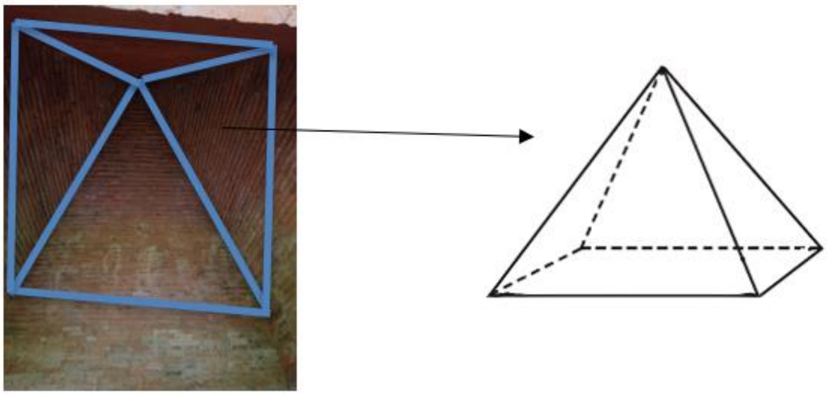

Figure 8. Mathematical concept of the rectangular pyramid geometry in the interior of the Bahal I, II, and III temples

In this study, it can be seen that in the architecture of the portibi temple building, there is ethnomathematics, one of which is the concept of spatial and flat shapes. The mathematical concept of spatial shapes has several parts, namely the cube in the main building of the temple (main temple), the tube/cylinder in the roof of the temple, the beam in the stairs of the temple monastery and the base of the temple body as well as the rectangular pyramid in the interior of the monastery room. There is a mathematical concept of flat shapes, namely rectangles and trapezoids, in the body of the temple (main temple) front/back view found in the Bahal I, Bahal II, and Bahal III temples.

Based on the research results, it can be concluded that the Portibi Temple not only serves as a place of worship and cultural heritage, but also represents the creative work of the Hindu-Buddhist community, who have applied the principles of geometry and mathematical measurements in a mature manner in its design. Geometric forms such as cubes, blocks, tubes/cylinders, rectangular pyramids, rectangles, and trapezoids found in the temple architecture not only have a structural function, but are also rich in symbolic meaning that reflects the cultural philosophy of its time.

This aligns with Nursahadah's [20] opinion, which states that the geometric shapes at Portibi Temple can be used as a resource for culturally based mathematics learning. Jayanti and Puspasari [27] also emphasised that integrating cultural elements into mathematics learning can improve students' relevance and understanding of geometric concepts. Safitri's [2] research supports this view by stating that ethnomathematics can link mathematics with local cultural values, making learning more contextual and meaningful. Similarly, Yusnizar and Yahfizham [4] emphasised that introducing mathematical elements in cultural objects enriches understanding of mathematical concepts and fosters a sense of pride in cultural identity. Thus, Portibi Temple has great potential as a medium for contextual mathematics learning through an ethnomathematics approach.

4. CONCLUSION

This research confirms that Portibi Temple's architecture contains geometric concepts with mathematical and symbolic value. This finding opens practical opportunities for teachers to use the temple as a contextual learning resource. Teachers can design learning activities that link the cube, cuboid, cylinder, rectangular pyramid, rectangle, and trapezoid shapes in the temple with geometry material in the classroom. For example, students can be invited to calculate the area and volume of geometric shapes while discussing their philosophical meaning in Hindu-Buddhist culture. To strengthen the learning experience, developing an ethnomathematics module based on the Portibi Temple is highly recommended, so that students receive systematic guidance that combines geometric concepts with local cultural values.

Furthermore, field trips to the temple site can be an effective learning strategy, as they provide direct experience in observing, measuring, and analysing geometric shapes. Further research is needed to develop interactive learning media, evaluate the effectiveness of using cultural sites in improving mathematical understanding, and expand the study to other temples in North Sumatra. With this step, cultural heritage is preserved and integrated into mathematics education as an authentic, contextual, and meaningful learning resource for students.

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