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ETHNOMATHEMATICAL EXPLORATION OF CETHO TEMPLE ON THE TOPIC OF PLANE FIGURES FOR ELEMENTARY SCHOOL

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Abstract: Education and culture that exist in everyday life are closely related. In order to bridge the gap between culture and education, especially mathematics education, there is ethnomathematics. The existence of mathematics is inherent in everyday life, but many people are not aware of it. Examples of daily activities that contain elements of mathematics are calculating the price of groceries, and calculating the area and volume of certain buildings. The purpose of this study is to explore and describe the ethnomathematics of Cetho Temple and to examine the plane figures related to the basic competencies of fourth grade mathematics learning for elementary school students. This type of research is descriptive qualitative with data collection methods using observation, interviews, and documentation. Data analysis activities started from the instrument validation test, reduction, data presentation, and drawing conclusions. Triangulation technique was used to reduce bias during data analysis. The results showed that at Cetho Temple there was a geometric concept. The part of the temple that contains the concept of geometry, namely the statues, reliefs, and other important parts. The concept of geometry consists of the concept of the plane figures, spatial, polygonal, similar, and reflection. Based on these findings, the study focused on the flat structure material related to the basic competencies of fourth grade mathematics learning for elementary school students.

Keywords: Ethnomathematics, Cetho Temple, geometry, elementary mathematics, basic competence

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INTRODUCTION

Mathematics is derived from the Greek word *Mathematike* which means to study. Mathematics is closely related to thinking or reasoning activities, so it is known as an exact science (Agustiningsih, Sugiarti, & Hartanto, 2018). Suhendri (2011) states that mathematics is a discipline that focuses on shapes, numbers, relationships among concepts, and the logic of using symbols. Mathematics is an effort to solve problems in

daily life. It is also a cultural product that comes from social humanitarian activities. Moreover, all societies practice mathematics that is considered culturally appropriate for their lives (Tiurlina, Supriadi, & Arisetyawan, 2016). Wulandari & Puspadewi (2016) argue that mathematical paradigms are used as tools and thinking skills to develop a culture into the superior one.

Almost all daily activities involve mathematics, for example in calculating grocery prices and measuring the volume of water tubs. Mathematics is inherent in life, but somehow it is not realized by many people. Even in the learning process at school, students also find it difficult to work on questions that are actually adapted to their daily lives. Students always think that mathematics is difficult, not fun, and even scary (Mulhamah, 2018). These assumptions make students feel unhappy while learning mathematics. In learning mathematics, students are supposed to associate concepts with cultures existing around students. The process of associating mathematic concepts and cultures is commonly known as ethnomathematics.

Ethnomathematics emerges through reasoning mathematics systems and understanding cultures (Andriani, Siska, & Septiani, 2020). Associating culture with mathematics concepts will make it easier to understand concepts that are considered absurd. One of the cultures that can be used in learning mathematics is Cetho temple which is located in Indonesia. This temple was investigated in this study because there were no studies focusing on the temple from the perspective of mathematics learning. Studies related to temples are usually in the fields of history, archeology, geography, and economics.

Research on ethnomathematics is not new because researchers especially those from Indonesia have conducted research on ethnomathematics. Setiana, Ayuningtyas, Wijayanto, & Betty (2021) studied the representation of ethnomathematics in Yogyakarta palace. It was found that plane shapes, symmetry, tessellation, and volumes of three-dimensional shapes are represented by objects around the palace. The findings can be integrated into mathematics learning. Yudianto et al. (2021) conducted ethnomathematics research at Jami' Al-Baitul Amien Mosque. The study found that two-dimensional shapes (trapezoids and circles), three-dimensional shapes (pentagonal pyramids, cones, tubes, spheres), reflection, and congruence can be learned from objects around the mosque. The findings were also made as a test. A cultural product, Malangan mask, was studied by Muchlas & Nisa (2019). They found that reflections on facial shapes and carvings on masks could be used as learning media in schools. Therefore, there is a need to preserve cultural products while learning mathematics.

For the sake of novelty, the researchers tried to investigate mathematical aspects presented by Cetho Temple which is located in Cetho village, Jenawi district, Karanganyar regency, Central Java, Indonesia. By exploring Cetho Temple from a mathematics standpoint, students can then link the learning materials with cultures existing in their environment, and there will also be more mathematics learning sources. Based on the stated background, the researchers tried to explore and describe ethnomathematics shown by the temple to learn plane shapes in the fourth grade of elementary school.

METHOD

This qualitative descriptive study employed the ethnography approach. Descriptive research describes the phenomenon being studied and does not attempt to draw conclusions about the general population (Sugiyono, 2019). This research presents words or sentences for describing phenomena as they are, without being manipulated, and it is developing naturally. The ethnographic approach is used because the researcher tries to see everything and focuses on mathematics that exists in the surrounding cultural practices (Kuntoro, Suyata, & Sukardi, 2015). This research was conducted in Cetho village, Jenawi district, Karanganyar regency, Central Java, Indonesia.

In this study, the researchers collected data through observation, interviews, and documentation. The observation was conducted to deeply explore whether there is a mathematical element related to the concept of Geometry. Meanwhile, the interviews were done to analyze the results of the observation. The interviews were done with *pemangku adat* (a village elder trusted to lead the tradition) in Candi Cetho and the staff of a conservatory, namely Cultural Heritage Management Office of Central Java. The documentation used as proof and support for the arguments is in the form of objects and transcripts of the interviews done. In addition, a literature study on the history of Cetho temple relics was done. The researchers believed that there had been no previous research that explored Cetho temple from the point of mathematics learning because most researchers studied the temple from economic, archeological, historical, and geographical perspectives. Besides, other researchers had not investigated the findings based on the basic competencies of mathematics for fourth-grade students of elementary school.

The stages in this research were selecting the topic/focusing on the problems, developing observation and interview guidelines, and validating the instruments to two lecturers whose expertise is ethnomathematics and language structure. The validation score is 2.93 (in the range of 0-3), so the instrument developed is considered valid. The observation guideline was used by two observers, and the interview guideline was used by two interviewees. The research findings were then condensed, analyzed, and systematically arranged into a descriptive text. Then, the last step is conclusion drawing (Sugiyono, 2019). The results of the study that is related to ethnomathematics and are presented in the descriptive qualitative explanation.

RESULT AND DISCUSSION

The result and discussion of this study were focused on mathematics elements found in Cetho temple and their association with basic competencies of Mathematics for fourth-grade students of elementary school. This part of the present article shows two aspects, namely ethnomathematics in Cetho temple and the integration of two-dimensional shapes that are related to the basic competencies of mathematics learning in elementary school and some questions.

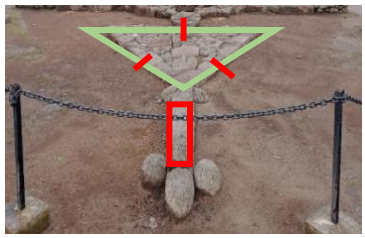
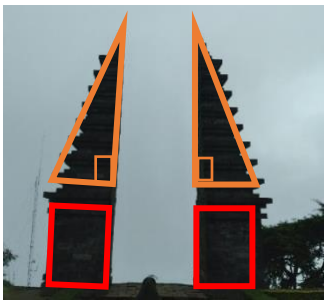
Ethnomatics in Cetho Temple

This research focused on exploring the area of reliefs and other important objects of the temple. In Cetho temple, there are concepts of two-dimensional shapes, three-dimensional shapes, polygons, congruences, and reflections.

The Concepts of Two-dimensional Shapes

Based on the observation and interview with *pemangku adat* and conservatory staff, data related to Cetho temple were obtained, and it was found that there are concepts of two-dimensional shapes in it. The length and width of the two-dimensional shapes are bounded by straight or curved lines, so it has a circumference and area called a plane shape (Alfarisi, Prihandini, & Dafik, 2018). Some examples of the plane shape concept are presented in Table 1.

Table 1. Examples of plane shapes found in the temple

Object	Description	Image
Garudeya	The geometric shapes shown by the temple are circles, rectangles, and equilateral triangles.	
Lingga-Yoni	There are equilateral triangles, rectangles, and circles.	
Surya Majapahit	Surya Majapahit resembles a circle.	
Gapura/Gate	The plane shapes shown by the temple gates are triangles and rectangles.	

After the observation, the researcher interviewed *pemangku adat* (S1) and conservatory staff. The excerpt from the interview is presented below.

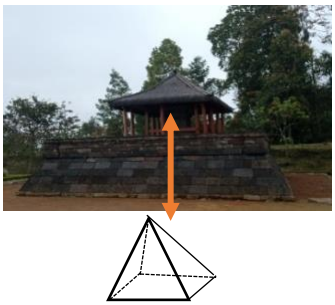
P1027 : The relief panels?
S1027 : Yes. The relief panels show that Garudeya and Lingga Yoni are triangles in shape.
P1028 : Lingga Yoni shape?
S1028 : Yes, its' form. According to the archaeologist, it shows the year the temple was built. "*Welut Wiku Anahut Iku*" means 1373.

Based on the results of the interviews and observations, it can be concluded that there are various plane shapes found in the reliefs and parts of the temple. The reliefs are Sudamala and Sengkalan (showing how the temple was built). Parts of the temple showing the plane shapes are Mandala Utama, the statue of King Brawijaya V, the statue of Sabdo Palon Naya Genggong, Pendopo/Javanese Gazebo, Petilasan (sites of ruins) Ki Ageng Krincingwesi, Lingga Yoni, Garudeya, Surya Majapahit, and Bentar gate. The concepts of plane shapes in reliefs and temples are rectangles, circles, trapezoids, equilateral triangles, and right triangles.

The Concept of Three-dimensional Shapes

Based on the observation and interviews with *pemangku adat* and conservatory staff, data about the concept of three-dimensional shapes were collected. It was found that the shapes have plane surfaces, edges, and vertexes that limit each other (Alfarisi, et al, 2018: 108). The following are examples of the three-dimensional shape concepts shown by the Table 2.

Table 2. Examples of three-dimensional shapes found in the temple

Object	Description	Image
Petilasan Ki Ageng Krincingwesi	The *joglo* house is made of palm fiber with a pyramidal roof shape (Joglo Ceblokan) and *petilasan* is made of rectangular stone piles that form a three-dimensional block shape.	
Terrace Stairs	The pile of rectangular stones forms a three-dimensional shape, called square prims.	

After the observation was carried out, interviews were done with pemangku adat (S1) and conservatory staff (S2). Based on the results of observations and interviews, it was found that there are three-dimensional concepts in Cetho temple. This is evidenced by the data obtained during observation and confirmed by S1 during the interview process. S1 said that Petilasan Ki Ageng Krincingwesi was designed based on Joglo Ceblokan in which the roof shape is a rectangular pyramid. S1 also said that the stairs on each terrace show rectangular, so the stairs resemble rectangle prisms. Therefore, Cetho temple shows geometric shapes, namely rectangular pyramids and rectangle prisms.

The Concepts of Polygon

The concepts of multidimensional shapes found in this study are regular polygon, irregular polygon, and non-polygon. The explanation of each finding is presented as follows.

The Concepts of Regular and Irregular Polygons

The concept of a regular polygon can be indicated from equal sides, regularity, and equal angles. Meanwhile, the concept of an irregular polygon shows sides that are different in length, regularity, and different angles. Some examples of the concept of regular polygons and irregular polygons are shown in Table 3.

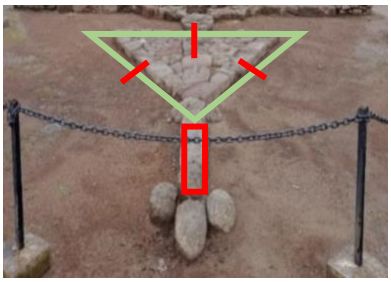
After the observation, the next stage was conducting interviews with pemangku adat (S1) and conservatory staff (S2) in Cetho temple. The excerpt of the questions and answers during the interviews is presented below.

P1005 : Mandala Utama is the last terrace or the thirteenth, but what is the shape?
S1005 : It is a rectangle, but the irregular one.
P2051 : What is it like, Sir? Is it a polygon?
S2051 : The circle is irregular, but the triangle is a regular polygon.

Based on the results of observations and interviews conducted by researchers with S1 and S2, it was found that in Cetho temple there is a concept of regular and irregular polygons. The concept of a regular polygon is found in Yoni and Gupala sites in Mandala Utama. The plane shape which is a regular polygon in Yoni and the location of the Gupala in the Mandala Utama is an equilateral triangle. *Gupala* is placed above Mandala Utama to function as decoration and as a fuse of Hinduism. The concept of irregular polygonal shape also exists in Cetho temple, where the concept is found in statues, reliefs, pavilions, gates, *Linga*, *Garudeya*, and *Mandala Utama*. The shape of the building is a rectangle, trapezoid, and right triangle which has unequal sides and unequal angles.

Table 3. Examples of regular and irregular polygons found in the temple

Object	Description	Image
Statue	The back part of Prabu Brawijaya statue is rectangular, and it is an irregular polygon.	

Object	Description	Image
Relief on the gate and Sundamala relief	The relief inscribed with the year the temple was built is written on a rectangular wall. A rectangle belongs to irregular polygons.	 
Lingga-Yoni	The rectangle found on Lingga is an irregular polygon, and the equilateral triangle on Yoni is a regular polygon. Meanwhile, the circle is obviously not a polygon.	
Mandala Utama	The flat shapes in the image are rectangles, equilateral triangles, and trapezoids. *Gupala* is equilateral triangle in shape and belongs to regular polygons.	

The Concepts of Non-polygon Shape

The concept of non-polygon shapes was also found during the process of observation and interviews conducted by researchers. The following are examples of the findings obtained from the observation shown by the Table 4.

Based on the results of observations and interviews by researchers, it was found that there is a non-polygonal shape concept found in the temple. This is evidenced by the data obtained during the observation and supported by S1 and S2 as research participants during the interview process. The part of Cetho temple which contains the non-polygonal concepts are Surya Majapahit, Garudeya, Lingga, and the statue of Nyai Agni. Then, the non-polygonal concept found in Cetho Temple is a circular flat shape.

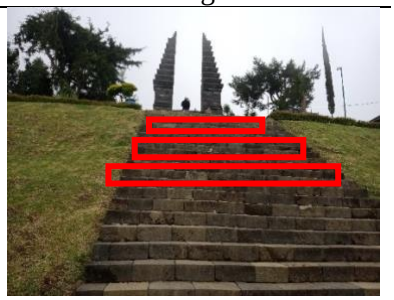
Table 4. Examples of non-polygon shapes found in the temple

Object	Description	Image
Lingga-Yoni	There are equilateral triangles, rectangles, and circles. Circle is not a polygon.	
Surya Majapahit	The shape of Surya Majapahit is a circle. Circle is not a polygon.	
Arca	There is a circle shape on the earring of the Nyai Agni statue. Circle is not a polygon.	

Congruence

Based on the obtained data, there is a concept of congruence in Cetho temple. Two figures are said to be congruent if they have the same shape, but the size does not need to be the same (Siswono & Lastiningsih, 2017). Some examples of the concept of similarity are presented in Table 5.

Table 5. Example of congruence concepts

Object	Description	Image
Terrace	The rectangular shape of the ladder is getting smaller when it is put higher.	

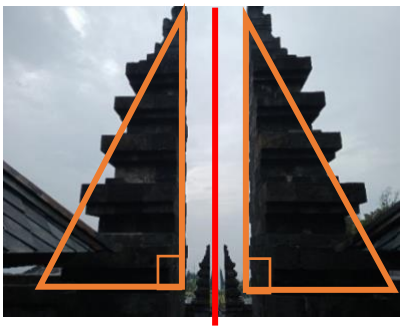
Object	Description	Image
Petilasan Ki Ageng Krincingwesi	The plane shape in the figure is a rectangle. The shape is getting smaller when it is put lower.	

Based on the interview with S1 who explained that there is a concept of congruence in Cetho temple because the temple itself is on the slopes of Mount Lawu. It is not centered, but the design is made in steps to adjust the contours of the land. Meanwhile, S2 explained that there is a concept of congruence in Cetho temple, and it can be found in the ruined site of Ki Ageng Krincingwesi. It is said to contain the concept of congruence because it has the same shapes (rectangles in different sizes).

Reflection

Based on the result of observation and interview, it was found that the temple also shows the concept of reflection. Overall, the temple has a symmetrical shape on both its right and left sides. Some examples of the reflection concepts are presented in Table 6.

Table 6. Example of reflection concepts

Object	Description	Image
Garudeya	When the vertical line is drawn between both spaces, it looks symmetrical.	
Gapura	The right and left sides of the gate are symmetrical.	

Based on the interviews with S1, it was obtained that there is a reflection concept in Cetho temple gate where the right and left sides complement each other. The second interviewee also said that some parts of the temple show symmetrical shapes on both the right and left sides. The concept of reflection is shown by the temple gate and Garudeya when they are equally divided vertically in two. They will show shapes of the same size.

The concept of plane shape was analyzed and integrated in accordance with the basic competence of mathematics learning for fourth-grade students at elementary school. The students learned about rectangles, triangles, circles, and trapezoids. Those plane shapes were then integrated into the basic competencies shown in the Table 7.

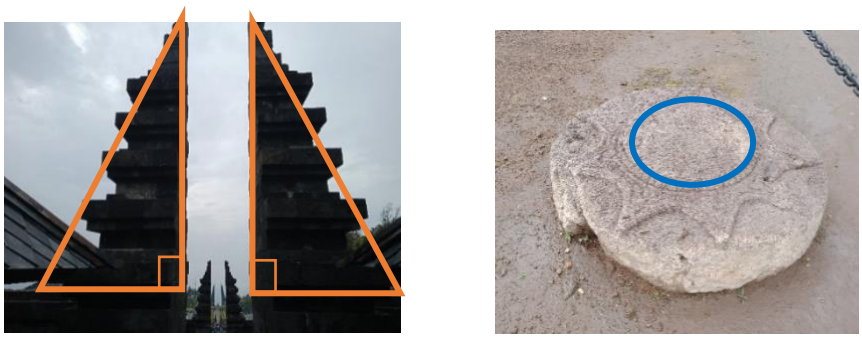
Table 7. Mathematics basic competencies for the fourth-grade students

Class		Basic Competences
	3.5	Identifying irregular and regular polygons that form Tessellation from the observation
	3.6	Identifying right angles based on the observation and comparing the result with other angles
	3.9	Understanding the width of triangles, squares, and rectangles
	3.10	Determining the connection among the attributes of measurement, units including the perimeter, and area of a rectangle
IV	4.2	Performing tessellation with regular polygons
	4.4	Breaking down and rearranging simple geometric grids
	4.5	Creating three geometrical nets that have never been made before
	4.6	Making an object based on the geometrical nets by recycling items found around schools, playgrounds, or their houses
	4.16	Representing an obtuse angle and an acute angle on a flat shape
	4.17	Combining the interior angles of the quadrilateral and triangle to draw a conclusion

Source: (Notodipuro, 2013)

The plane shapes found in the temple can be integrated into Basic Competencies (BC) 3.6; 3.9; 3.10; 4.16; and 4.17. In Basic Competencies 3.6, namely Identifying right angles based on the observation and comparing the result with other angles, the teacher can conduct mathematics learning while visiting and observing the temple. Then, she may ask the students to compare the angles made by Gapura Bentar (right triangle in shape) and the angles made by Yoni that are located on the seventh terrace of the temple (equilateral triangle in shape). This observation may help students identify directly the difference between right angles and other angles using concrete objects. An example of the implementation of Basic Competencies 3.6 in a math question is presented below.

> *"Rudi looked at the Gapura Bentar Padu Raksa and Surya Majapahit (Figure 1). At the moment, Rudi concluded that the site was right triangle and circle in shape. Based on the angle, what is the difference in the angle between the gate and the Surya Majapahit statue? What is the size of the angle on the parts of the temple?"*



(a) (b)

Figure 1. Bentar Padu Raksa Gate (a) and Surya Majapahit Sculpture (b)

Basic Competencies 3.9 (understanding the width of triangles, squares, and rectangles) and 3.10 (determining the connection among the attributes of measurement, units including the perimeter, and area of a rectangle) can be taught by introducing the shape circumference using non-standard units. There is a staircase on the terrace at the temple which is rectangular in shape. The teacher instructs students to make observations and then asks them to do an experiment (walking on the edge of the stairs while counting the number of rocks arranged on the edges only). Through this activity, students will find the learning activities fun and easy to understand because they experience the learning process directly. Examples of questions related to Basic Competencies 3.9 and 3.10 are presented below.

> *"On Sunday, Adi visited Cetho Temple to pray. At that time, Pak Mangku Hari was also praying. After praying, Adi had a talk with Pak Mangku, and he talked about the Petilasan of Ki Ageng Krincingwesi (Figure 2). Mr. Mangku Heri said that the petilasan stone was in the shape of a rectangle with a length of 60 cm and a width of 10 cm. At that time, Adi thought about the wide of the stone and its circumference"*

Figure 2. Petilasan Ki Ageng Krincingwesi

Basic Competencies 3.5 is identifying irregular and regular polygons that form tessellation from the observation while Basic Competencies 4.2 is performing tessellation with regular polygons. Both Basic Competencies show that the teacher can introduce polygons, non-polygons, and types of polygons. Through observation at Cetho temple, the teacher can also introduce the concept of circles by showing Lingga, Surya Majapahit, and jewelry in Nyai Agni statue. The teacher may also tell why they are categorized as non-polygons by describing the characteristics of the shape.

Then, the teacher may introduce the concept of polygonal shapes presented by Cetho temple from the statues of Gupala on the Mandala Utama and Yoni on the seventh terrace that looks like an equilateral triangle. In addition, students may check the shapes based on the side lengths and conclude whether the statue is correctly categorized as a regular polygon. Experimental activities carried out by students can also be applied in class when students observe the shape of the tiles on the classroom floor in order to combine the tiles to form new plane shapes.

To teach Basic Competencies 3.5 and 4.2, the teacher and students may carry out observation activities at Cetho temple and then determine which shapes belong to irregular polygons. By doing such an activity, the teacher may direct the students to identify the plane shapes of rectangles, trapezoids, and right-angled triangles in the gate, *Lingga*, pavilion roof, Mandala Utama, Garudeya, and Sudamala reliefs. The students should learn that those objects belong to irregular polygons because their sides are not in the same lengths and angles are not in the same degrees. The teacher can also ask the students to identify certain objects and measure them using unstandardized-measurement units, such as footsteps and hands. The example of the application of Basic Competencies 3.9 and 3.10 in math questions for fourth-grade students are presented below.

> "Fourth-grade students had a field trip at Cetho Temple on July 21, 2022. After the trip, Mrs. Ana, their teacher, asked them to do an exercise on identifying polygons in Cetho temple. Please help the students match the picture with the description."

Segi banyak beraturan

Segi banyak tidak beraturan

bukan segi banyak

After matching the pictures with the descriptions, answer the following questions.

a. *How do you identify regular polygons? What are the characteristics?*
b. *How do you identify irregular polygons? What are the characteristics?*

Based on the observation and experiment done in Cetho temple, teachers may ask students to make a visit report containing things they can learn in the temple. Besides, the students may be asked to present about obtuse angles and acute angles on flat shapes found in Cetho temple. This activity is to learn Basic Competencies 4.6. Then, based on the results of the presentations made by the students, the teacher can ask them to combine the inside of a triangle (two or more triangles) to obtain a new rectangular shape such as rectangles, squares, trapezoids, etc. This activity is to learn Basic Competencies 4.17.

CONCLUSION

Students can learn about the mathematical concept of geometry in Cetho temple. Geometry is related to the concepts of plane shapes (rectangles, circular trapezoids, equilateral triangles, and right triangles), three-dimensional shapes (rectangle pyramids and beams), regular polygons (equilateral triangles), irregular polygons (rectangle, trapezoid, and right triangle), non-polygons (circle), congruence (rectangles of different sizes), and reflection (two right triangles and two symmetrical rectangles). The shapes can be found on statues, reliefs, *petilasan* Ki Ageng Krincingwesi, *Gapura Bentar*, *Garudeya*, *Lingga-Yoni*, pavilion, and *Mandala Utama*. The geometrical concepts can be further analyzed in accordance with the basic competencies for fourth-grade students at elementary school. Based on this current study's findings, it is suggested other researchers further explore objects in Cetho temple and use the findings to develop supporting learning materials for fourth-grade students to learn problem-solving on plane shapes and polygons.

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