Ethnomathematics Journal
Volume 3, No. 2, September 2022 (51-61)
Online: http://journal.uny.ac.id/index.php/ethnomath

ETHNOMATEMATICS OF GEOMETRY SHAPE IN THE GEDONGSONGO TEMPLE

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Abstract: The objective of the study is to explore and find out the ethnomathematics of Gedongsongo Temple, located in Central Java, Indoensia. The type of study is qualitative with an exploration way and ethnographic approach. The data obtained in the form of qualitative data, the source of research data obtained through observation, interviews, documentation, and study of literature related to Gedongsongo Temple. The data collection technique was done by questioning, observing, interviewing, and documenting. The results showed that the ethnomathematics of Gedongsongo Temple has the potential to be integrated into mathematics learning. Ethnomathematics that can be integrated includes the concept of flat area, volume of space, comparison/ratio, reflection, and symmetry. The flat-geometry concept is found in the several parts of Gedongsongo Temple including square, rectangle, triangle, and trapezoid. The spatial-geometry concept is also found in several parts of Gedongsongo Temple including cubes, blocks, tubes, and a triangle prism. Meanwhile, the comparison/ratio concept found is the Golden Ratio on the fore-temple of Perwara in the area of Candi Gedong III. The symmetry and reflection concept is found in Candi Gedong I. These concepts can be applied in mathematics learning as a contextual geometry problem as well as a way of introducing cultural elements to students.

Keywords: Geometry, ethnomatematics, Gedongsongo temple

How to cite:

Khasanah, U., Murtianto, Y.H., & Kartinah, K. (2022). Ethnomathematics of geometry shape in the Gedongsongo Temple. *Ethnomathematics Journal*, 3(2), 51-61. http://dx.doi.org/10.21831/ej.v3i2.52696

INTRODUCTION

Learning Mathematics is regarded as a very boring subject so students' attention to mathematics is not as intensive as to other subjects. Students' interest in learning mathematics is very low, so there is a need for contextual learning that can bridge students' understanding. Learning mathematics should be carried out by developing innovations, so it can help students learn. One of the efforts is by introducing culture to students. The cultural diversity that exists in Indonesia can certainly become a learning medium, especially learning mathematics which has a close relationship with culture.

According to Ahmadi (2003), culture is the result of the human mind or reason to achieve perfection in life. Culture is a human creation that takes place in life (Akkase, 2017). Meanwhile, Mathematics in cultural elements is the right bridge to creating mathematics learning. Mathematics is realized because of human activities (Soedjadi, 2007). Mathematics also supports maintaining and transmitting cultural traditions (Nida, Buchori, & Murtianto, 2017). Gilsdorf explains that mathematical concepts are generated from a particular culture (Gilsdorf, 2012).

The approach that links mathematics and culture is often referred to as ethnomathematics. According to Rosa & Orey (2007), the ethnomathematics approach is presented as a cultural response to the needs of students by making connections between cultural background and mathematics. This approach supports the view that mathematics is understood as a cultural product that has been developed as a result of various activities (Bishop et al., 1993). Ethnomathematics is a science that links culture and mathematics, which is expected to increase students' interest in culture, and students can know the functions and uses of mathematics from a cultural perspective (Kencanawaty & Irawan, 2017). Ethnomathematics integrates mathematical practices historically developed in different cultures and proposes a multicultural approach to education (Massarwe, Verner, & Bshouty, 2010). Therefore, many studies that link between mathematics and culture were widely carried out. *"The term requires a dynamic interpretation because it describes concepts that are themselves neither rigid nor singular-namely, ethno and mathematics"* D'Ambrosio (Marsigit, 2016).

The term ethno describes all the things that make up the cultural identity of a group namely language, codes, values, jargon, beliefs, food and clothing, habits, and physical characteristics. Meanwhile, mathematics includes a broad view of playing activities, designing activities, locating activities, counting activities, measuring activities, and explaining activities. *Mathematical questions can be created in stages which include exploring and recalling: facts, principles, and concepts, practicing exercises and skills, solving problems, and investigating* (Rasiman, Prasetyowati, & Kartinah, 2020). Ethnomathematics serves to express the relationship between culture and mathematics. Thus, ethnomathematics is a science that is used to understand how mathematics is adapted from a culture (Haza'a, Dyatriningrum, & Ngathoillah, 2004).

The development of ethnomathematics-based learning can be started by identifying ethnomathematics objects. One of the learning resources that can be explored from an interesting ethnomathematics point of view is Gedongsongo Temple. It is located on Jalan Kyai Bidayah RT 03 RW 09 Dusun Darum, Candi Village in Bandungan District, Semarang Regency, Central Java Province. This complex was built on a hill with an area of 230,161,590 m^2. Gedongsongo Temple is a group of Hindu temples. This can be seen from the statues and reliefs that occupy the niches of the temple building, such as the statues of Ciwa Mahadewa, Ciwa Mahaguru, Ganeca, Durga Mahisasuramardhini, Nadiswara, Mahakala, and Yoni found in the temple chamber. The features of Gedongsongo Temple include a statue of an elephant in a squatting position (njerum: Javanese) at the foot of Gedong III, and a *yoni* in a rectangular shape in the chamber of Gedong I (Hariyanto, 2011).

Of the nine intact temples, only five remain, while the other four are in the form of foundations and ruins of buildings. The five groups of buildings that still stand are scattered, starting from Group one or Gedong I which is located at the bottom, and ending with Group five or Gedong V which is located at the top. All temples consist of three parts, namely the lower part (the base of the temple) which describes the human realm, the middle part of the temple (the body of the temple) describing the realm that connects the human realm and the divine realm, and the upper part (top of the temple) which describes the realm of the gods (Rahma, 2007).

So far no research had been carried out to explore ethnomathematics values at Gedongsongo Temple, so researchers were trying to identify the ethnomathematics values found at Gedongsongo Temple and their potential for integration in learning mathematics. The ethnomathematics values at Gedongsongo Temple are mathematics learning in which cultural elements are embedded in the temple, both in the development of learning instruments and in the learning process. These cultural elements can be acculturated with mathematical concepts, one of which is geometry. Research that has been conducted by Sumiyati, Netriwati, & Rakhmawati (2018) shows that ethnomathematics-based geometry learning has a positive impact on student's critical thinking skills. This is in line with research (Suhartini & Martyanti, 2017) which shows that one of the improvements in students' critical thinking skills in geometry material is influenced by ethnomathematics-based learning. This is reinforced by Putra, Wijayanto, & Widodo (2020) who also revealed that learning flat shapes with a mathematical approach can have a creative impact on students. Regarding the urgency of the research and the research findings on ethnomathematics-based geometry, the researcher intended to study the ethnomathematics of the Gedongsongo temple from the geometry perspective.

METHOD

This was qualitative research using an ethnographic method. Creswell (2013) mentions that qualitative research with the ethnographic method can be used to explore and understand the meanings that some individuals or groups of people ascribe to social or humanitarian issues. The researchers conducted a study of culture in natural conditions through the process of observation, survey, and interviews. The ethnographic method discusses the activities carried out by the community and interprets these activities.

Using the ethnographic method, the researcher analyzed the description level. The research was conducted at Gedongsongo Temple, located in Candi Village, Bandungan District, Semarang Regency, Central Java Province. A total of 26 research subjects consisted of one of the managers of Gedongsongo Temple, namely the Cultural Heritage Preservation Center of Central Java Province, and 25 visitors to Gedongsongo Temple. The data collection was carried out in natural settings (natural conditions). The primary data sources and observation were a data collection technique that has more roles, as well as Participant Observation, In-depth interviews, surveys using Questionnaires, and documentation. The main instrument was the researcher himself. The supporting instruments in this study were questionnaires, observation sheets, and an interview guide. The instrument had been validated so that it was appropriate to be used in research.

Based on the research subjects who met the criteria, the data collection was carried out in various settings, various sources, and various ways. The data in this study were collected directly by the researchers so the main research instruments were the researchers themselves (Sugiyono, 2016) assisted by supporting instruments such as observation sheets and questionnaires. The observation sheet and questionnaire were used to collect written data regarding the behavior and activities of individuals at Gedongsongo Temple. In addition, there was also a supplement instrument, i.e., an interview guide. The interview was recorded with a video recorder as documentation of activities analyzed using the QSR NVivo 11 software.

The survey with questionnaire was carried out via Google Forms and the interview was conducted directly with the manager of the Central Java Cultural Heritage Preservation Center. The data collection was carried out using questionnaires, interviews, and documentation. The researchers used source triangulation, namely digging up the truth of information with various data sources such as documents, archives, interview results, and observation results, and interviewing one subject who was considered to have a different point of view. Of course, each method will produce different evidence or data which will then provide different insights about the phenomenon under study. The level of reliability in this study was measured through Cohen's Kappa coefficient using QSR Nvivo 11 software on the Coding Comparison Query feature. The kappa coefficient can be interpreted using the guidelines in Table 1.

Table 1. Kappa coefficient interpretation guidelines

Kappa Value	Interpretation
< 0.40	*Poor Agreement*
0.40 – 0.75	*Fair to Good Agreement*
> 0.75	*Excellent Agreement*

RESULTS AND DISCUSSION

The 25 research subjects were selected by determining the background variance. The determination of the research subjects also considered the profession, shown in detail in Table 2.

Table 2. Research subjects by profession

Profession	Frequency	Percentage
Student	3	12%
University Student	12	48%
Teacher	2	8%
Entrepreneurs	3	12%
Visitors	5	20%
Total	25	100%

Based on Table 2, from 25 research subjects with a percentage level of 12%, 3 research subjects were students. There were 12 research subjects with a percentage level of 48% among university students. Then, there were 2 research subjects as teachers with a percentage level of 8%. The 3 research subjects with a percentage level of 12% were

entrepreneurs. Then, as many as 5 research subjects with a percentage level of 20% were the visitors. Therefore, the largest number of samples was the university students as research subjects. The 25 research subjects were given 8 main questions related to mathematical concepts that were directly integrated with the Gedongsongo temple.

Table 3. Research subject responses to mathematical concepts of Gedongsongo Temple

Question Item	The number of research subject answers				
	1	2	3	4	5
1. The roof of Gedong I has a trapezoid shape.	-	6	-	19	-
2. There is a building with a triangular prism.	-	1	1	22	1
3. The *stupa* from the top of the temple is cylindrical or tube-shaped.	1	11	-	13	-
4. The walls of the building are in the form of blocks and cubes.	-	1	-	19	5
5. Each temple has the same space between temples.	3	15	1	6	-
6. There are nine Gedongsongo temples.	2	6	-	12	5
7. The shape of the Gedongsongo Temple is different.	-	5	-	16	4
8. Gedongsongo Temple has a permanent building.	1	2	-	19	3

Based on Table 3, there were 25 research subjects with a percentage index of 70.4% of the measurement of the score interpretation of the main statement that the roof at Gedong I Temple has the shape of a trapezoid, so the results obtained based on the interval 60% -79.99% were in the agree category. There were 25 research subjects with a percentage index of 78.4% of the measurement of the score interpretation of the main statement that there is a triangular prism-shaped building, the results obtained based on the interval 60% -79.99% are in the *agree* category. Triangulation results on the following Attribute Values Diagram.

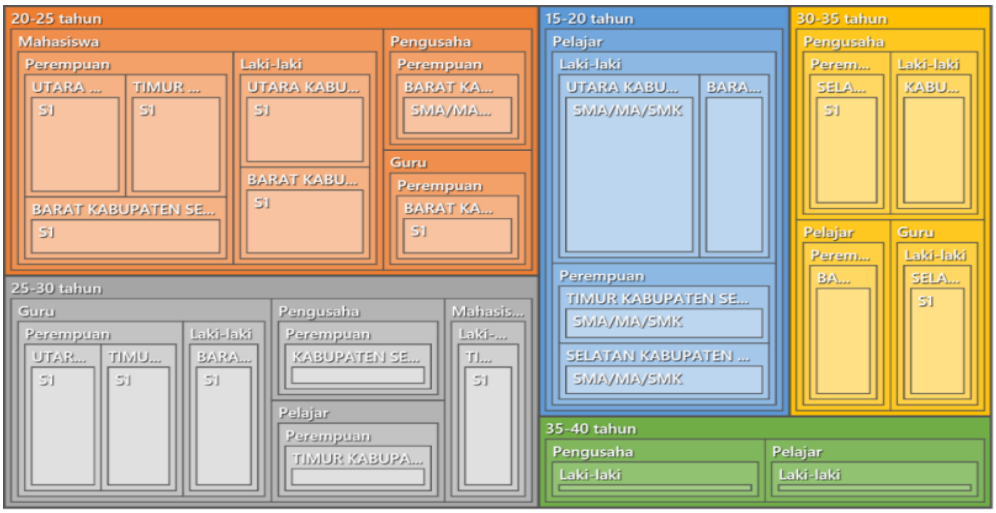


Figure 1. Attribute Values Diagram on the triangulation process

Figure 1 shows clearly that visitors aged between 20-25 years give a lot of comments and responses. The students with female sex and origin are sequentially from north of Semarang Regency, east of Semarang Regency, and west of Semarang Regency. Students with male sex and origin are sequentially from north of Semarang Regency and west of Semarang Regency. Entrepreneurs of female sex and origin are from the west of Semarang Regency. The teacher is female and comes from the western area of Semarang Regency.

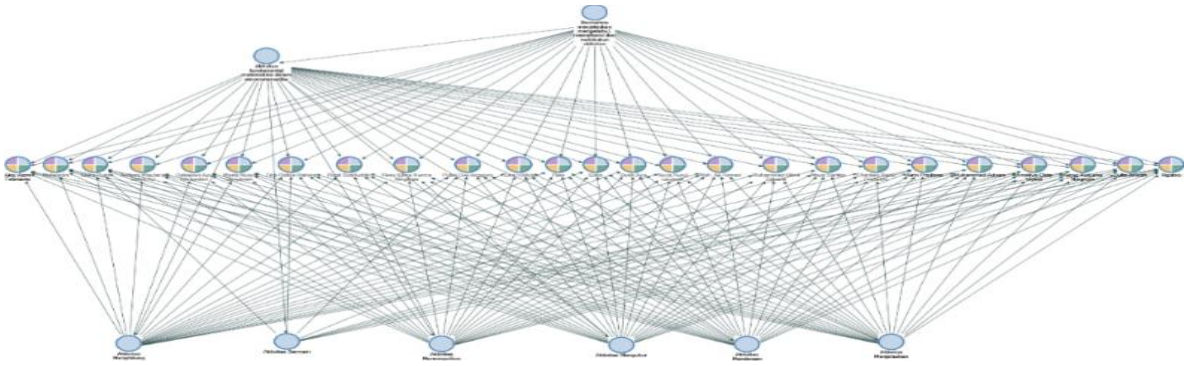


Figure 2. Project Map of culture and techniques according to the research subjects

To find out the relationship between concepts and generalization of data on socio-cultural aspects with fundamental mathematical activities and techniques at Gedongsongo Temple by research subjects based on Figure 2 was carried out using QSR Nvivo 11 software with the Project Map Query feature. In this way, the researcher was able to present the analysis results of the linkages between the sub-category themes and demographic data. Figure 2 clearly shows the understanding of each mathematical and technical theme by the research subjects

The discussion focuses on the mathematical concepts of ethnomathematics objects at Gedongsongo Temple and their potential for integration in learning mathematics. The discussion in this study is divided into three parts, namely: 1.) Presentation of mathematical elements in the Gedongsongo Temple 2.) Mathematical concepts in ethnomathematics objects at Gedongsongo Temple. 3.) The concept of the structure of geometric shapes that form the base of the Gedongsongo Temple building.

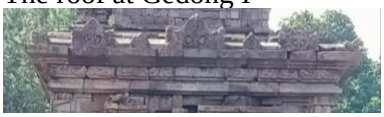
The Mathematical Concept of Ethnomatematics Objects at Gedongsongo Temple

All objects at Gedongsongo Temple are ethnomathematics objects in which mathematical concepts can be explored. Mathematical studies that can be developed include the concept of flat shape, spatial shape, symmetry, and ratio.

Concept of Flat Shape Area

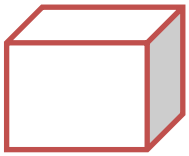
Ethnomathematics in Gedongsongo Temple can be explored based on various mathematical concepts, one of which is the broad concept of flat shape area. Some examples of the concept of flat shape areas in the ethnomathematics of Gedongsongo Temple can be seen in Table 4.

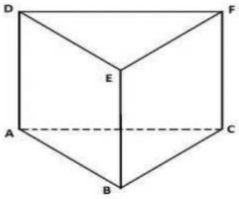
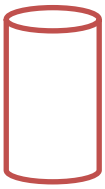
Table 4. Examples of the concept of flat shape areas

Flat Shape	Figure		Concept
Rectangle	Stairs at Gedong I 		$L = p \times l$ With: L: Area p: length l: width
Square	Walls at Gedong I 		$L = s \times s = s^2$ With: L: Area s: side
Trapezoid	The roof at Gedong I 		$L = \frac{(Side\ 1 + Side\ 2) \times t}{2}$ With: L: Area t: height
Triangle	Roof at Gedong I 		$L = \frac{a \times t}{2}$ With: L: Area a: triangle base length t: height

The cultural objects at Gedongsongo Temple are very diverse in shape, material, pattern, and layout. Various geometric shapes can be explored from various concepts, i.e., the concepts of volume and surface area. The concept of geometrical volumes for several ethnomathematics objects at Gedongsongo Temple is found in the aisles of the temple, beams on the temple walls, curved pyramid-like roofs, and tubular peaks which can be seen in Table 5.

Table 5. Examples of the Concept of 3D shape Volume

3D Shape	Figure		Concept
Cube	Cubes in the aisle of the temple 		$V = s \times s \times s = s^3$ With: V: volume of cube s: length of cube
Rectangular Prism	Beams on the temple wall 		$V = p \times l \times t$ With: V: volume of rectangular prisms p: length of rectangular prisms l: width of rectangular prisms t: height of rectangular prisms

3D Shape	Figure	Concept
Triangular Prism	The roof arch in the form of a triangular prism  	$V = A \times t$ With: V: volume of triangular prism A: base area of triangular prism t: height of triangular prism
Cylinder	The tubular top of the temple  	$V = A \times t$ With: V: volume of cylinder A: Area of circle = $\pi \times r^2$ π = 3,14 or 22/7 r: radius of circle t: height of cylinder

Symmetry

Symmetry is principally a transformation that is applied to a flat shape as the medium (Prihandoko, 2006). The lines or axes of symmetry are depicted with dotted lines. If a flat shape is folded or cut by following the lines of symmetry, the shape will have two equal parts. The concept of symmetry in mathematical objects in Gedongsongo Temple is in Gedong I and can be seen in Figure 3.

Figure 3. Gedong I

Ratio

In the buildings of Gedong IIIA and Gedong IIIB, it can be seen that there are parts of the temple that can be identified by observing the length of the upper temple, the length of the side of the temple body, the length of the temple body, the height of the temple body, the length of the upper temple base, the length of the *swarloka* level 1, the length of the *swarloka* level 2, the length of the *swarloka* level 3, the length of the observable *swarloka* level 4. There is a Golden ratio that is used to determine the exact proportion of the Front *Perwara* Temple building design (Figure 4). The golden ratio is used to calculate the ratio which produces a value of 1.618.

Figure 4. Golden Section Rectangle

The concept of geometry as the basis for the Gedongsongo Temple building

All mathematical concepts in the construction of Gedongsongo Temple consist of rocks in the form of blocks, cubes, tubes, and irregular 3D shapes. Gedongsongo Temple was built using mathematical concepts. The results of the discussion can be suggested to carry out mathematics learning activities, especially geometry with stages: 1) the teacher presents learning instruments based on the story of the Gedongsongo temple in various visualizations of parts of the temple, 2) students explore the geometry concept that has been presented in the instrument, 3) students make group discussions to make geometric sketches that they obtain from the results of exploration, 4) students present the findings of geometric sketches from the Gedongsongo temple parts, 5) the teacher provides feedback based on the presentation and explains the geometric concepts found by each student from the Gedongsongo temple parts, 6) the students and teacher draw conclusions related to ethnomathematics concepts in learning geometry through the learning process.

CONCLUSION

Based on the findings, analysis, and discussion of the research, the conclusions are as follows: (1) There are mathematical aspects known as ethnomathematics. The mathematical elements in the architecture of the Gedongsongo Temple complex include squares, rectangles, triangles, trapezoids, cubes, beams, tubes, and triangular prisms. (2) There are mathematical concepts in the architecture of Gedongsongo Temple including the concepts of flat shape geometry, 3D shape, ratio, and symmetry. (3) There is a concept of the geometric shape structure which forms the base of the Gedongsongo Temple including squares, rectangles, triangles, trapezoids, cubes, blocks, tubes, and triangular prisms. (4) Based on the results of data analysis using QSR Nvivo 11 Software with a reliability level of 0.95 and a credibility level of 99.73%, this research was declared credible with an Excellent Agreement.

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