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An exploration of ethnomathematics at Sewu Temple in Yogyakarta

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ABSTRACT

This study aimed at exploring the elements of geometry and arithmetic in Sewu Temple. This was qualitative research with an ethnographic design. Data collection techniques in this study were observation, interviews, and documentation. Data analysis techniques used were data reduction, data presentation, and drawing conclusions. The validity of the data using triangulation techniques. The results of this study indicated that there were mathematical elements in the shape of the building and the reliefs of Sewu Temple such as flat shapes, spatial shapes, geometric transformations, and arithmetic sequences. The existing flat shapes include squares, rectangles, isosceles trapezoids, and right trapezoids, circles, triangles, and octagons. Building the existing space includes blocks, tubes, and rectangular pyramids. The existing geometric transformations include reflection (mirror), translation (shift), and dilation (multiplication). So the results of the ethnomathematical exploration at Sewu Temple can be used as teaching materials for mathematics in schools, especially for geometry, geometric transformations, and arithmetic sequences.

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INTRODUCTION

Mathematics is a knowledge that humans use to solve their daily problems. Hsu et al., (2013) stated that mathematical concepts derived from everyday life experiences are knowledge systems developed to solve problems related to numbers, relationships, and space in everyday life. Therefore, mathematics can be applied in various matters relating to everyday life, for example trade transactions, carpentry activities, and measurements (Krismonita et al., 2021). At various levels of education, mathematics is a compulsory subject. In discussions on mathematics subjects are described using variables, so that they are often referred as abstract subjects. For some students mathematics is often considered as a difficult science to learn (Asnawati & Dewi, 2019). So students must be actively involved in the learning process in order to understand mathematics (Sari et al., 2016). In addition, giving examples of the interrelationships of mathematics in everyday life has great potential in making it easier for students to understand the mathematics.

Culture according to the Big Indonesian Language Dictionary (KBBI) means mind and reason, that means culture can be seen as something related to mind. Culture is a unified, comprehensive and applicable in a society. In a society, people has different mindsets and habits so that cultural diversity is also found between the community(Astriandini & Kristanto, 2021). Culture comes from the Sanskrit word ‘buddayah‘ which means the whole of human knowledge as a social being used to understand the environment and its experiences and its behavior (Nuh & Dardiri, 2016). Culture is a thing that is inherent in human life. Culture according to Edward B.Taylor is a complex totality that includes knowledge, beliefs, art, law, morals, customs, and the abilities and habits acquired by people as members of society (Sulaeman, 2015).

Mathematics and culture are two things that cannot be avoided or will always be encountered in everyday life. According to Karnilah & Juandi (2012) from the results of a meeting at the International Community of Mathematics Education, they stated that problems related to culture inevitably surround the process of learning mathematics, even all forms of mathematics. Wahyuni et al., (2013) stated that one thing that can bridge the gap between culture and mathematics education is ethnomathematics.

According to Sylviyani (2017) ethnomathematics is a science that is used to understand how mathematics is adapted from a culture, and ethnomathematics functions to express the relationship between culture and mathematics. According to Rusliah (2016) ethnomathematics is an approach that can be used to explain the reality of the relationship between environmental culture and mathematics in teaching. According to Irawan & Kencanawaty (2017) ethnomathematics is a cultural element that contains mathematics learning. So, it can be concluded that ethnomathematics is a learning strategy that linking cultural elements in mathematics lessons. Ethnomatematics can be divided into six basic activities, involving counting/counting activities, location determination activities, measuring activities, designing activities, playing activities, and explaining activities, where these six mathematical activities can always be found in a number of cultural groups (Sylviyani, 2017). The application of ethnomathematics as a means to motivate and stimulate students can overcome boredom and difficulties in learning mathematics (Sirate, 2012). Supported by Widada et al., (2019) who argued that the application of learning with an ethnomathematics approach aims to facilitate students' abstract thinking. This is because ethnomathematics is part of the daily life which is the initial conception acquired from the local socio-cultural environment. In addition, ethnomathematics provides new nuances that can be used as an alternative in learning mathematics. So, based on some of the statements above, it can be an inspiration in the world of mathematics education to apply ethnomathematics in mathematics learning activities (Owens, 2012).

The Special Region of Yogyakarta is an area located in the southern part of Java Island, precisely in the middle and is bordered by Central Java Province and the Indian Ocean. The Special Region of Yogyakarta is known as the "city of culture" because it has a lot of cultural diversity, such as customs and traditions in tourist spots which is still preserved by the local community. The Special Region of Yogyakarta has many historical tourist attractions and the temples. One of the temples in the Special Region of Yogyakarta which has a well-known history in the community related to the origin of the name of the temple is Sewu Temple. Sewu Temple is a temple with a Buddhist background and the second largest Buddhist temple after Borobudur Temple in Central Java. Sewu Temple was founded between 782-792 AD or around the VIII century AD under the reign of Rakai Panangkaran (Hamdoun et al., 2015). Sewu Temple is older than Borobudur and Prambanan Temples. Temples in each region have different shapes, motifs and the architecture of the building. The motifs or architecture of buildings in a temple usually contain elements of mathematics. Likewise, with Sewu Temple which has a unique temple shape and contains its own mathematical elements.

Rani (2018) conducted research to explore ethnomathematics elements at Ratu Boko Temple as a supporter of realistic mathematics learning has found that on the Ratu Boko Temple building site there were several buildings that have links with mathematics learning material, especially flat plane geometry material, including triangles, squares, rectangle, trapezoid, parallelogram and circle. Meanwhile, Utami et al., (2020) conducted research on ethnomathematics at Borobudur Temple which obtained the following research results: 1) Borobudur Temple as an ethnomathematics product presents various religious, moral, cultural, and mathematical concepts, 2) these concepts have relationships and interrelationships between one another, 3) agreed concepts and applied in everyday life have brought mathematics as a cultural product that has been embedded since ancient times even though people were not aware of it, and 4) Borobudur Temple is an example of a monument of a mathematics orchestra in the form ethnomathematics. Jayanti & Puspasari (2020) conducted research on ethnomathematics at the Sanggrahan Tulungagung Temple. The research showed that the link between Sanggrahan Tulungagung Temple and mathematics is only in the physical form of the temple. The mathematical concepts in the physical form of the Tulungagung Sanggrahan Temple are geometric shapes, lines, angles, congruence, and also geometric transformations. Based on the description above, this study aims to explore the elements of mathematics including geometry and arithmetic found in Sewu Temple. This research is expected to be developed into mathematics learning material and can increase the existence of Sewu Temple.

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METHOD

This research used qualitative research with an ethnographic design. Ethnography is a type of qualitative research in which researchers conduct studies of group culture under natural conditions through observation and interviews (Safei, 2017). So, the ethnographic design is used to describe, explain and analyze the mathematical elements in the Sewu Temple building. The subjects in this study were tour guides and temple employees, while the object of this research is Sewu Temple. This research was conducted at Sewu Temple which is located at Jalan Raya Solo-Yogyakarta KM. 16, Bugisan, Prambanan District, Sleman Regency, Special Region of Yogyakarta. This research was conducted from April 1 to June 15, 2022.

The data collection techniques used were observation, interviews, and documentation. Observations were carried out using the passive participatory observation method, where the researcher came directly to the location to obtain complete data but was not involved in the activity. The purpose of the observation is to acquire information and data regarding the physical and non-physical conditions of Sewu Temple directly. During the observation, the researcher used observation guide instruments to collect data about the address or location of Sewu Temple, the flat shapes, the geometric shapes, the geometric transformation shapes, and the form of arithmetic sequences found in Sewu Temple. The interview technique uses semi-structured interviews, in which the researcher prepares a list of questions as a guide, but in real practice, it is developed and adapted to the realities on the ground. The aim of the interview was to gather information about the history, restoration, and arrangement of the stones at Sewu Temple. The documentation technique is carried out by documenting the research process and results in the form of photos of flat shapes, spatial shapes, geometric transformations, and arithmetic sequences found in Sewu Temple. Documentation aims to support and complement the data that has been obtained from the observations and interviews.

Data analysis techniques are carried out using three paths; data reduction, data presentation, and drawing conclusions (Sutama, 2019). First, is the data reduction stage, in which the researcher records the results of the interviews, makes observations at the research site, and documents the research location. Second, the data presentation stage is presented in the form of narrative/writing and pictures. Presentation of data in narrative/written form includes the results of interviews with tour guides and temple employees, as well as explanations of flat shapes, spatial shapes, geometric transformations, and arithmetic sequences found in the temple, then the presentation of data in the form of pictures/photos including documentation flat shapes, spatial shapes, geometric transformations and arithmetic sequences found in the temple. Third, the stage of drawing conclusions from the results of the appearance/presentation of data in accordance with the research questions and research objectives. The validity of the data from this study uses technical triangulation which is carried out by checking data from the same source using different techniques.

RESULTS AND DISCUSSION

Result

The following is a brief description of the interviews results with two informants; the tour guide (tour guide) and temple employees regarding the history of Sewu Temple:

"The name Sewu Temple comes from the word 'sewu' which means one thousand in Javanese. This is related to a myth circulating in society, the legend of Roro Jonggrang who asked Bandung Bondowoso to make 1,000 temples in one night. The original name of Sewu Temple is Manjusigrha. Manjusi means a disciple of the Buddha who has succeeded in achieving perfection or a level similar to Buddha, so that Manjusigrha or Sewu Temple is often called the home of Buddha. The Sewu Temple was built in 792 AD which was initiated by Rakai Panangkaran, who was the king and who reigned for 38 years, the longest in the ancient Mataram kingdom',then the source added that *"Sewu Temple is the second largest Buddhist temple after Borobudur Temple. The Sewu Temple Complex is composed of 249 temples consisting of 1 Main Temple, 8 Apit Temples, and 240 Perwara Temples''.*

The following is a brief description of the results of the interview with the two informants; the tour guide (tour guide) and temple employees regarding the restoration of Sewu Temple:

"The reasons for the restoration of Sewu Temple are: 1) to preserve ancient buildings, 2) to make Sewu Temple can be used as a place of worship for Buddhism besides Borobudur Temple so that the waisak ceremony can also be held at Sewu Temple, and 3) so that Sewu Temple can become a big

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asset, namely by having tourist visits. So, the restoration of the temple serves as the maintenance or protection of cultural heritage and religious tourism. Until now the restoration of Sewu Temple is still being carried out and continues to be excavated to find forts that are still buried under the area of Sewu Temple''.

The following is a brief description of the results of the interviews with the two informants; the tour guide (tour guide) and temple employees regarding the rules for arranging stones at Sewu Temple:

"There are rules for arranging stones in the restoration process of Sewu Temple including 1) new stones must be marked like nails, 2) new stones may not be carved, and 3) the number of new stones may not be more than 40% of the number of stones that existed previously''.

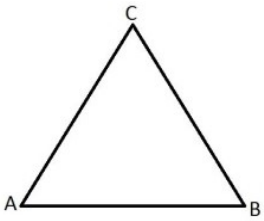
Based on the observations made, data were obtained regarding the flat shapes, geometric shapes, geometric transformations, and arithmetic sequences found in Sewu Temple as follows.

1. Flat Shapes and Space

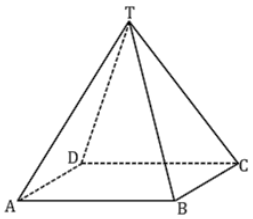
   On the roof of Sewu Temple, there are building forms that contain mathematical elements of flat shapes, triangles, and circles, as well as geometric shapes, like rectangular pyramids and tubes, as shown in Figure 1.1 below.

Figure 1.1. The roof of the Sewu Temple

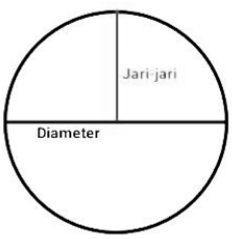
Figure 1.1 can be illustrated in the following form:



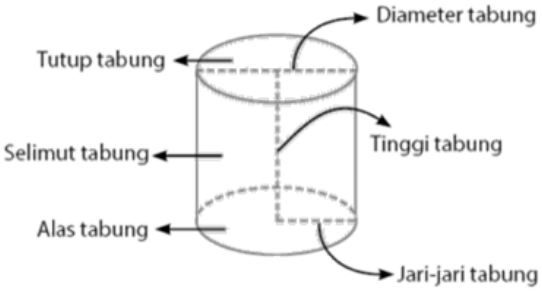
(1) Triangle



(2) Rectangular Pyramid



(3) Circle



(4) Tube

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(1) A triangle, because it is two-dimensional in shape and has 3 sides of the same length, namely AB, BC, CA, (2) a rectangular pyramid, because it is three-dimensional in shape, has a base quadrilateral ABCD, and has 4 triangular upright sides involving ABT, BCT, DCT, ADT, (3) a circle, because it is two-dimensional and has a diameter and radius, (4) a cylinder, because it is three-dimensional, has sides curved (blanket), and has an upper side (lid) and a lower side (base) which are circular.

On the outer side of Sewu Temple, there are building shapes that contain mathematical elements of flat shapes, such as octagons, squares, and rectangles, as well as geometric shapes, namely blocks, as shown in Figure 1.2 below.

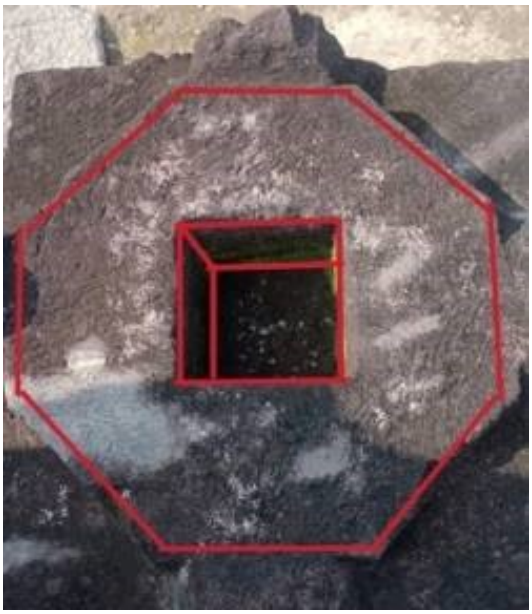
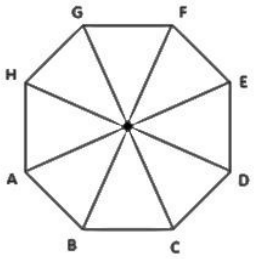
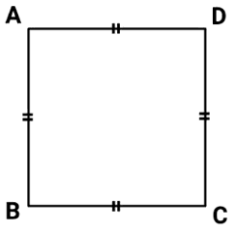


Figure 1.2. The outer side of Sewu Temple

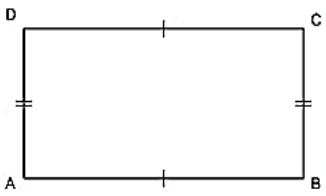
Figure 1.2 can be illustrated in the following form:



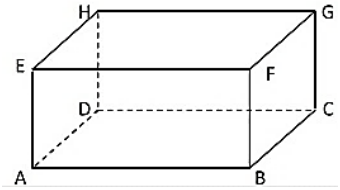
(1) Octagon



(2) Rectangle



(3) Rectangular



(4) Beam

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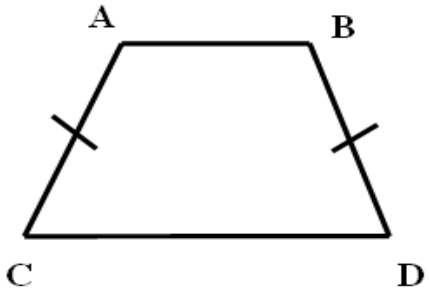
(1) An octagon, because it is a two-dimensional shape and has 8 sides of the same length; AB, BC, CD, DE, EF, FG, GH, HA, (2) a rectangle, because it is two-dimensional and has 2 pairs of parallel sides that have the same length; AB with CD and AD with BC, (3) a square, because it is two-dimensional and has 4 pairs of equal sides; AB, BC, CD, DA, (4) beams because they are three-dimensional, have 6 sides, namely ABCD, EFGH, ABFE, DCGH, ADHE, BCGF, and have 12 ribs, namely AB, BC, CD, DA, EF, FG, GH, HE , BF, CG, AE, DH.

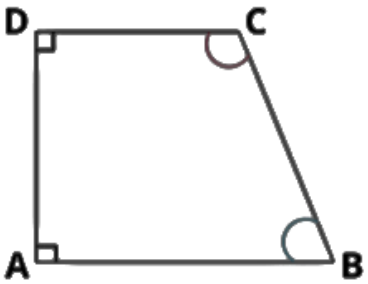
In the Sewu Temple courtyard, there are building forms that contain mathematical elements of flat shapes; isosceles trapezoids and right-angled trapezoids, as shown in Figure 1.3 below.

Figure 1.3. The courtyard of the Sewu Temple

Figure 1.3 can be illustrated in the following form:



(1) Isosceles trapezoid



(2) Right-Angled Trapezoid

(1) An isosceles trapezoid, because it is two-dimensional in shape and has a pair of equal sides; AC and BD, (2) a right-angled trapezoid, because it is two-dimensional and has two right angles that lie between its four sides; $\angle ADC$ and $\angle DAB$.

2. Shapes of Transformation Geometry

On the roof of Sewu Temple, there are building shapes and reliefs that contain mathematical elements of geometric transformation, namely reflection, as shown in Figure 2.1 below.

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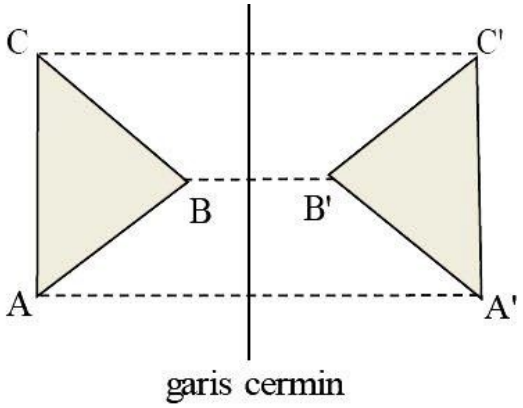
Figure 2.1. The roof of the Sewu Temple

Figure 2.1 can be illustrated in the form of a reflection as follows:



The red line in Figure 2.1 is illustrated as a mirror line, then the building to the left of the red line in Figure 2.1 is illustrated as triangle ABC which is the initial position of the plane, while the building to the right of the red line in Figure 2.1 is illustrated as triangle A'B' C' which is the final position of the field. The triangles ABC and A'B'C' are the same distance from the red line or mirror line and have a mirrored plane shape, so this is called a reflection.

On the roof of Sewu Temple there is a building form that consists of geometric transformation mathematics elements like dilation (multiplication), as shown in Figure 2.2 below.

Figure 2.2. The roof of Sewu Temple

Figure 2.2 can be illustrated in the dilated form as follows:

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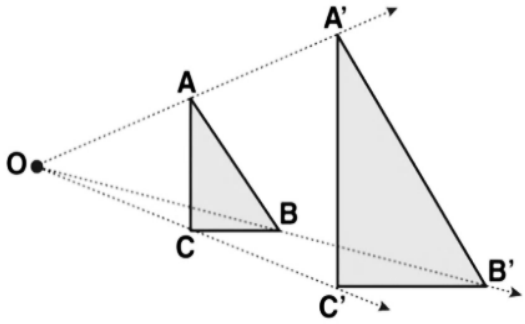
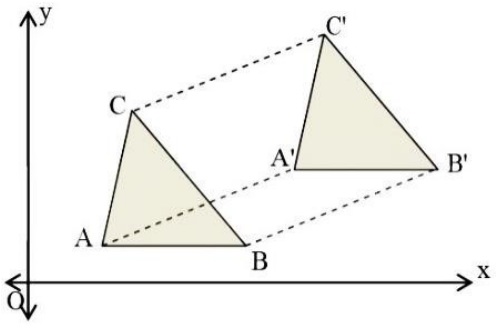


Pada In Figure 2.2 There are three buildings that are located sequentially; the left, center and right. The buildings located on the left and right are illustrated as triangle ABC because they have the same shape and size while the building located in the middle is illustrated as triangle A'B'C'. Triangle ABC is the initial position of the plane, while triangle A'B'C' is the final position of the plane. Triangle ABC and A'B'C' have the same shape but have different sizes whereas triangle A'B'C' is larger than triangle ABC, so this is called dilatation (multiplication or magnification).

On the outer side of Sewu Temple there is a building form that contains elements of geometric transformation mathematics such as translation (shift), as shown in Figure 2.3 below.

Figure 2.3. The outer side of Sewu Temple

Figure 2.3 can be illustrated in translational form as follows:



One of the buildings in Figure 2.3 is illustrated as triangle ABC which is the initial position of the plane while the other buildings are illustrated as triangle A'B'C which is the final position field. Triangles ABC and A'B'C' have the same shape and size, so it can be said that changing the position of triangle ABC to triangle A'B'C' will not change the shape and size of the triangle, this is called a translation (shift).

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3. Forms of Arithmetic Sequences

On the walls of Sewu Temple there are building forms that contain mathematical elements, like arithmetic sequences, as shown in Figure 3.1 and Figure 3.2 below.

Figure 3.1 Part of the Lower Wall of Sewu Temple

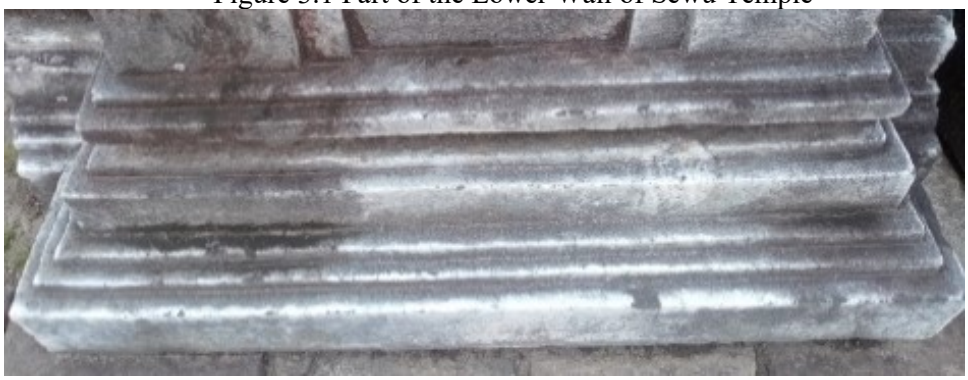

Figure 3.2. The Upper Wall of Sewu Temple

Figure 3.1 and Figure 3.2 can be illustrated in the form of an arithmetic sequence as follows:

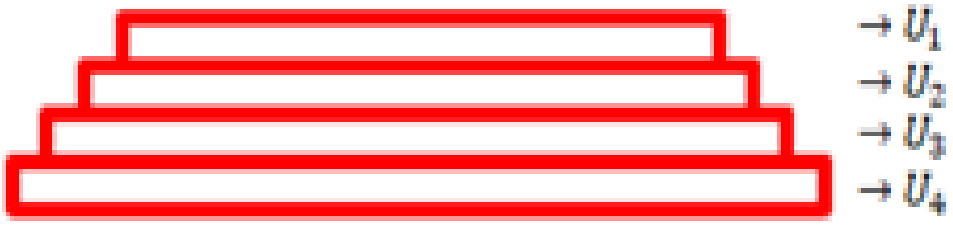

Figure 3.1 and Figure 3.2 are illustrated as stairs where each level has a different length, every time you go down one level, you will experience some increase in length on the left and right. The top rung of the ladder is denoted by U_1, and the next rung sequentially down is denoted by U_2, U_3, U_4, and so on. This is called an arithmetic sequence because the sequence of steps has a certain pattern.

Discussion

Statements from sources; *"Sewu Temple is the second largest Buddhist temple after Borobudur Temple."* in line with research conducted by Pertiwi et al., (2020) which also stated that Sewu Temple is the second largest Buddhist temple after Borobudur Temple. The floor plan of the Sewu Temple is as follows (Figure 4).

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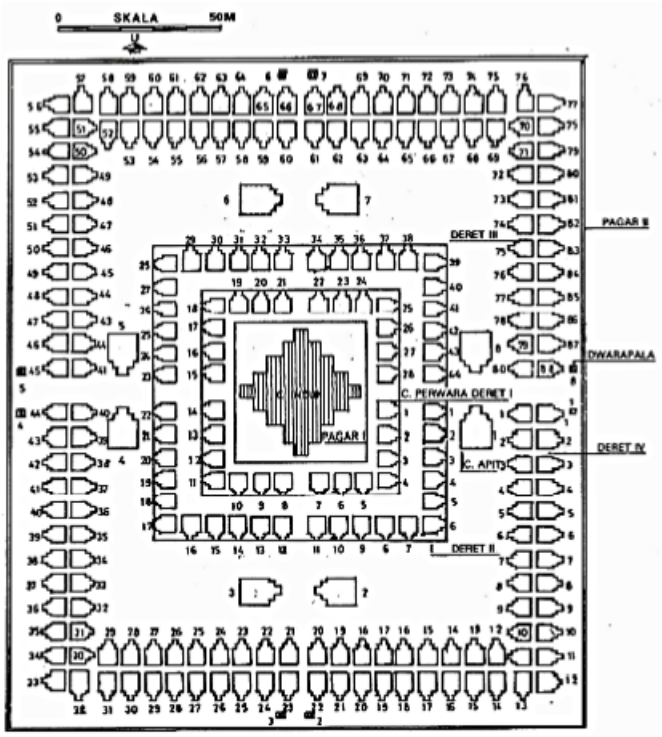

Figure 4. Floor plan of the Sewu Temple Complex

Based on the information from sources regarding the many Sewu Temple complexes: "*The Sewu Temple complex is composed of 249 temples consisting of 1 Main Temple, 8 Apit Temples, and 240 Perwara Temples.*", Murdihastomo (2018) added that the Perwara Temple building is divided into four rows including row I, row II, row III, and row IV. In row I there are 28 ancillary temple buildings, in row II there are 44 ancillary temples, in row III there are 80 ancillary temples, and in row IV there are 88 ancillary temples. Apit Temple is located between row II and row III with two temples on each side.

According to Law Number 11 of 2010 Article 1 paragraph 28, restoration is an effort to restore the physical condition of damaged cultural heritage objects, cultural heritage buildings, and cultural heritage structures in accordance with the originality of materials, shapes, layouts, and/or workmanship techniques to extend their life (Kebudayaan, 2018). Restoration is an effort to protect and preserve cultural heritage (Kebudayaan, 2018). This statement is in line with statements from sources: *"So the restoration of the temple functions as a maintenance or protection of cultural heritage and religious tourism"*. Hamdoun et al., (2015) added that restoration is carried out in order to maintain cultural heritage buildings and information to be passed on to future generations in the form of real construction so that it is not only in the form of stories and pictures.

Flat geometry is a geometric shape that is two-dimensional in shape or only has area but does not have volume, for example rectangles, circles, triangles, and others (Hendri & Kenedi, 2018). Spatial geometry is a geometric form that does not lie in a flat plane or a space object that is three-dimensional in shape so that it has length, width, and height, for example, cubes, beams, cones, tubes, prisms, pyramids and spheres (Utama, 2014). In the results of the ethnomathematics exploration carried out at Sewu Temple, there are several geometric shapes and geometric shapes. In the application of learning mathematics at school, the results of the exploration of Sewu Temple can be developed into teaching materials for students, especially on the material for flat shapes the types of flat shapes for the 3rd-grade elementary school level, and the spatial material on the types of geometric shapes for the 4th-grade elementary school level. One of the reasons is important for students to study geometry is that when learning about geometry might enable people to visualize, describe, and compare various geometric shapes in various positions (Mulyo et al., 2019).

Geometry transformation is a change in the position of a point in Cartesian coordinates according to certain rules (Jayus & Oktaviani, 2017). The types of geometric transformations are reflection (reflection), translation (shift), rotation (turnaround), and dilation (multiplication). Reflection (reflection) is a transformation in the form of displacement of each point in a plane with the

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nature of reflection, translation (shift) is a transformation in the form of displacement of every point in a plane with a certain distance and direction, rotation (rotation) is a transformation in the form of object rotation with a certain center point, and dilation (multiplication) is a transformation in the form of an increase in the size of a shape. In the results of the ethnomathematics exploration carried out at Sewu Temple, there are geometric transformation forms included such as reflection, translation, and dilation. In the application of learning mathematics at school, the exploration results at Sewu Temple can be developed into teaching materials for students on geometric transformation material regarding types of geometric transformation for grade 9 junior high school level. Geometry transformation has an important role in students' mathematical development by studying geometric transformations, students have broad opportunities to develop their spatial visualization and geometric reasoning abilities to gain mathematical proving abilities (Albab et al., 2014).

An arithmetic sequence is a sequence that has certain characteristics such as the difference between two successive terms always having a fixed value (constant). The difference between two successive terms always has a fixed (constant) value is called the difference (b). Tribes are numbers that make up a sequence (Anwar, 2017). The terms in the arithmetic sequence are expressed as U_1, U_2, U_3, …, U_n (Isnaini & Surya, 2017). The formula for determining a certain term in an arithmetic sequence is the formula used to determine the number of the first term to a particular term in question where a is the first term, b is the difference, n is the number of terms, and U n is$_{\text{the}}$ term nth. In the results of the ethnomathematics exploration carried out at Sewu Temple, there are arithmetic sequences. In the application of learning mathematics at school, the exploration results at Sewu Temple can be developed into teaching materials for students on the subject of arithmetic sequences regarding the introduction of arithmetic sequences for the grade 11 high school level. Arithmetic sequences need to be understood and mastered by students because it is one of the materials in mathematics which is important to apply in everyday life.

With the suitability of the exploration results at Sewu Temple with mathematics subject matter in schools at various levels; elementary, junior high, and high school levels, this research can be used as a reference in the development of mathematics teaching materials that can be linked to historical places around students and objects that exist in everyday life, so that it can make it easier for students to learn the material of flat shapes, geometric shapes, geometric transformations, and arithmetic sequences. In addition, the results of this study can also strengthen the results of other studies which state that in cultural center buildings such as places of worship and traditional houses, there are elements of mathematics that can be used as an alternative source of learning to teach geometry material to students (Ainurriza et al., 2020). This research is in line with this research because Sewu Temple is also a place of worship, a place of worship for Buddhism. Then Zayyadi (2017) states that ethnomathematics learning can be done by assembling mathematical concepts from the results of culture that develops in society such as cultural heritage in the form of temples, inscriptions, pottery, batik, traditional games, and patterns of community settlements. The application of ethnomathematics in schools can improve students' mathematics learning outcomes because learning with an ethnomathematics approach can make students interested in finding a solution to a problem themselves so it can encourage students to actively participate in learning activities (Ajmain et al., 2020). This is important because the problems faced by students in problem-solving tend to be complex, not routine, open, and challenging (Khotimah & Masduki, 2016). The application of ethnomathematics in schools can also teach students to always preserve the culture that surrounds them. This is supported by Sutarto et al., (2021) who state that ethnomathematics can increase a sense of love for a culture and can be used as an effort to prevent local wisdom values from fading.

CONCLUSION

Based on the results of research on the ethnomathematics exploration of Sewu Temple, it can be concluded that there are mathematical elements in the shape of the buildings and reliefs of Sewu Temple. The elements of mathematics are plane shapes, spatial shapes, geometric transformations, and arithmetic sequences. The types of flat shapes found in the shape of the Sewu Temple building are squares, rectangles, isosceles trapezoids, right-angled trapezoids, circles, triangles, and octagons. The types of geometric shapes found in the Sewu Temple building form are beams, tubes, and rectangular pyramids. The types of geometric transformations found in the buildings and reliefs of Sewu Temple

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are reflections, translations, and dilations. So, the results of ethnomathematics exploration carried out at Sewu Temple can be developed into teaching materials for students in mathematics at school at various levels such as flat shape material for grade 3 elementary school level, geometric transformation material for grade 4 elementary school level, geometry transformation material for junior high school level 9, and material for arithmetic sequences for grade 11 high school level. The application of ethnomathematics in school learning can improve students' learning outcomes in mathematics and can teach students to always preserve the culture that surrounds them. In this research, the results of the ethnomathematics exploration of Sewu Temple are not complete because there are several types of plane shapes, spatial shapes, and geometric transformations that have not been studied. For further research, it is hoped that it will be able to study in full the types of shapes, shapes, and geometric transformations.

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