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GEOMETRIC ASPECTS OF THE *GEDHE KAUMAN* MOSQUE IN YOGYAKARTA

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Abstract: This research aims to analyze ethnomathematics in a mosque named *Gedhe Kauman* in Yogyakarta. The ethnomathematics studied is related to the mathematical concepts of area and perimeter of two dimensional shapes. This research is qualitative research with an ethnographic approach. The data source in this research is the result of direct observation and documentation by the researcher. Data collection techniques were carried out by observing and documenting mosque buildings. Testing the validity of the data was carried out using technical triangulation. The subject of this research is the historic building of the *Gedhe Kauman* Mosque. Based on the research results, it was found that the Mosque building is quite closely related to ethnomathematics learning resource. This is proven by the presence of geometric elements in the structure and contents of the building that have easyly reognized patterns. The geometric shapes found are squares, rectangles, circles, triangles and trapezoids. These plane shapes can be integrated into the mathematical concepts of perimeter and area for learning elementary mathematics. This instructional approach might evoke student's disposition towards mathematics.

Keywords: Ethnomathematics, geometry, mosque, yogyakarta

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INTRODUCTION

Mathematics is one field of science that can be linked with cultures in the environment. In fact, mathematics and cultures are two things that cannot be seperated. Mathematics in cultures is known by the term ethnomathematics. According to D'Ambroiso in Ndoya & Ledu (2024), the term ethnomathematics needs solid translation, not merely on the aspects of ethno- and mathematics. The word ethno- refers to cultural identities owned by a certain group of people concerning various aspects of life such as languages, values, beliefs, habits, and so on. Meanwhile, mathematics covers various

sciences about arithmatics, logics, drawing conclusions, etc. Marsigit *et al*. (2016) stated that ethnomathematics is a science which is used to understand how mathematics is adapted from a culture.

Ethnomathematics refers to a group of ideas concerning history of mathematics, cultural roots of mathematics, implicit mathematics in daily-life environments, and mathematics education. Ethnomathematics, as an educational idea, advocates that the content of mathematics education be rooted to what is implicit in the cultures of school children. However, ethnomathematics should not only refer to the perspectives of mathematics education, but it must also refer to implicit mathematics from the cultural group in question (Vithal & Skovsmose,1997).

A cultural context refers to values which are adopted by a group of people (Rosmawaty, 2013). Cultures also reflect the identities of a group of people and how these people interact among each other in the group. Sumarto (2019) mentioned seven elements of a culture which are namely language, knowledge, sociality, technology, occupation, religion, and art. Religious elements can be found in cultural objects which are related to religion, such as a mosque. As a cultural centre, the mosque is a venue for religious, social, and political activities. A mosque, therefore, functions to nurture civilization and culture (Rosadi, 2014). In this regard, a mosque, as one of cultural objects, can be integrated into mathematics education and learning,

Mathematics learning is a process that needs serious and directed efforts. Learning is help given by the teacher to the learners (Suardi, 2018). Help is given by the teacher to the learners so that they can obtain knowledge and skills and develop their attitudes and self-confidences. The teacher holds a central role in helping the learners to understand and master mathematics well. The teacher has the responsibilities to transfer the instructional materials clearly, build in-depth understanding of the topic, and motivate learners to study mathematics enthusiastically. Furthermore, according to Rosa in Kurniawan & Hidayati (2019), mathematics learning materials should not stick on mathematical concepts, but more on thinking skills and the application in daily life. By application here is meant the use of cultural mathematics materials in the learning process. In such a way, mathematics learning will be more contextual and rooted on the learners' cultures.

Mathematics learning will also sharpen learners' skills in problem solving. In this case, learners are trained to find correct solutions, use critical thinking, and think systematically when facing mathematical problems. Furthermore, mathematics learning has a crucial role in helping learners to build strong mathematics understanding, critical

thinking skills, and useful abilities in applying mathematics in real life. This is in line with the objectives of mathematics learning according to Kemendikbudristek (2022); namely that learners are able to: 1) understand concepts so that they are able to apply them correctly, 2) use their thinking skills, 3) solve problems, 4) communicte ideas, and 5) value the use of mathematics in daily life. When learners understand mathematical concepts well, they will be able to see the relations between mathematics and the real world. They will be able to identify and apply mathematics in daily-life situations, both in their private life and their professional contexts.

There are five content elements in mathematics learning. Content elements are perspectives that mathematics is a subject matter that must be mastered by learners (Kemendikbudristek, 2022). These five content elements or subject-matter materials are numbers, algebra, measurement, geometry, data and probibility analysis, and calculus for higher levels. One of the materials which will help learners to develop their logical-thinking abilities, abstract, and analytical, and improve their problem-solving skills is the flat shape. The flat shape material is a content element that cannot be separated from geometry in the field of mathematics. Geometry is a part of mathematics that studies about the concepts of shapes and spaces (Ridwan, Hidayat & Abidin, 2020).

In studying geometry, mature concepts are needed so that learners will be able to apply geometric skills such as presenting, describing, comparing, and analyzing various flat shapes and space shapes (Fauzi & Andika, 2020). In all educational levels, geometry becomes one of the materials that is highly relevant for and close to the learners; that is taught in the elementary-school level up to the higher-level education. In the mathematics curriculum, the geometry learning of flat shapes has an important role in helping learners to develop their understanding on the characteristics and relations among the elements in flat shapes, learn related mathematical formulas, and improve their logical and spatial thinking skills. Besides, geometry learning of flat shapes also gives the opportunities to learners to apply mathematical concepts in real-life situations such as measuring land, planning a flower garden, or building architectural models. Therefore, understanding and applying flat-shape geometry are two important aspects in the proces of mathematics learning, contributing to the development of learners' mathematics literacy and preparing them to face the challenges of more complex mathemtics in the future.

Mathematics learning based on ethnomathematics can be initiated by looking at ethnomathematical objects. *Masjid Gedhe Kauman* (The Grand Mosque of Kauman) can become an option to become an object in ethnomathematics. The Grand Mosque of Kauman becomes a symbol of harmonization of the specific cultures of Yogyakarta

Kingdom which is full of historical events and the religiousities of the people. As a whole, the building arrangement and detais of the Grand Mosque are very much characterized by the cultures of the Javanese Islam.

The ethnomathematical values of the Kauman Grand Mosque of Yogyakarta can become mathematics learning in which cultural elements are abundant. Based on these backgrounds, the present study is aimed at exploring mathematical concepts of the geometrical field that are found within the Grand Mosque of Kauman, Yogyakarta.

Previous research has looked into the relations between observations of mathematics objects in the real-life environment contexts on learners' understanding of mathematics concepts. Several studies have explored uses of objects in various environments; however, discussion of the use of mathematics objects related to mosques. No study has discussed more specifically ethnomathematics on a mosque. For example, the study by Rohayati, Karno, & Chomariyah (2017), involved uses of parts of the Grand Mosque to help learners in understanding geomatrical concepts such as features, areas, circumferences, and volumes. The study presented various geometrical shapes and their concepts that were found in Kauman Grand Mosque. However, explanation given in the study was not completely in details. This was because the study involved more than one mosque found in Yogyakarta. As a result, there are still many parts of the Grand Mosque that have mathematics concepts that have not been covered. Meanwhile, the study by Nisa *et al.* (2023) also talked about the Grand Mosque; but, it merely focused on the identification of the standing of points, lines, and planes. For this reason, the present study is aimed at describing in more details the ethnomathematic objects in the Grand Mosque focusing on the areas and circumferences of flat shapes.

METHOD

The study is a piece of qualitative research using an ethographic approach. According to Creswell (2015), the ethographic research approach is suitable to be used to study patterns of behaviours, beliefs, or languages of particular groups of people. The ethographic approach makes it possible for the researcher to explore ethnomathematics by probing into and obtaining deeper understanding of the mathematics objects in Kauman Grand Mosque in the learning of the concepts of areas and circumferences of flat constructions. The study was carried out in the Grand Mosque of Kauman, Yogyakarta as the main location for data collection of the research. Data collection was done by way of direct observation on the ethnomathematics objects of study in the Grand Mosque, documentation by photographing using a personal camera, and literature study

concerning the Grand Mosque of Kauman, Yogyakarta. Data validation was done by way of a triangulation technique of comparing data obtained by the different techniques of documentation and observation.

Research data were results of observation on the research objects such as the flooor, walls, dome, and *mihrab* niche of the mosque; results of documentation in the forms of photographs; and results of the literary study conducted mainly by the researchers. Subsequently, the collected data were then subjected to a reduction, presentation, and analysis processes to obtain more comprehensive data. Data were analyzed by way of a qualitative data analysis method, involving interpretation processes, to obtain patterns, findings, and conclusion that were relevant with the research objectives. By ways of the explorative approach and qualitative analysis method, the study is expected to be able to give updated contributions in widening one's understanding on how results of observation on the mathematics objects in the mosque contexts can become meaningful and useful learning sources for the understanding of the concepts of areas and circumferences of flat constructions.

RESULTS AND DISCUSSION

Observation on the the mathematics objects related to Kauman Grand Mosque has uncovered important potentials in understanding the concepts of areas and circumferences of flat shapes. Through direct observation on the mosque, it is expected that learners are able to know and study the mathematics concepts concretely and relevant with the situations in their environment. However, up to the present time, there has not been a discussion that specifically deals with how learners can actually attain knowledge on the mathematics concepts through such observation. The question that arises is why it is important to calculate the areas or volumes of the parts of the mosque and how they must do it. The concepts of areas and circumferences of flat shapes are cores of mathematics materials related to flat shapes as rectangles, triangles, or circles. In relation to the research objects of Kauman Grand Mosque, understanding of these concepts will make it possible for learners to measure and calculate the area of the floor, circumference of the dome, or area of the walls of the mosque.

Why is it needed to calculate the areas and volumes of certain parts of a mosque? First, through this measuring and calculation, learners are able to apply mathematics concepts in real and meaningful contexts. They are able to see how mathematics is used in daily life, especially in the design and construction of buildings, including a mosque. The calculation of areas and volumes also can help learners developing their measuring

skills which is important in mathematical modeling and data analysis. Second, observation on the mathematics objects in the mosque can enrich learners' understanding of the mathematics application in the cultures and heritages of the nation.

Furthermore, understanding of the concepts of areas and circumferences of flat shapes through observation in a mosque can be done in learning processes that involve the active participation of the learners. One of the effective methods is by asking learners to measure the lengths and widths of rooms, height of the tower, diametre of the dome, and so on using the appropriate measuring devices. After that, learners are asked to apply the formulas they learn in class to calculate the areas or circumferences of these flat constructions.

During the instructional processes, the teacher takes the important role in giving examples of actual cases concerning the mosque. This may give learners motivation and make them more involved in the class activities. Group discussions, learners' collaborations, and use of visual media like pictures or models of of flat constructions may also increase their understanding of the concepts of areas and circumferences. Through these techniques, learners can study mathematics interestingly and meaningfully and relate these to their wider life environments.

Based on the results of the data collection and analysis, mathematical concepts are gained from the geometric forms of the parts of Kauman Grand Mosque. The mathematics concepts in question are areas and circumferences of flat shapes. Through observation on the parts of the mosque, learners recognise and probe into the concepts by looking at the building parts that have relation with flat shapes such the walls, floor, dome, and so on. By studying these concepts of areas and circumferences, learners are able to develop their concrete understanding of mathematics and relate it to the actual world that they can see and feel.

In the contexts of the Kauman Grand Mosque, learners are able to see how mathematics concepts are used in the design and architecture of the mosque building. They can also measure and calculate the floor area by identifying and combining the flat shape that is formed, measure the height of the tower using the correct measuring tools, or calculate the circumference of the dome using the correct formulas. By doing all these, learners not only study mathematics concepts theoretically, but they also see their applications in the real daily life.

Observation on the mathematics objects in the contexts of Kauman Grand Mosque gives the opportunities to leaarners to see how mathematics is related to cultures and heritages of the nation. The mosque is an important cultural symbol in the life of the

society, and through observations on the mosque, learners are able to understand how mathematics concepts are used in the construction and preservation of this national heritage. Hence, observation of the mathematics objects of Kauman Grand Mosque has important potentials in understanding the concepts of areas and circumferences of flat shapes.

By way of direct observations on the building, learners are able to develop concrete understanding of these mathematics concepts and relate them to the actual world that they can observe and feel. It is important for learners to study mathematics concepts such as areas and circumstances through observing mathematics objects of cultural heritages like mosque buildings since it will make it possible for them to apply mathematics concepts in real and meaningful contexts. The teacher holds the important role to facilitate learners in the instructional processes by giving examples of real cases, hold class discussions, and use relevant visual learning media. Through approaches which involve active participation of the learners and relate instruction to learners' environments, learners will be able to obtain deep understanding of mathematics concepts and develop their problem-solving skills which are useful in their daily life.

1. Circle

Figure 1. Wall clock

Through the research observation conducted in the study, circle flat shapes are found on the mosque building. One circle can be found on the front part of the mosque in the form of a wall clock (Figure 1). The flat shape circle has the chracteristics that it does not have an angle point, has a curve side, and has diagonals in an unlimited number. The existence of the wall clock on the front wall of the mosque signifies that the mathematics

concepts of circumference and area of the flat shape circle are relevant in the research observation and analysis. The concept of a circle circumference, calculated by the formula $2\pi r$ (two times *phi* multiplied by radius), is the length of the curving line that completes the circle. Meanwhile, the concept of the area of a circle, calcukated by the formula $2\pi r^2$ (two times *phi* multipled by radius squared), is the area that is covered by the circle.

Understanding on the application of the mathematics concepts areas and circumferences of a circle flat shape of the wall clock on the mosque wall gives the opportunities to learners to see and know the practical use of the mathematics concepts. Besides, learners will be able to relate this observation with other situations in their daily life. For example, they will relate this experience to the calculation of the circumference and area of a field or a surface of an object which has the shape of a circle.

2. Trapezoid

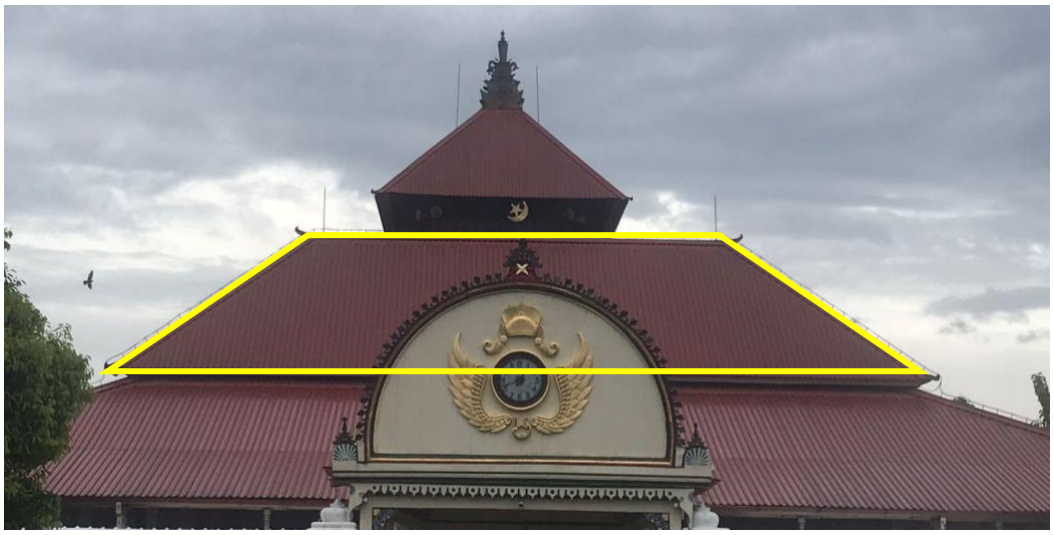

Figure 2. A trapezoid (on the roof)

In the building architecture of the mosque, there is a flat shape on the roof part in the form of a trapezoid as shown in the Figure 2. In mathematics, a trapezoid is a polygon with two parallel sides and two unparallel sides, two acute angles and two obtuse angles, and the total amount of the angles closest to the two parallel sides is 180°.

For the trapezoid, the mathematics concepts are also related to the calculations of its area and circumference. For the circumference, calculation involves the addition of all the four sides to obtain the length of the sides of the shape. The formula for the circumference of the trapezoid is K = 4s, where K is circumference and s is side. Meanwhile, for the area, the calculation needs 2 parallel sides and the height of the trapezoid. The formula to calculate the area of the trapezoid is 1/2 of the sum of the parallel sides multified by the height. By using this formula, the area of a trapezoid shape in the mosque building can be calculated.

3. Triangle

Figure 3. A triangle (on the roof)

On the roof of the mosque, a triangle flat shape can also be found, as can be seen in the Figure 3. It is interesting that it is an isosceles triangle which has two identical angles at the base side. The concepts of area and circumference of this triangle are the same as those applied for all other triangles. The circumference of a triangle is the sum of the lengths of its sides. Meanwhile, the area of a triangle can be calculated using the formula 1/2 × base × height, that is, half of the multiplication of the base side and height of the triangle.

Understanding of the concepts of the area and circumference of the triangle flat shape is important in observing and analyzing the mathematical objects of the mosque. In the same way, the recognition and understanding of the triangle flat shape found in the mosque building can be used by learners to recognize and understand similar shapes in other buildings or objects actually found in their surroundings. In other words, learners are trained to be able to calculate the measurements of triangular objects they find in their daily life.

4. Square

Figure 4. A square (in the floor)

In the floor of the Grand Mosque, floor tiles are found in the square flat shape which aesthetically decorate the mosque construction (Figure 4). As one of the geometric shapes, the square becomes an important focus in the mathematical analysis of the mosque building. A square is a rectangular shape that has four identical sides and four right angles. The circumference of a square, as a parametric measure, is defined as the total sum of the lengths of the four sides of the shape which are identical in length. Meanwhile, the area is calculated by using the formula for the rectangle. So, the area of the square is calculated by multiplying one side with another.

5. Rectangle

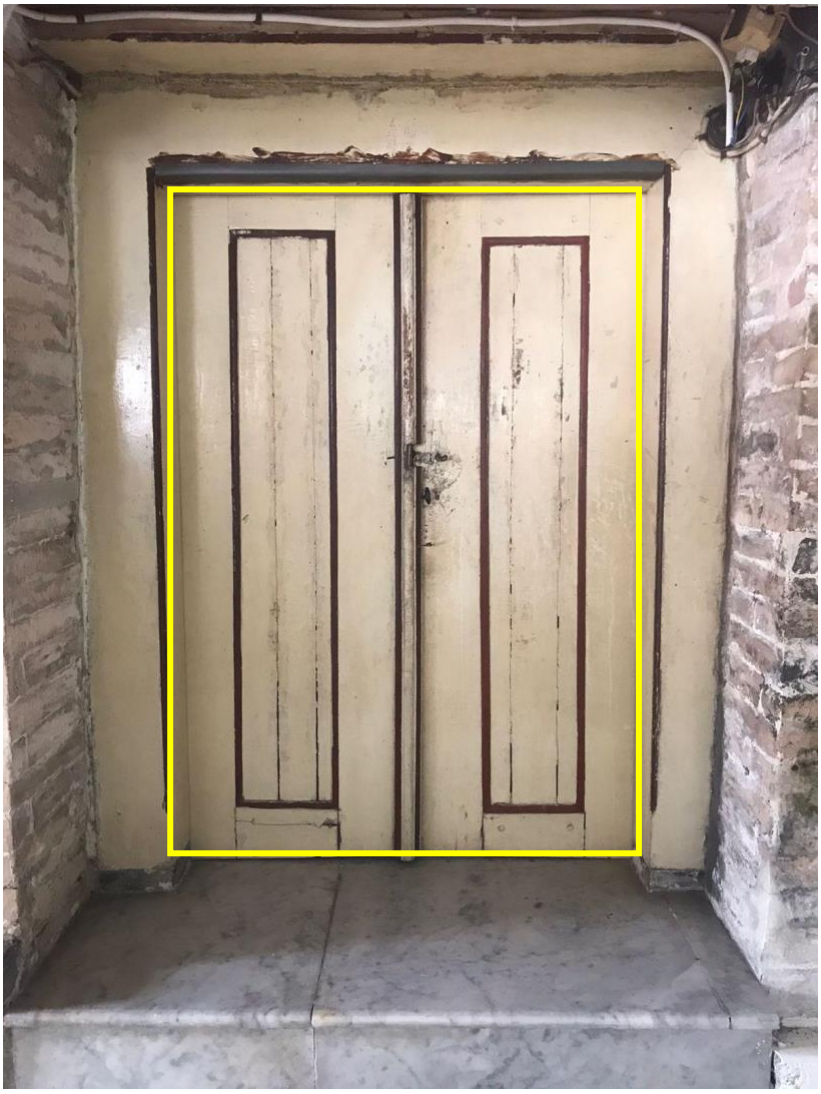

Figure 5. Rectangular shapes (in the door)

Finally, rectangular shapes can be found in the building construction of the mosque such as in the door, as can be seen in the Figure 5. The rectangle is a four-side polygon where the four angles are right angles and the opposing sides are parallel. The circumference of a rectangle is the total sum of the lengths of the four sides, i.e. the sum of the two parallel length sides and the two parallel width sides.

Meanwhile, the area is the length side multiplied by the the width side. In the same cases as the other shapes, the geometric concepts of the rectangle, including its area and circumference, are relevant concepts in the observation and analysis of the mathematics objects of the mosque such as that of the door. And, similarly, recognizing and understanding these mathematics concepts through observation will help learners enrich their knowledge and understanding of the concepts and apply them in actual contexts. In turn, learners will be able to practice these skills on other objects having the rectangle shape in their surroungdings by applying the correct formulas.

In the contexts of the instructional processes, there are some techniques and activities that can be conducted to bridge the learners reinforcing their understanding and skills in mathematics concepts. Direct observation is an important initial step. The learners are asked to directly observe the floor, walls, dome, and *mihrab* niche in the mosque. Later, they are managed to be involved in measuring lengths, widths, heights, and areas and circumferences selected objects using the correct measuring techniques and tools.

At this step, learners are expected to practice their visual and concrete understanding of the objects and their skills to measure objects. The teacher gives relevant examples of objects and the application of the formulas for calculating areas and circumferences. Classroom discussion and reflection will be the next useful step. The teacher facilitates the class discussion where learners share experiences in observing and measuring the objects and showing the results. In this case, learners strengthen their understanding and measuring skills of the objects under discussion and share their reflections and opinions with each other.

In addition, project-based instructional strategies are effective to be applied. The teacher designs the project assignments which involve learners in planning, observing, and measuring certain objects of the mosque. Projects may even involve more advanced assignments such as calculating or predicting the kinds and amounts of materials used to construct the selected objects. Through critical thinking and problem solving, classroom discussions of the project-based activities will give learners more varied learning and experiences in understanding the mathematics concepts concerning the parts of the Grand Mosque and the application in their wider daily life contexts.

CONCLUSION

Through the presentation of the results and discussion of the study above, it can be concluded that the building of Kauman Grand Mosque is one of the ethnomathematics

objects that has relation to mathematics concepts. In the construction structure of the mosque, various geometric flat shapes can be found both in the exterior of the building, such as the roof, and the interior such as the floor and doors. The flat shapes that can be identified include squares, rectangles, circles, triangles, and trapezoids. Findings of these various flat shapes can be used to give deeper understanding on the mathematics concepts of circumferences and areas. For example, through the observation of square and rectangular objects on the walls and floor of the mosque, learners can gain understanding of how to calculate the circumstances and areas of these shapes. In the same way, the circle shape of the dome and triangular shapes on the ornaments can become learning sources which can be used to enrich learners' understanding of the concepts of the circumferences and areas of flat shapes.

Through this study, it can be seen that the building of Kauman Grand Mosque does not only have aesthetic and religious values, but also learning sources that are rich of mathematics objects. In the contexts of mathematics learning, the use of these objects in the instructional process makes it possible to help learners relate abstract concepts to real life situations so that they can improve their understanding of the concepts of areas and circumferences of flat shapes in more concrete and applied ways.

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