

MATHEMATICAL CONCEPTS FOR ELEMENTARY TO SECONDARY SCHOOL FOUND IN THE AL-JABBAR MOSQUE: AN ETHNOMATHEMATICS STUDY

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Abstract: *A meaningful learning process for students can be done by linking mathematics with real contexts and applied with approaches that are in accordance with the characteristics of students. Ethnomathematics studies include various forms of cultural products related to mathematical concepts and activities in the form of buildings, artefacts, social activities, or in various cultural products. In this study, mathematical concepts will be studied in the form of buildings architecture, namely the Al-Jabbar mosque. This research aims to find mathematical concepts in the Al-Jabbar mosque that can be raised in the learning process in the classroom. The method used is qualitative research. Data analysis techniques with literature study, documentation, field observation, and document analysis. The results of the study are many mathematical concepts contained in the Al-Jabbar mosque and can be raised in classroom learning, namely the concept of area under a parabolic curve, parabolic curve equation, integral, geometry transformation (rotation, dilation, reflection, translation), one-dimensional geometry concepts (point, lines and angles), two-dimensional geometry (various triangles, quadrilaterals, circles), three-dimensional geometry (Hemisphere, prisms, tubes), and number patterns. All concepts found are important materials in learning mathematics in elementary to secondary schools so that they can be integrated in the mathematics learning.*

Keywords: *Ethnomathematics, Al-Jabbar Mosque, Mathematical Concepts, Elementary School, Secondary School.*

INTRODUCTION

Mathematics and culture are something that cannot be avoided in everyday life, because culture is a whole and comprehensive unit, applies in a society while mathematics is knowledge that humans use in solving everyday problems (Hardiarti, 2017). But sometimes mathematics is generally considered to be unaffected by culture. Different things are expressed by Buyung and Hendriana (2020) that the environment as a place of daily interaction and students are

always in and influenced by the culture that exists in the environment.

Mathematics is often used differently inside and outside of school (Nares, 2015). Currently, there are still few effective ways to connect formal mathematical understanding in school with the cultural context or students' everyday lives. An approach is needed that can integrate both aspects, yet efforts in this direction remain limited within the formal education curriculum (Sirat, 2012). Moreover, previous research tends to focus

on the application of formal mathematics, often overlooking the influence of culture and local environments, as stated by Rosa *et al.* (2016), who emphasize the importance of examining the relationship between mathematics and culture.

Ethnomathematics studies how mathematics interacts with culture (D'Ambrosio, 1999). According to Barta and Shockey (2006) ethnomathematics is a complex and dynamic representation that describes the cultural influence of the use of mathematics in its application. Culture is the result of mathematics (D'Ambrosio, 1985; Ernest, 2012). Language, religion, morals, economics, social, and politics are some of the factors that influence human mathematical thinking (Rosa *et al.*, 2017). Various mathematical symbols appear in religion, customs, clothing, and others (Katsap & Silverman, 2016).

To encourage students to apply mathematics, it is imperative to change the curriculum and find answers to various actual problems facing society. It is impossible to teach math in a way that ignores students' experiences (Rosa *et al.*, 2017). The knowledge and skills described in real-life situations greatly assist students in their achievement in PISA, particularly in the area of mathematics, and this has an impact that cannot be ignored (Hasanah et al., 2024).

Ethnomathematics is helpful in applying classroom knowledge to non-academic situations (Fitriza *et al.*, 2019). Research on ethnomathematics is growing rapidly and can provide great benefits for mathematics learning. The results of ethnomathematics research show that incorporating cultural elements benefits students in the long run. Cultural elements help students recognize that mathematics is part of their daily lives (Eglash *et al.*, 2006). Ethnomathematics can also help students

become more creative in solving math problems (Massarwe, Verner, & Bshouty, 2010). In addition, student achievement increased significantly. The integration of real-life problems from students' daily experiences is one of the main components that improve student achievement. (Katsap & Silverman, 2016).

As a result, ethnomathematics should be immediately incorporated into the classroom curriculum. Ethnomathematics, in accordance with constructivist theory, has the potential to help students build their knowledge through things they have learned before. In other words, ethnomathematics has the potential to help students feel accepted and more accepting of others. Mathematics can be found and applied in every culture, and should be part of the school curriculum (Brandt & Chernoff, 2015). The mosque, the result of acculturation between Islamic culture and local culture, is one of the tangible manifestations of culture. This is due to the fact that when Islam was adopted, local culture continued to follow religious rules (Sidiq, 2011).

Mosques in West Java not only function as places of worship, but also as centers of social and cultural activities. Many students are involved in activities held at mosques, such as recitation, mosque youth activities (remas), and various social activities (Ridwanullah & Herdiana, 2018; Khikmawati, 2020). Mosques are often the venue for various religious education events and social activities, which strengthens the emotional and cultural closeness between students and mosques. Studies of Sundanese culture show that West Javanese communities have a strong tradition of integrating religious activities in daily life, including children's education in mosques.

Al-Jabbar Mosque, located in Bandung, West Java, is one example of

architecture that reflects the beauty and complexity of mathematics in its design. The mosque not only serves as a place of worship but also symbolises the rich culture and art of Islamic architecture. The design of Al-Jabbar Mosque reflects the use of mathematical concepts such as symmetry, geometry, and complex patterns that have deep meaning in cultural and religious contexts. This research is important because study mathematical concepts that exist in a culture (Rosa *et al.*, 2016) and it can reveal how mathematical concepts are applied in traditional and modern architecture, and how mathematical understanding is influenced by cultural and religious contexts. According to Ascher (2017), "Ethnomathematics provides a view of how mathematics is practised in different cultures, which helps us understand the role of mathematics in everyday life". Through the study of ethnomathematics at Al-Jabbar Mosque, it is hoped to gain a deeper understanding of the interaction between mathematics and culture and how this knowledge can be used in education. Ethnomathematics in mosque buildings or also helps to develop question designs that can stimulate students' geometric thinking activities (Fajriah *et al.*, 2024). Ethnomathematics in mosque buildings or other cultural structures helps in developing problem drafts that can stimulate students' geometric thinking activities. Moreover, teaching materials that utilize the context of cultural buildings also have a positive impact on the mathematics learning process. This aligns with research by (Hasanah *et al.*, 2023), which shows that teaching materials in the form of student worksheets using the context of traditional houses are considered valid and practical.

Ethnomathematics studies in the context of mosques architecture are still quite limited, especially in linking mathematical

concepts with cultural elements that can be utilized in school learning. Although there is research that discusses ethnomathematics in general, a specific focus on modern mosques such as the Al-Jabbar Mosque, with its contemporary architectural design, has not yet been thoroughly explored. This gap indicates that there is still room to further explore how mathematical concepts applied in these buildings can be adapted to enrich mathematics education in schools. Therefore, this research is necessary to address the need for an approach that can connect school mathematics with relevant cultural contexts, such as mosque architecture, to enhance students' understanding and the relevance of learning mathematics.

The novelty of this research lies in a more specific exploration of the Al-Jabbar Mosque building, specifically at the elementary to secondary school levels. Furthermore, this study explores relevant mathematical material in greater depth than what has been covered in the existing literature. The new mathematical concepts identified in the ethnomathematics research of the Al-Jabbar mosque include transformation geometry, calculus (integrals), and algebra (quadratic equations). Previous research, focused only on certain geometric shapes and number patterns (Lutfi & Martadiputra, 2023)

METHOD

This study used a qualitative approach to research ethnomathematics (Rosa *et al.*, 2017). In qualitative research, the research location is selected by purposive sampling, which means that the location is chosen with special consideration (Yin, 2016).

This research took the object of the Al-Jabbar Mosque in Bandung which was inaugurated in December 2022. In the study of ethnomathematics, the researcher chose

Al-Jabbar Mosque as the object of study based on several reviews, namely from: 1) architectural and design aspects, Al-Jabbar Mosque has a unique and modern architecture that reflects the combination of art and mathematics; 2) Cultural and Historical Context, Al-Jabbar Mosque was built with the aim of becoming a new religious and cultural icon in Bandung. This reflects the cultural and religious values of West Javanese society that can be explored in ethnomathematics studies; 3) Location aspect, the mosque is located in Bandung City, which is one of the cultural centers in West Java and is easily accessible to researchers and has many visitors, which allows for richer and more diverse data collection; 4) Activities and community aspect, Al-Jabbar Mosque is active in various social and educational activities, which include recitation, religious education, and other social activities. This provides a rich context for examining how mathematics is applied; 5) As an ethnomathematics project, Al-Jabbar Mosque can serve as a model for how mathematical concepts are applied in architectural design, Islamic art, and religious and cultural activities at the mosque.

The researcher acts as a research instrument (Creswell & Poth, 2018). Observation, documentation, and literature searches were used to collect research data. The participatory observation technique involved the researcher as a participant in the daily activities at Al-Jabbar Mosque to

observe and record the mathematical practices that occurred. Document analysis was also conducted to analyse written documents related to the history, traditions, and religious activities at Al-Jabbar Mosque. The observation process was also carried out by looking directly at the ornaments in the Al-Jabbar Mosque related to mathematics subjects, especially geometry material. The observation guidelines used are unstructured, so that researchers can develop observations according to the circumstances in the field. Data collected from observations are stored in the form of photographs and field notes. The research data was complemented by literature studies from journal articles and other sources from the internet.

RESULTS AND DISCUSSION

Based on the analysis of field observations, documents, and literature studies, many mathematical concepts are obtained in the Al-Jabbar mosque, namely from the ornaments, motifs, and shapes found in the mosque building.

One-Dimensional Geometry Concepts (Lines and Angles)

The concepts of lines and angles are widely found in the architecture of the Al-Jabbar mosque, which is consistent with the research conducted by Marhummah and Mariana (2020). One of them can be seen in the carved motif on one of the doors of Al-Jabbar Mosque, as shown in Figure 1 below.

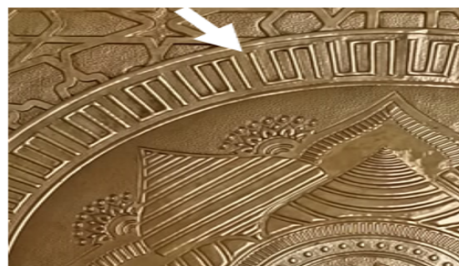


Figure 1 Lines

Observe the white arrows showing straight lines that form beautiful patterns. The concept of lines and angles, types of angles, and the

position of lines can also be found in one of the mosque fence motifs. See Figure 2 below.



Figure 2 Types of Angles and Lines

This is in line with the research conducted by Musbaiti *et al.* (2023) which describes the architectural drawing of cowhide on the mosque drum with 2 different lines. This research shows that the concept of line is found in the mosque's architectural motifs.

Two-Dimensional Geometry (Various Triangles and Quadrilaterals, Rectangles, Circles)

Kites and rhombus

The ornaments on the fence of the A-Jabbar mosque are in the form of two kites, namely a large kite and a small kite inside. The shape of the glass of the main building of the A-Jabbar mosque is in the form of a kite and a rhombus. See Figure 3 below.

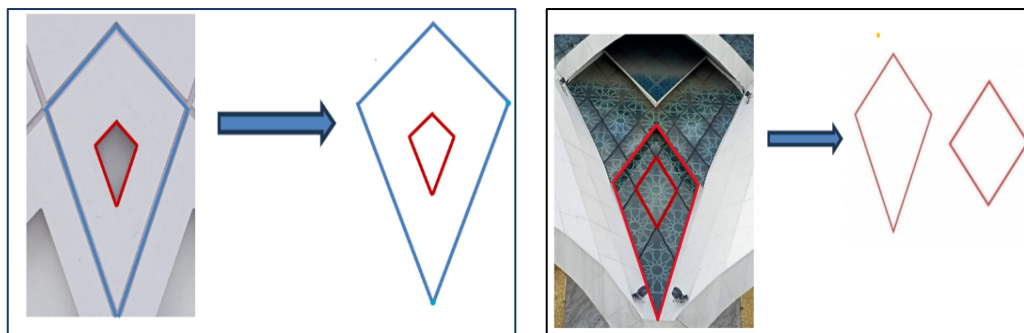


Figure 3 Kite and Rhombus

Circle and eight hexagon-shaped Sculpture outside the Al Jabbar mosque has Al-Jabbar writing made by one of the artists from Bandung (DKM Al-Jabbar, 2023). Seen from

above, this sculpture is in the form of a circle and inside the circle there are 8 hexagon-shaped gardens. See Figure 4.



Figure 4 Circle and Hexagon
(Source: Nurrohmah, G.F)

Rectangle

There are 27 doors made of iron sheets with gold paint. The doors are rectangle and there

are mosaics made by local craftsmen (DKM Al-Jabbar, 2023). See Figure 5 below.

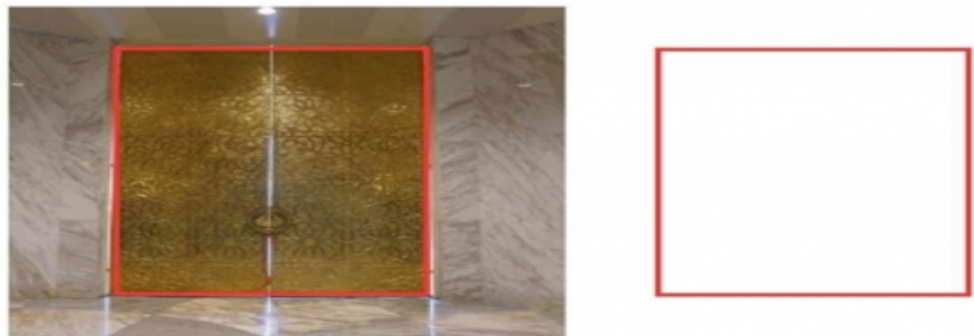


Figure 5 Rectangle

Triangle

The floor of the outer courtyard of the mosque has an arbitrary triangular motif

that has three sides of different lengths, as shown in Figure 6.



Figure 6 Arbitrary Triangle

Furthermore, the spire of the mosque has a right triangle motif that forms two

perpendicular sides as shown in Figure 7.

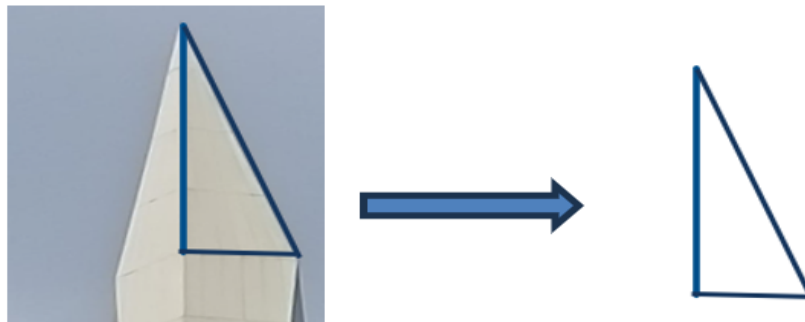


Figure 7 Right Triangle

Square

The Royal Crown is positioned above the prayer area, which contains the calligraphy of the word "Allah" that hangs down and is very

large (DKM Al-Jabbar, 2023). The Royal Crown is square in shape. See Figure 8 below.

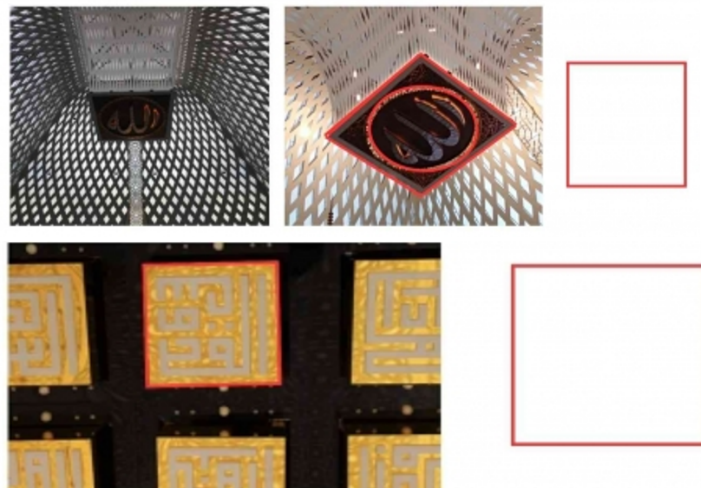


Figure 8 Square

This square-shaped lamp is located on the ceiling of the marodh area with a calligraphic design of 99 asmaul husna to show the beauty of the asma of Allah SWT (DKM Al-Jabbar, 2023).

Trapezoid

The motif of the fence in the mosque building forms 2 trapezoids that are congruent to each other. See Figure 9 below.

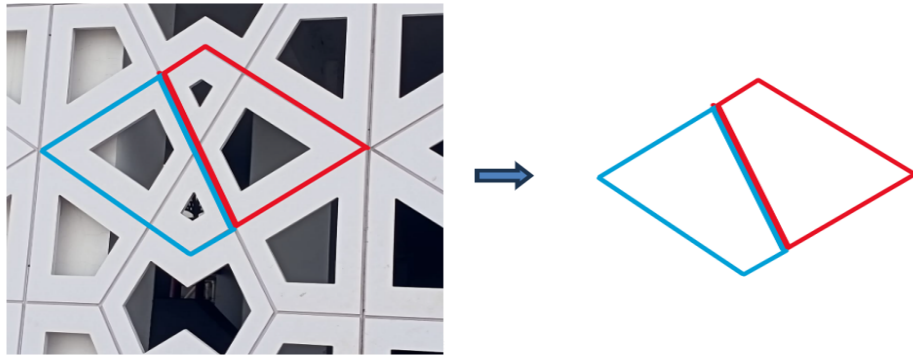


Figure 9 Trapezoid

The ablution pole for purification located in the outer courtyard of the

mosque is an isosceles trapezoid. See Figure 10.

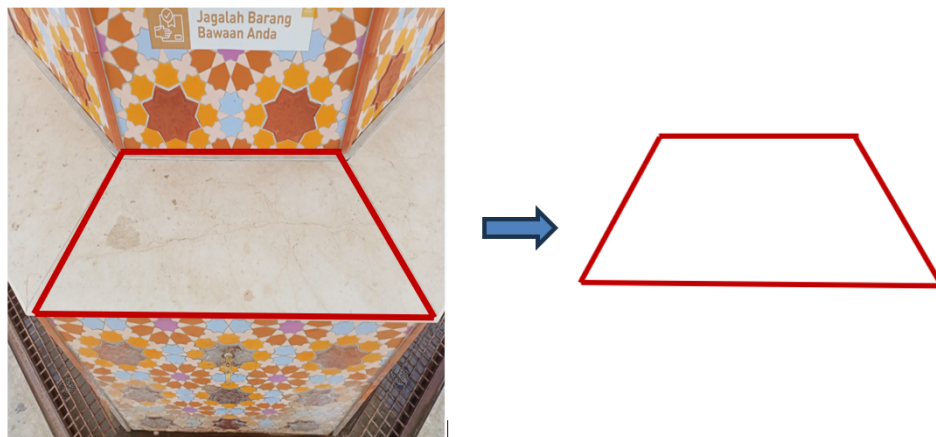


Figure 10 Isosceles Trapezoid

Parallelogram

The flowerpot ornament made just below the stairs of the mosque is in the form of several

parallelograms that are congruent with each other. See Figure 11.

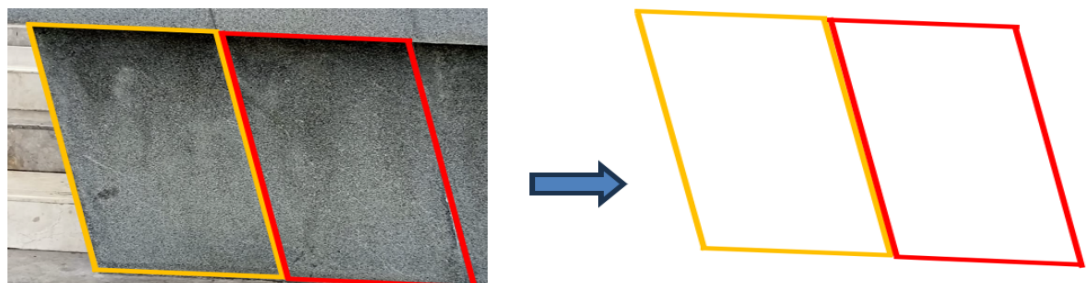


Figure 11 Parallelogram

Three-Dimentional Shapes

a height of 40 meters (DKM AL-Jabbar, 2023). See Figure 12.

Hemisphere

The main building resembles a hemisphere (half sphere) measuring 99 x 99 meters with

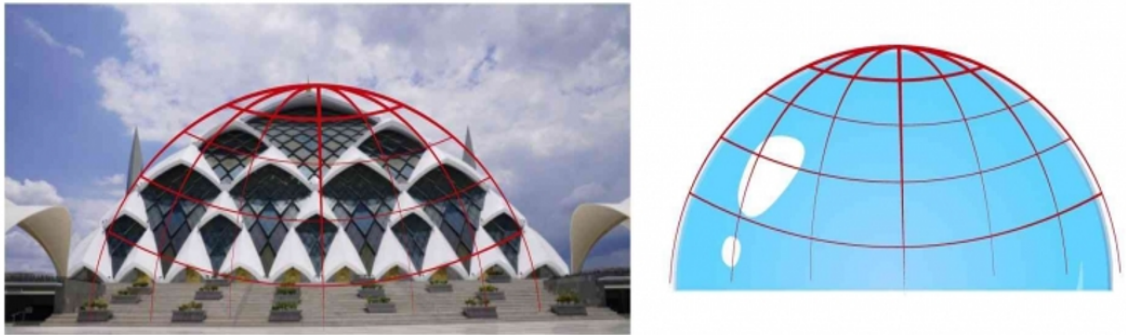


Figure 12 Hemisphere

Trapezoid prism

The top ornament of the flowerpot is in the shape of a prism. This shape is bounded by 4

rectangles with a trapezoid base and top, so it is called a trapezoid prism. See Figure 13.

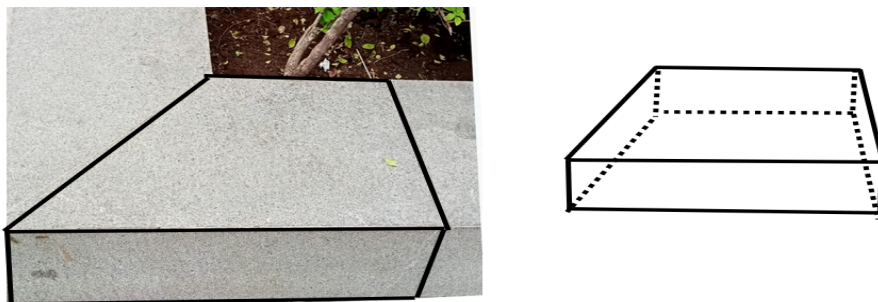


Figure 13 Trapezoidal prism

Cylinder

The pillars of this mosque are cylindrical. See Figure 14.



Figure 14 Cylinder

Concept of Quadratic Equation and Integral to Determine the Area Under the Curve

Some of the pillars in the mosque are shaped like a parabola. Where the quadratic equation

and the area under the parabolic curve can be determined using integrals. See Figure 15 below.

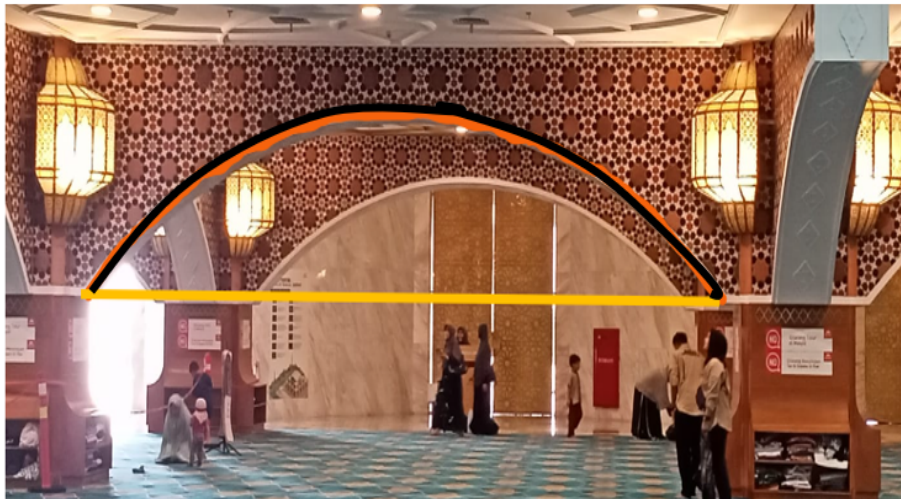


Figure 15 The Pillars of the Building

The pillars of the mosque that are shaped like a parabolic curve in Figure 15 can

be represented in mathematical form as shown in Figure 16 below.

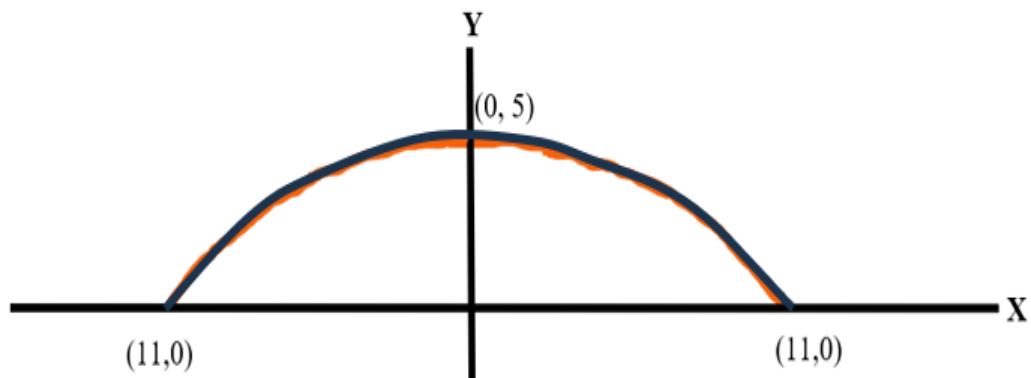


Figure 16 Sketch of a Parabolic Curve

The quadratic equation can be determined using the intercepts with the X-axis and the vertex of the parabola. The concept of integrals can also be applied to find the area bounded by the parabolic curve with the X-axis at points $(11,0)$ and $(0,11)$, and bounded by the Y-axis at $Y = 0$, as shown in Figure 16.

Number Pattern

The dome of the mosque forms a mixed number pattern of addition (arithmetic) and multiplication (geometry). Take a look at figure 17.



Figure 17 The Dome of the Mosque Forms a Number Pattern

Note the yellow arrows above that show the shape of the building like a paper aeroplane, from the top to the bottom of the

dome forming a jump number one pattern as follows:

$$\begin{array}{ccccccc} & & \times 2 & & \times 2 & & \\ & & \text{---} & & \text{---} & & \\ 1, & 2, & 4, & 5, & 10, & \dots & \\ \text{---} & & \text{---} & & & & \\ +1 & & +1 & & & & \end{array}$$

This is relevant to previous research conducted by Saviraningrum and Wahidin (2023), where the fence pattern of the great mosque of Tasikmalaya city incorporates the concept of arithmetic sequence. This is also in line with research by Ramadhina *et al.* (2021) which shows that one of the ethnomathematics contexts (traditional games) contains the concept of number patterns, which can be developed in a learning design for number pattern material, so that it can change students' paradigm that

mathematics is still considered an abstract science into a more fun mathematics.

Geometric Transformation

Some mosque motifs and ornaments contain forms of geometric transformation consisting of rotation, reflection, translation, and dilation.

Dilation

The octagonal star motif is found on the mosque's glass. It can be seen that the octagonal star motif has been enlarged from its initial form. See Figure 18.

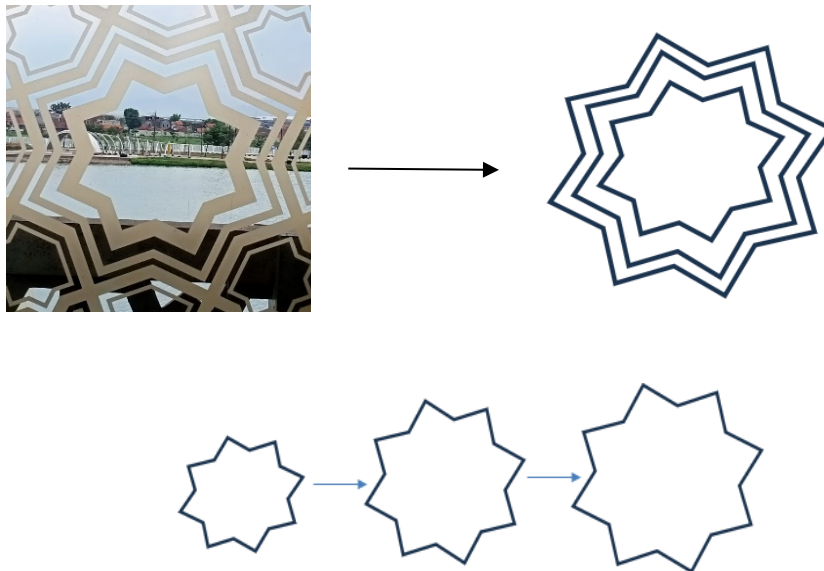


Figure 18 Dilation on the Mosque Glass Motif

Translation

The lamp decoration in the mosque shows the displacement of the object on the X-axis. See figure 19.

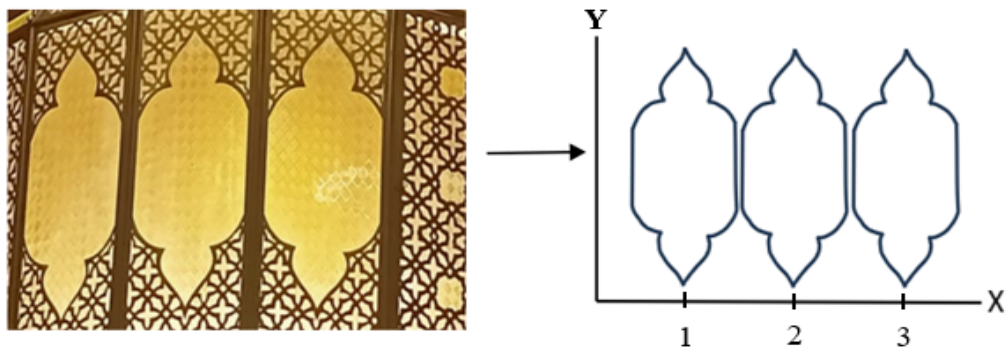


Figure 19 Translation on the Lamp Decoration

The translation (displacement) of the object is one unit horizontally on the X-axis of the cartesian coordinate.

Rotation

One of the mosque ornaments with floral motifs shows the rotation of the flower petals about the centre point (0,0) on the cartesian coordinate. See figure 20.

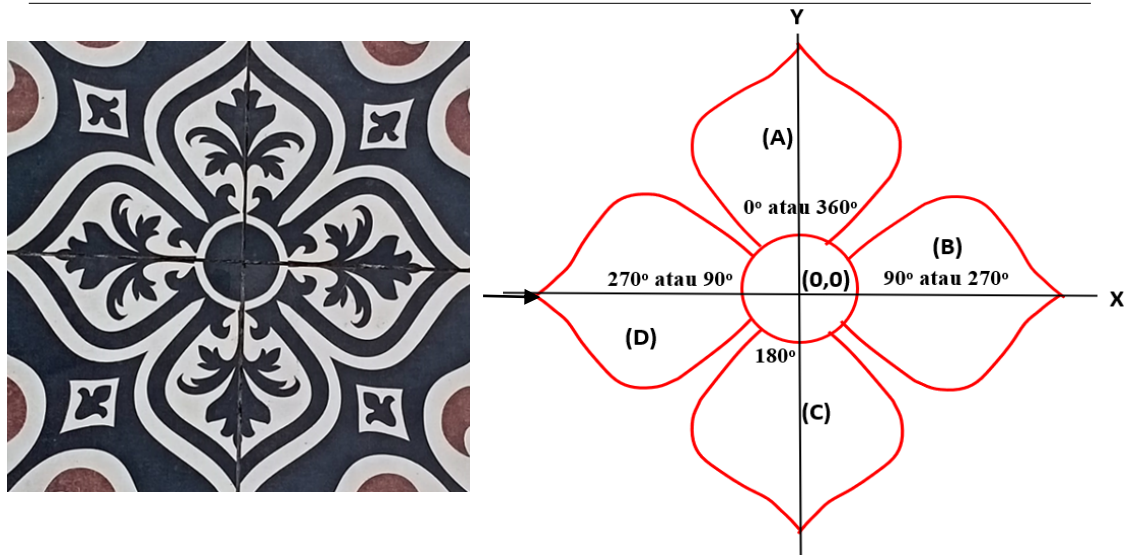


Figure 20 Rotation on the Mosque Ornaments

Rotation of the object occurs at the initial position of the petal (A) with respect to the centre point (0,0) by 90° clockwise to petal position (B) or counterclockwise to position (D). Rotation also occurs 270° clockwise or counterclockwise. Petal rotation also occurs by 180° from petal position (A) to petal

position (C). A full rotation of 360 degrees will restore the petal's initial position (A).

Reflection

The process of object reflection on the Y-axis occurs on the carpet motif. See Figure 21.

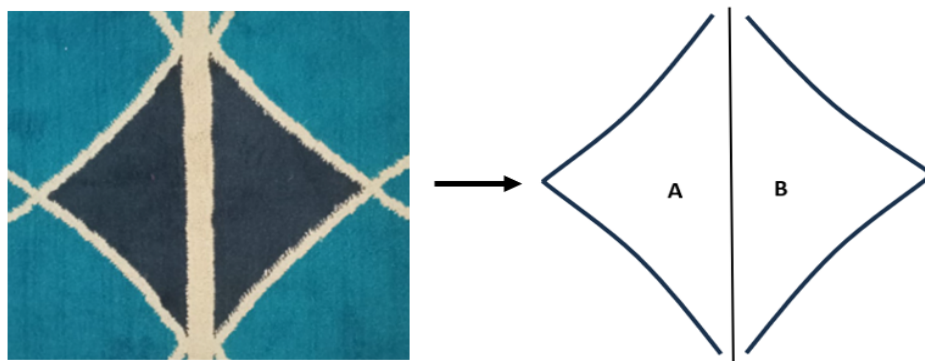


Figure 21 Reflection on The Carpet Motif

Reflection about the Y-axis occurs when the object's position at A becomes the position at B.

This research is in line with what Hamzah and Muhlisrarini (2014) said, that geometry is one of the abstract branches of

mathematics. Geometry in mathematics studies points, lines, angles, fields, spaces, and two forms of shapes, namely flat and spatial shapes. Geometry learning requires many contextual examples to be understood more easily, such as describing mathematical

concepts from visualisation of real images, sketches of images, or forms of buildings that can be seen concretely in everyday life (Yulianti & Retnowati, 2016). The ethnomathematics content in the Mosque Building can be used for mathematics learning for schools in the vicinity. Thus, learning mathematics at school will be more fun and able to improve mathematics skills and instil local wisdom values to students and students can maintain and preserve it (Sanyoto, Setiana, & Agustito, 2021).

The discussion on the forms in the architecture of the Al-Jabbar mosque delves into the ethnomathematical aspects from the perspective of Islamic culture and architecture, which have been integrated into the construction of the mosque. In the philosophy of Islamic culture and architecture, the shape of the sphere or circle, and its derivatives such as polyhedrons, regular polygons, hemispheres, etc., hold specific meanings. The sphere represents "the threshold between form and the formless principle, as symbolized by the point without extension." In geometric order, a sphere or circle signifies planes formed by the collection of points representing principles, which, in the philosophy of Islamic culture and architecture, is understood as the universal order. The sphere corresponds to the spirit (ar-Ruh) that radiates from the point of existence beyond comprehension. The immutable reality (al-a'yan ath-thabitah) is contained within the spirit and manifests as the accidental forms of perishable creatures (Burckhardt, 2009).

The main building of the mosque is shaped like a hemisphere, with its reflection in the pool forming a complete sphere, standing majestically in the middle of a retention pond spanning more than seven hectares. The Grand Mosque of Al-Jabbar appears to float when the pool's water reaches a certain level. Aside from its aesthetic function, the pool is

also an effort to control flooding in East Bandung. The design of this mosque was inspired by the algebraic formula discovered by the Muslim scientist Muhammad ibn Musa Al-Khwarizmi. This formula also inspired the name of the mosque, in addition to it being one of the Asmaul Husna (the 99 Names of Allah) and a homonym for the acronym of West Java. The algebraic formula is represented in the form of overlapping curve arches. The mosque's canopy, which consists of 88 arches, symbolizes a number pattern. The façade of the Grand Mosque of Al-Jabbar is made up of over six thousand colorful glass panels, layered like fish scales (in the shape of kites). At the top of the main building, there is an ornament shaped like a skewer, surrounded by five circular rings. These five rings symbolize the five pillars of Islam. The Grand Mosque of Al-Jabbar is encircled by 27 niches/columns representing the cities and regencies in West Java (shaped like cylinders). In each of these niches, one can find batik motifs characteristic of each city and regency in West Java, made from copper plates manually engraved by hundreds of artisans from Boyolali.

The most favored patterns are based on dividing circles into six, eight, and five. The geometric progression of the octagon, or more precisely, two squares inscribed in a circle, is the most common in Islamic art. This is also found in the construction of domes on square bases, mediated by an octagon. A series of hexagons layered upon one another ensures a very harmonious proportional development. The transformation of a sphere into a cube represents the philosophical transformation of the heavenly model to the earthly realm, where heaven is characterized by its infinite circular motion and the earth by its polarization into the contrasting four sides,

such as hot and cold, moist and dry (Burckhardt, 2009).

CONCLUSIONS

Al-Jabbar Mosque is a testament to the application of ethnomathematics in architecture. The design is rich in mathematical concepts that have been discovered by researchers and can be applied to elementary and junior high school mathematics lessons, such as the concept of one-dimensional geometric shapes (point, line, angle), two-dimensional geometric shapes (various triangles, quadrilaterals, circles), and three-dimensional geometric shapes (hemisphere, prism, tube). Mathematical concepts for senior high school are also found in the material of the area under a parabolic curve using integrals and quadratic equations. In addition, the concept of geometry transformation (rotation, dilation, translation, and reflection) is also found. The integration of cultural values shows that mathematics is not only an abstract science, but can also be applied in a cultural context to create beautiful and meaningful architectural works. This research confirms the importance of understanding and appreciating cultural contributions in the development of mathematics and architecture, and opens up opportunities for further exploration in the study of ethnomathematics. This research shows that mathematics and culture can be harmoniously integrated in architecture, as seen in the Al-Jabbar Mosque. This proves that an understanding of ethnomathematics can provide new insights in understanding how mathematical concepts are applied in a specific cultural context. In addition, this research also makes an important contribution in enriching the literature on ethnomathematics and Islamic architecture, and can serve as a reference for researchers interested in similar topics.

Suggestion for further research and exploration is this study open avenues for further exploration into the field of ethnomathematics, particularly in Islamic architecture. Researchers could investigate other cultural and religious structures to identify additional mathematical principles, expanding the current literature and understanding of how different cultures contribute to mathematical development.

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