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LEARNING GEOMETRY AND ALGEBRA: ETHNOMATHEMATICS ON THE GRAND MOSQUE OF AL-JABBAR

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Abstract: This study aims to explore the concepts of geometry and algebra used in mosque buildings using a qualitative approach to ethnographic methods. This study uses the Grand Mosque of Al-Jabbar as a sample located in Bandung, West Java, Indonesia, because the mosque since its inauguration has invited public enthusiasm by presenting a new history of beautiful and magnificent mosque architecture. Triangulation techniques were used to generate valid data through observation, documentation (photos and videos), interview, and literature studies in the form of studies on building structures. The results of this study show that the building structures of the Grand Mosque of Al-Jabbar contain elements of plane geometry, namely triangle, square, rectangle, hexagon, and circle. There are also elements of three-dimensional geometry, namely, pyramid, prism, and tube. The concept of number patterns can be found in the arrangement of mosque domes which have patterns 1, 2, 4, 5, 10. Based on this, the construction of the Grand Mosque of Al-Jabbar contains geometry and algebra concepts that can be used as an alternative to contextual learning, so that students can know the meaning of mathematics learned at school and have the ability to solve problems in real life. Ethnomathematics learning can also be applied through online learning.

Keywords: Ethnomathematics, Mosque, Al-Jabbar, Geometry, Algebra, Online Learning

Introduction

Education is an important element for a nation, good education can create human resources that have high competitiveness, so that it will lead to the progress of a nation. Learning mathematics is one of the processes that take place in education. Mathematics learning can be broadly defined as the acquisition of new knowledge, skills, and affect related to magnitude, space, and structure (Verschaffel et al., 2012). There are many abilities that are developed in learning mathematics, ranging from communication, reasoning, problem-solving, creative thinking, critical thinking, and many others (Siregar, 2018; Hadar & Tirosh, 2019; Suarsana et al., 2019; Costa et al., 2020; Kollosche, 2021). Of course, these abilities will be needed by students in living their daily lives. For example, reasoning skills will lead students to make good conclusions and decisions. This shows that learning mathematics is important for every student to master well.

One of the characteristics of learning mathematics is that it has abstract material that makes it difficult for students to learn the material. Several studies that have been conducted show that students still have difficulty in mastering mathematics learning (Amallia & Unaenah, 2018; Utari et al., 2020). Students

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have difficulty in understanding and combining logic and concepts to solve mathematical problems (Muthmainnah et al., 2017). Another difficulty is that students have difficulty in understanding the problem so that they cannot interpret it into mathematical sentences, and students tend to guess answers without a thinking process (Phonapichat et al., 2014). Students have difficulty in understanding geometry, arithmetic, and algebraic material (Tatlah et al., 2017). Students' difficulties in learning maths continue in later grades (Nelson & Powell, 2018; Lima et al., 2019). Current conditions regarding the implementation of online learning also show that students also experience difficulties in learning mathematics, so teachers have to spend more effort in implementing learning (Toptaş et al., 2021).

The difficulties faced by students are caused by several factors, according to Elastika et al. (2021) students' difficulties in mastering mathematics are influenced by internal factors (themselves) and external factors (from outside the students themselves). Internal factors of mathematics learning difficulties experienced by students can be in the form of learning interest factors, motivation factors and student attitudes, as well as student learning habits, while external factors of student learning difficulties are teacher learning methods, and learning facilities (Jayanti et al., 2020). Research conducted by Pandit (2004) states that students' difficulties in learning mathematics are related to poor learning factors, poor parental behaviour, and teacher negligence in the classroom. It can be seen that the learning factor of the teacher plays an important role in relation to students' difficulties in learning mathematics.

Poor teaching, for example, most teachers use conventional learning too often, even though conventional learning is not able to improve students' abilities (Jazuli et al., 2017). Mathematics learning in schools still tends to be rigid, often limited to memorisation of numbers and formulas (Yudianto et al., 2021). It shows that the learning of mathematics in the classroom is less related to students' daily lives. Such learning can make it difficult for students to understand mathematics. Therefore, learning strategies that are related and close to students' daily lives are needed.

Learning that is closely related to real experiences that students can imagine and is closely related to students' lives is contextual learning (Tilaar, 2015). Contextual learning in mathematics learning can make students able to solve everyday problems by connecting the context of existing problems with mathematical concepts that have been learned (Hartono, 2020). Contextual learning can train students to think critically, carefully, logically, and systematically (Johnson, 2002). The use of contextual problems offers some potential to engage and motivate students in learning mathematics but also presents some challenges for students in the classroom (Widjaja, 2013). Research conducted by Jazuli et al. (2017) showed that contextual learning strategies have a significant effect on concept understanding and problem solving skills in mathematics subjects. Research by Yeni et al. (2019) also showed that the concept understanding ability of contextual learning is better than conventional learning.

One way to support contextual learning in mathematics is by implementing learning related to local wisdom or culture that is often found in the surrounding environment (Janan, 2022). Contextual learning based on culture is proven effective in improving students' problem solving skills (Samo et al., 2018). Education and culture are inseparable, as culture is an integral part of society (Sanyoto et al., 2021). In recent decades, there has been a growing body of literature that focuses on the relationship between culture and mathematics, and describes examples of mathematics in cultural contexts (Barton, 1996). Mathematics learning that uses a culturally themed contextual approach in connecting students' understanding from contextual to formal mathematics is called contextual learning based on ethnomathematics (Sopyan, 2022).

The development of ethnomathematics was introduced by Brazilian mathematician D'Ambrosio (1985) in his article entitled *Ethnomathematics and its place in the history and pedagogy of mathematics*. Ethnomathematics can make student learning outcomes better (Soebagyo et al., 2021), as in the research of Mulyasari et al. (2021) which shows that contextual learning based on the ethnomathematics game "engklek" in elementary school students can improve understanding of geometry concepts. Research by Herawaty et al. (2018) showed that contextual learning based on ethnomathematics of the traditional house "Rejang Lebong" can develop students' problem solving skills through planning, monitoring, and evaluating the implementation of the thinking process. In the study, it was shown that students combined pieces of information about the parts of the traditional house "Rejang Lebong" which had properties similar to spatial shapes, namely pyramids, prisms, and cubes. Therefore, there is a need for more cultural context mathematics learning so that teachers can easily teach mathematics concepts in the classroom.

Ethnomathematics learning can be found in a building that has become an icon of one of the regions, namely the Grand Mosque of Al-Jabbar. The mosque, nicknamed the floating mosque, is the pride of the people of West Java, Indonesia. The Grand Mosque of Al-Jabbar is a mosque with a unique architectural design that uses the principles of mathematical calculations, namely algebra and geometry. The naming of the Al-Jabbar mosque itself was inspired by the term algebra in mathematics, al-jabbar in asmaul husna which means omnipresent, and omnipotent, and Jabar as an acronym for the name of the province of West Java (Jawa Barat in Indonesian). The Grand Mosque of Al-Jabbar has several features including iconic architecture, a floating mosque, four minarets, and a monumental prayer room (Dewan Kemakmuran Masjid Raya Al-Jabbar Bandung, 2023). Based on the background of the problem, the purpose of this study is to explore the concepts of geometry and algebra found in the Al-Jabbar Grand Mosque building that can be utilised in contextual learning based on ethnomathematics which can also be applied in online learning.

Methods

This research uses a qualitative approach with the type of ethnography to reveal the ethnomathematics found at the Al-Jabbar Grand Mosque. Qualitative research according to Creswell (2009) is a research process conducted in a natural setting to understand social problems, information that is presented clearly, thoroughly and complexly using words. Data in qualitative research is descriptive of all forms of speech, writing and images of objects and subjects observed. Ethnographic research is used to describe, explain and analyse the cultural elements of a society or ethnic group (Zayyadi, 2017). The ethnographic approach is an empirical and theoretical approach that aims to get an in-depth description and analysis of culture based on field research.

The instrument in this research is the researcher himself. Qualitative research as a human instrument, where researchers determine the focus of research, research informants and conduct data collection to further assess data quality, analyse, interpret and conclude their findings. The data collection techniques used are observation, documentation (photos and videos), interviews, and literature studies in the form of mosque building structure studies. Observation was carried out at the Grand Mosque of Al-Jabbar which is located at Street of Cimincrang No. 14, Gedebage District, Bandung City, West Java Province, Indonesia. Observation and documentation were conducted to see, find, and classify objects into mathematical concepts. Documentation in the form of taking photos and video recording on the objects of the Grand Mosque of Al-Jabbar that have mathematical content. Interviews conducted in this research are semi-structured interviews, which are interviews that take place referring to a series of open-ended questions. This method allows new questions to arise because of the answers given by the interviewees so that during the session the information extraction can be done more deeply. Literature review was conducted in various sources including internet sources and other media which can be in the form of brochures.

In order to obtain valid data, researchers triangulate data, namely by triangulating methods. Triangulation of methods is done by comparing information or data in different ways. Data that has been obtained from observation, documentation, interviews and literature studies is then reduced, analysed, and then arranged systematically.

Results and Discussion

In this section describes the findings of ethnomathematics at the Grand Mosque of Al-Jabbar, the discussion begins with the architectural design, overall philosophical value, and features of the Grand Mosque of Al-Jabbar, followed by findings regarding ethnomathematics at the Al-Jabbar Grand Mosque. The results presented are the results of findings through observation techniques, documentation (photos and videos), interviews, and literature studies in the form of mosque building structure studies. The interviewees in this study were the chief architect, landscape, and maintenance of the Grand Mosque of Al-Jabbar.

Profile of the Grand Mosque of Al-Jabbar

Figure 1: The Grand Mosque of Al-Jabbar View from Above
Source: https://aljabbar.jabarprov.go.id

The Grand Mosque of Al-Jabbar is located at Street of Cimincrang No. 14, Gedebage District, Bandung City, West Java Province, Indonesia. In addition to having the main function as a mosque, the selection of the location also aims to increase the quality value of the Gedebage area, because the Grand Mosque of Al-Jabbar not only has the main function as a place of worship, but also as a centre for education and religious tourism. Al-Jabbar Grand Mosque was designed in 2015 by Mochamad Ridwan Kamil as a Provincial Government-level Grand Mosque.

One of the features of the Grand Mosque of Al-Jabbar is its iconic architectural design, which has a floor size o$99 \times 99\ m^2$ with a height of $40\ meters$, with a consistent shape from any side and this mosque stands without a single supporting column. Other features are that when viewed from a distance, the mosque building will appear to float on the water, there are four minarets with a height of $99\ meters$, a monumental prayer room so that someone entering the room will feel small, a prayer area surrounded by 27 niches with different batik motifs representing the number of cities and regencies in West Java, a royal crown at the top of the ceiling of the prayer area, and colourful glass as the skin of the mosque.

Based on the results of data collection, it was found that there are ethnomathematics values in several buildings of the Grand Mosque of Al-Jabbar. The structure of the Grand Mosque of Al-Jabbar contains plane geometry shapes, namely triangles, squares, rectangles, hexagons, and circles. There are also elements of space geometry, namely pyramids, prisms, and tubes. For the concept of algebra, namely in the form of number patterns that can be found in the arrangement of mosque domes that have number patterns 1, 2, 4, 5, 10.

Triangle

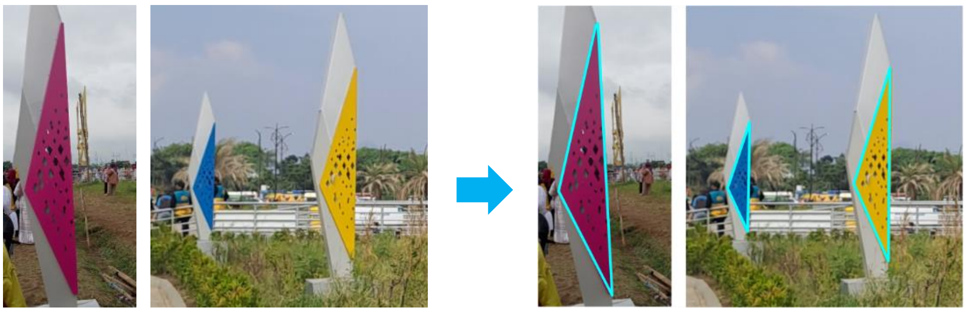

Figure 2: Triangles

This part can be found around the front area of the mosque, which is often found when first entering the mosque area. There are several similar shapes with different colours. The colours are the same as those found on the four minarets, namely blue, yellow and purple. This part has a function as a lamp around the mosque area. When viewed in Figure 1, this section forms a triangular flat shape because there are three sides that intersect and form three corner points. In Putra et al., (2020) research, triangular elements were also found in the ethnomathematics exploration at Soko Tunggal Mosque. Students can explore and identify the size of the triangle, and calculate its area and perimeter. Students can also explore the comparison of one triangle with another because there are several different shapes.

The triangle in Figure 2 is an arbitrary triangle. Teachers can use the context of this shape in learning about the area of an arbitrary triangle for example making a worksheet in advance which is left to students to explore. There are two possible ways that students can do it, namely by using the area of an arbitrary triangle or with the general formula for the area of a triangle, namely $\frac{1}{2} \times b \times h$. The use of this triangle context can be used as an alternative for teachers in overcoming misconceptions experienced by students (Altıparmak & Gürcan, 2021).

Square

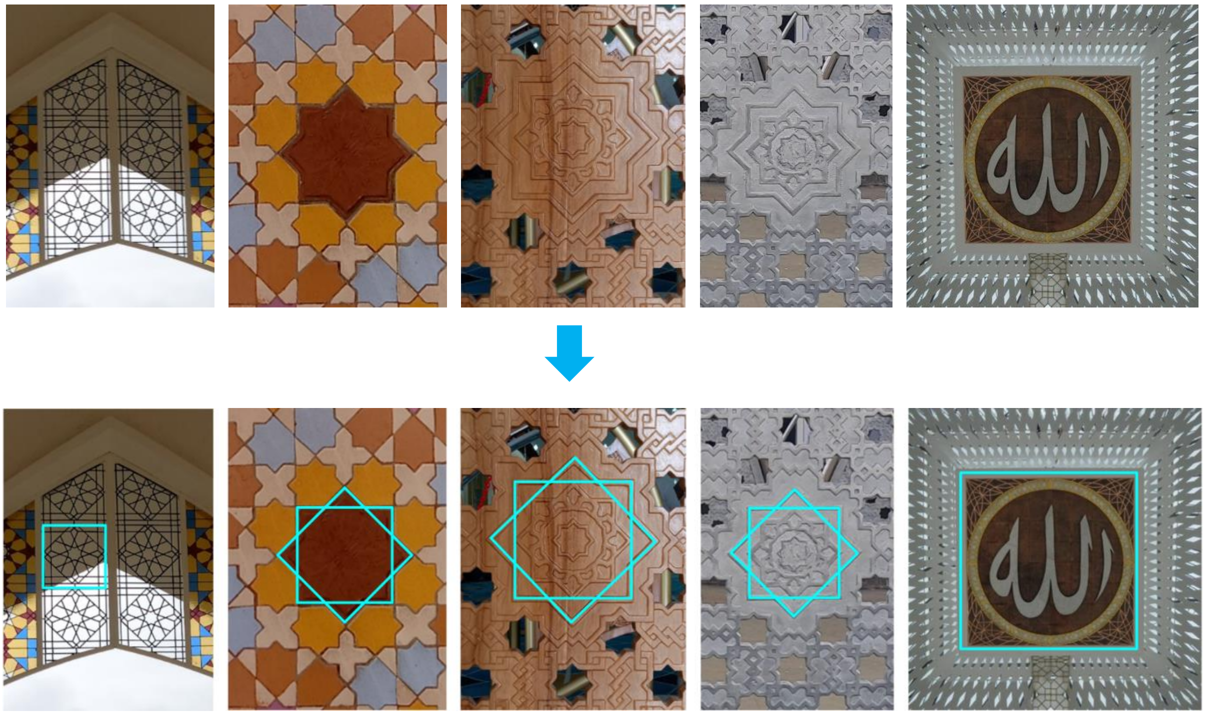

Figure 3: Squares
Source: https://topkonstruksi.com/

The next shape found is square. In Figure 3, it can be seen that the square shape can be found in various parts of the mosque, including the ornaments of the corridor building surrounding the main building of the mosque, ornaments of outdoor ablution places, carved ornaments of stair dividers made of wood and iron, and the frame of the word of Allah on the ceiling of the mosque. Square ornaments found on outdoor ablution places, and stair divider ornaments were also found in research Purniati et al., (2022) conducted at the Grand Mosque of Bandung. The square shapes on the ornaments must use careful observation to find them. It can be seen that the parts form a flat shape consisting of 4 equal-length sides and all the angles are equal and right-angled.

These square shapes can help teachers connect quadrilateral material with contexts in everyday life. Questions about the area of a quadrilateral and the perimeter of a quadrilateral can be asked by the teacher to the students. More specifically, teachers can use this context in creating worksheets. For example, in learning about the area of a square, students will work on a worksheet provided by the teacher.

Rectangle

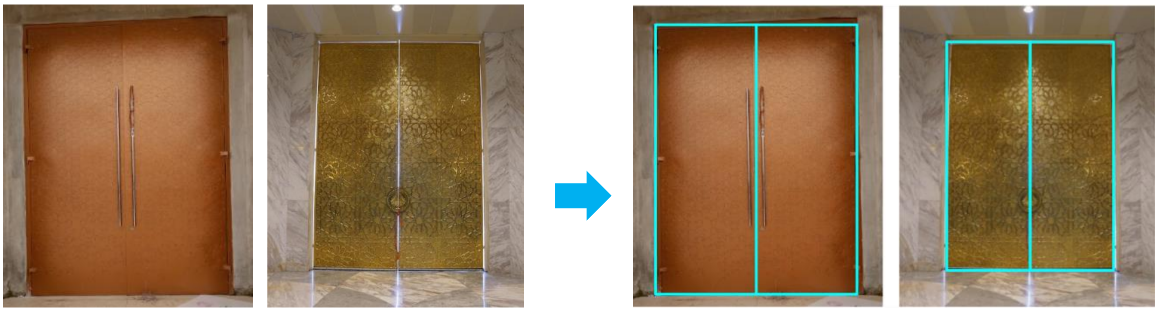

Figure 4: Rectangles
Source: https://aljabbar.jabarprov.go.id/

In Figure 4 above is the door of the Al-Jabbar Grand Mosque. The making of this door involves local craftsmen who are hand made. When viewed in Figure 4, the door of the Al-Jabbar Grand Mosque forms a rectangular flat shape because it has two pairs of parallel sides that are the same length as the four right angles. In the research of Irsyad et al., (2020) it was also found that there are rectangular elements that can be used as an ethnamathematics context. Students can explore and identify the size of the rectangle, and calculate its area and perimeter. The concept of rectangular congruence is also found in the shape of this door.

Hexagon

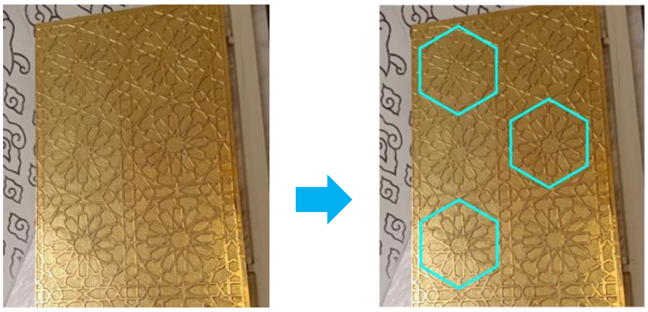

Figure 5: Hexagons

Figure 5 above is the door of the Al-Jabbar Grand Mosque. When viewed in Figure 5, there is a hexagon-shaped ornament. The ornament forms a regular hexagon because it has 6 equal sides and 6 equal angles. The number of angles in the hexagon is 720°.

Circle

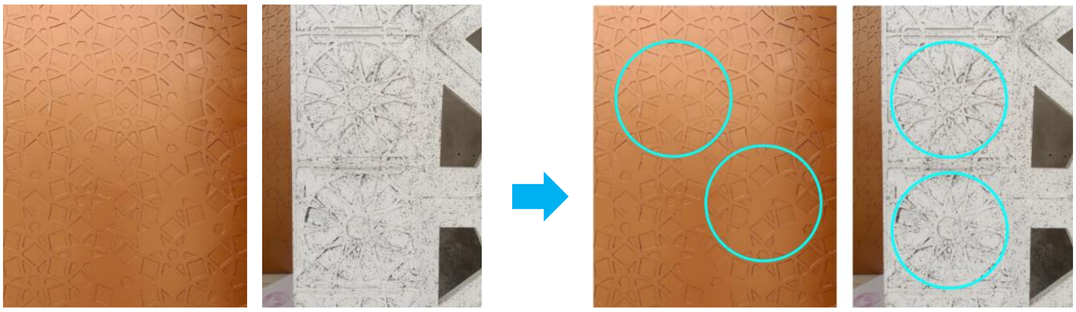

Figure 6: Circles

The circular concept in the picture above is found in the mosque ornaments, and the side door ornaments of the majid. These ornaments are very distinctive. They form a set of points at a constant or regular distance from a fixed point on a plane.

Pyramid

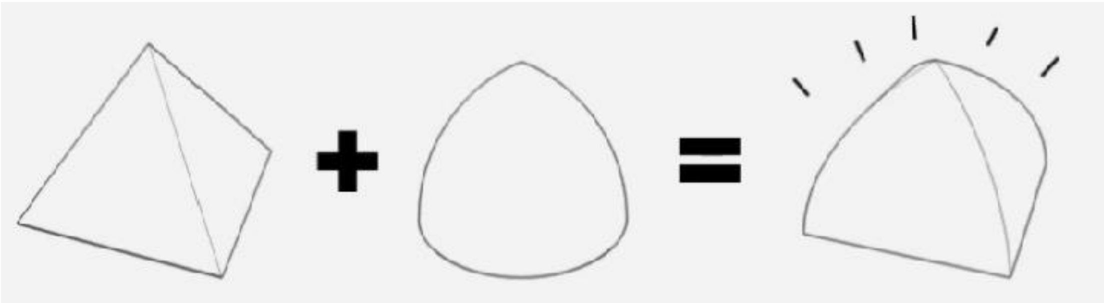

Figure 7: Pyramid
Source: https://www.instagram.com/urbane.indonesia/

Figure 6 above is an illustration of the main form of the mosque. It is a reconstruction of a pyramid and a tent. The structure of the mosque forms a three-dimensional space bounded by a rectangular base and triangular upright sides.

Prism

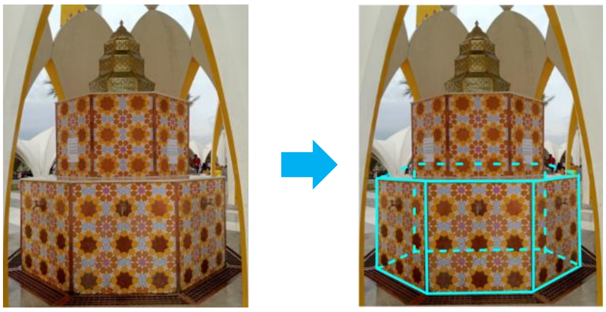

Figure 8: Prism

In Figure 7 above is the outdoor ablution place of the Al-Jabbar Grand Mosque. When viewed in Figure 7, this outdoor ablution building forms a space, namely a hexagon prism. The building forms a prism because it has a base plane and a parallel and congruent top plane.

Tube

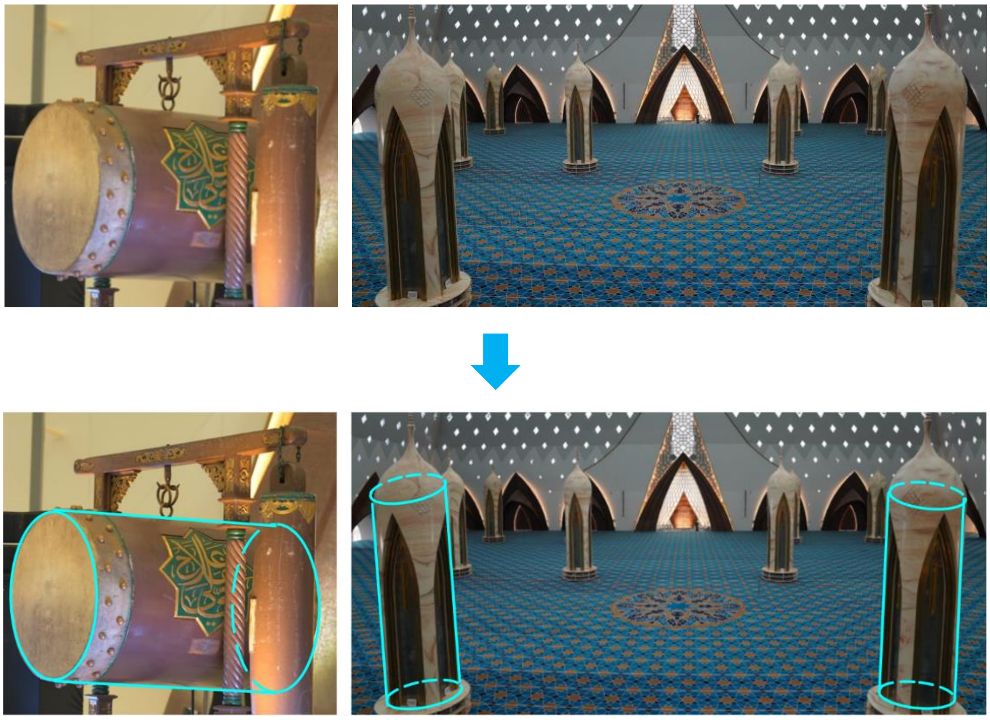

Figure 9: Tube
Source: https://seratusnews.id/; https://aljabbar.jabarprov.go.id/keistimewaan

In Figure 8 above is a drum in the Al-Jabbar Grand Mosque and a pole that rises in the main part of the mosque which totals 12 poles. This drum and poles are a representation of the shape of the tube. This section represents a three-dimensional space formed by two identical circles that are parallel and a rectangle that surrounds the two circles.

Number Patterns

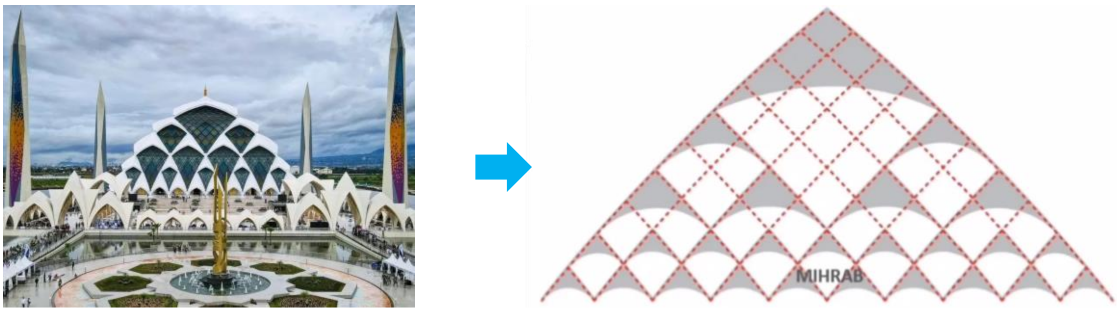

Figure 10: Number Pattern
Source: https://genzpedia.com/; Sumber: https://www.instagram.com/urbane.indonesia/

As explained in the previous section, the naming of the Al-Jabbar Grand Mosque was inspired by Algebra in mathematics. This is one of the unique features of the Al-Jabbar Grand Mosque building. The construction of the dome of the Al-Jabbar Grand Mosque with curved arches forms a number pattern from the order of the top dome to the bottom, namely 1, 2, 4, 5, 10. This number pattern can be used by teachers as a context in learning about number patterns. This number pattern consists of two rules: arithmetic with difference 1 and geometry with ratio 2. The details are as follows.

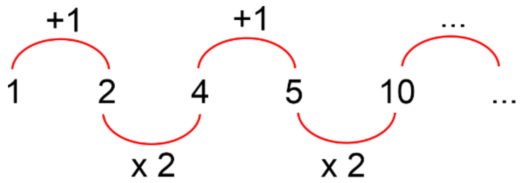

Figure 11: Pola bilangan

Teachers can use this ethnomathematics-based contextual problem in implementing mathematics learning in the classroom. Contextual learning uses a variety of contextual problems, so that students learn to use their knowledge and abilities to solve problems, both problems related to lessons at school, problems outside school or in the real environment (Nurhana & Abdullah, 2021). With this ethnomathematics-based contextual learning, students are more interested in participating in the mathematics learning process and are motivated to learn while loving culture (Rosikhoh & Abdussakir, 2020).

Conclusion

The building of the Grand Mosque of Al-Jabbar contains spiritual and cultural significance. The mosque, whose construction was inspired by the mathematical formula of algebra, can be found several mathematical concepts that can be applied in learning. The researcher's exploration found several concepts that can be used in learning mathematics, especially regarding geometry and algebra. There are parts of the Grand Mosque of Al-Jabbar building that represent the shape of plane geometry and three dimensional geometry. Plane geometry consists of triangles, squares, rectangles, hexagons, and circles. three dimensional geometry consists of pyramids, prisms, and tubes. The construction of the Grand Mosque of Al-Jabbar dome with curved arches forms a number pattern from the order of the top dome to the bottom, namely 1, 2, 4, 5, 10. Teachers can use the results of this study to make one of the alternative contextual problems in learning mathematics. Students can learn through the building structure found in the mosque. Learning will be more fun and can improve student understanding. The exploration carried out by researchers is only limited to the concepts of geometry and algebra, for further research can use other ethnomathematics exploration studies, for example based on the theory described by Bishop. Other studies can also use a quantitative approach to see how effective the use of the ethnomathematics context of the Grand Mosque of Al-Jabbar building in learning mathematics, especially geometry and algebra.

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Declaration of Interest Statement

The authors declare that they have no conflict of interests.

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