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Ethnomathematical Exploration in the Architectural Design of *Masjid Agung Al-Jami' Pekalongan*

Nadia Risqi Sabita[1*], Muhammad Ulinnajah[2], Syifa' Nur Latifah[3], Rayya Rahma Aulya[4], Ahmad Faridh Ricky Fahmy[5]
[1]Mathematics Education, Universitas Islam Negeri K.H. Abdurrahman Wahid *Pekalongan*, Indonesia.
✉ Author Corresponding: nadia.risqi.sabita24022@mhs.uingusdur.ac.id*

ABSTRACT

This research is motivated by the importance of contextual mathematics learning through a local cultural approach, particularly in the study of ethnomathematics in mosque architecture. The Great Mosque of *Al-Jami' Pekalongan* contains various architectural elements that reflect geometric and transformation geometry concepts that can be utilized as learning resources in mathematics. This study aims to explore the ethnomathematical concepts found in the architecture of the Great Mosque of *Al-Jami' Pekalongan* and their implications for mathematics learning. This study employed a qualitative approach using an ethnographic method. Data were collected through observation, documentation, and interviews with mosque administrators. Data analysis techniques were carried out through data reduction, data presentation, and conclusion drawing. The results showed that the architecture of the Great Mosque of *Al-Jami' Pekalongan* contains concepts of plane and solid geometry, such as squares, rectangular prisms, cylinders, spheres, and pyramids, as well as transformation geometry concepts including reflection, translation, rotation, dilation, similarity, and congruence. In addition, symbolic elements were found in the 27-meter tower height and the 99 steps, which represent religious values in Islamic culture. These concepts function not only as aesthetic and structural elements of the building, but also contain cultural and religious values that reflect the relationship between mathematics and community life. The implications of this study indicate that mosque architecture can be utilized as a contextual learning medium to help students understand geometric concepts more concretely and meaningfully through an ethnomathematics approach.

Keywords: Exploration; Ethnomathematics; Mosque; Geometry.

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1. INTRODUCTION

Masjid Agung Al-Jami' Pekalongan is one of the oldest religious and cultural icons in *Pekalongan* City, Central Java. Located in the *alun-alun* area of *Pekalongan* City, this mosque serves as a center for worship activities, Islamic education, and a gathering place for the community in various social and cultural activities. Established in the 19th century, *Masjid Agung Al-Jami' Pekalongan* holds high historical value as it witnessed the development of Islamic preaching and the growth of civilization in the northern coastal society of Java. Architecturally, this mosque combines traditional Javanese architectural style with Islamic influences, as reflected in its three-tiered roof resembling a joglo, carved wooden ornaments with Arabic calligraphic nuances, and a towering minaret standing on the eastern side. This combination demonstrates that the mosque

functions not only as a place of worship but also as a symbol of harmony between local culture and Islamic values (Amaris, 2019).

The existence of *Masjid Agung Al-Jami' Pekalongan* demonstrates a close relationship between local culture and religious teachings in community life. Javanese cultural values emphasizing harmony, simplicity, and balance are integrated with Islamic values that teach monotheism, togetherness, and obedience to Allah SWT. In addition to its historical and religious significance, Masjid Agung Al-Jami' also possesses architectural characteristics that can be associated with mathematical concepts, making it relevant to the focus of this study. These mathematical elements can be observed in the mosque's structure, which contains geometric concepts, both plane and solid geometry, in its roof, pillars, doors, and windows. The three-tiered roof can be associated with the concepts of ratio and similarity, while the spatial arrangement and symmetrical ornaments reflect the concepts of symmetry and mathematical patterns. Furthermore, the arrangement of pillars and floor motifs demonstrates regularity and repetition related to number patterns and geometric transformations. Therefore, *Masjid Agung Al-Jami' Pekalongan* not only possesses philosophical and religious values but also contains mathematical elements that can serve as a contextual learning resource in ethnomathematics studies.

The relationship between culture and religion in Islamic architecture opens significant opportunities for education, particularly in the development of contextual mathematics learning. Mathematics is often perceived as an abstract discipline that is difficult to understand and disconnected from everyday life. Many students consider mathematics to be a difficult and intimidating subject because they are unable to find its direct relevance to their surrounding environment (Permatasari, 2021). In fact, mathematical concepts are inherently present in community life, including in cultural works and architecture such as mosques, temples, batik, and traditional houses. According to many scholars, mathematics is both the queen and servant of all sciences (Walihah, 2024). Therefore, mathematics learning connected to cultural contexts can help students understand that mathematics is tangible and closely related to their daily lives (Rakhmawati, 2018).

Ethnomathematics demonstrates that mathematical concepts can be found in various cultural activities within society, including in the architecture of traditional and religious buildings. Through this approach, mathematics learning can be connected to cultural environments familiar to students, making mathematical concepts more contextual and meaningful. One branch of mathematics closely related to architectural forms is geometry. This can be observed in how students are required to represent visual and spatial experiences into various forms, such as lines, planes, spaces, and mappings (Nugraha, 2018). Therefore, architectural structures can be utilized as media to help students understand geometric concepts concretely.

A contextual approach in mathematics learning is an important strategy for developing deeper conceptual understanding. Through this approach, students are encouraged to connect mathematical concepts with real-life experiences so that they not only memorize formulas but also understand their meanings. One effective approach to achieve this is ethnomathematics, which is the study of the relationship between mathematics and culture (Dewi, 2019). This term was first introduced by D'Ambrosio in 1977 and has since become a popular approach in integrating local values into mathematics learning. In the context of mosque architecture, ethnomathematics can reveal various concepts of geometry, symmetry, proportion, and patterns applied in building design, while also demonstrating how cultural and Islamic values are represented through architectural structures and forms (Zaenuri, 2021).

Previous studies have also shown that religious buildings in Indonesia are rich in ethnomathematical values. Izah & Malasari (2021) found concepts of plane and solid geometry in the architecture of Sunan Bonang Mosque, reflecting the simplicity and steadfastness of Islamic teachings. Faturrahman & Soro (2021) revealed the presence of reflection transformation and symmetry in the design of Al-Alam Marunda Mosque, illustrating the unity between form and function. Meanwhile, Sihombing & Tambunan (2021) studied the ornaments of Rumah Bolon Batak Toba and found applications of circles, triangles, and rectangles as representations of cosmological balance that can be utilized as mathematics learning media. These studies indicate

that ethnomathematics not only functions to uncover mathematical aspects within culture but also serves as a bridge to bring students closer to meaningful local values (Faturrahman, 2021; Izah, 2021; Sihombing, 2021).

However, until now, there have been limited studies specifically examining ethnomathematical values in the architectural design of *Masjid Agung Al-Jami' Pekalongan* in depth, particularly those connecting local cultural elements with mathematical concepts and their utilization as contextual learning resources. Previous studies generally focused only on identifying geometric forms or mathematical patterns in certain cultural buildings, such as traditional houses and ornaments, without comprehensively examining philosophical meanings, cultural values, and their relationship to culture-based mathematics learning. In fact, this mosque has great potential as an object of study because it integrates traditional Javanese architecture, coastal culture, and Islamic values into a single structure. Elements such as roof structures, supporting pillars, floor patterns, and calligraphic ornaments not only display visual beauty but also contain mathematical concepts such as symmetry, similarity, plane and solid geometry, and proportional comparison. An ethnomathematical study of this building will provide an understanding of how the people of *Pekalongan* comprehend and apply mathematical concepts through their culture and religion. Therefore, this study not only examines the concepts of transformational geometry found in the architectural elements of *Masjid Agung Al-Jami' Pekalongan* but also analyzes its educational value as a source of ethnomathematics learning.

Based on the explanation above, this study aims to explore the ethnomathematical values contained in the architectural design of *Masjid Agung Al-Jami' Pekalongan*. This study is expected to enrich knowledge regarding the relationship between mathematics, culture, and religion, while also contributing to the development of contextual mathematics learning models based on local culture. Through this exploration, students are expected to understand that mathematics is not merely a collection of numbers and formulas, but a living discipline embedded in every aspect of human life, including the cultural and religious heritage of the nation.

2. METHODS

This study employed a qualitative approach with an exploratory-descriptive design. The purpose of this study was to explore the ethnomathematical values embedded in the architecture of *Masjid Agung Al-Jami' Pekalongan*. This approach was selected because the research focuses on the meanings and cultural contexts contained within the mosque's architectural structure (Moleong, 2019). The qualitative method was chosen because this study aims to understand phenomena in a deep and contextual manner (Creswell, 2018). Through this approach, the researcher was able to interpret the symbolic meanings of each architectural element of the mosque and relate them to mathematical concepts and cultural values within the *Pekalongan* community. Thus, this study not only describes the geometric forms or structures of the mosque but also reflects the philosophical meanings behind the application of ethnomathematical concepts in religious architecture (Rachmawati F., 2021).

The research was conducted at *Masjid Agung Al-Jami' Pekalongan*, located in *Pekalongan* City, Central Java. The data sources consisted of two types, namely primary data and secondary data. Primary data were obtained through direct observation of various architectural elements, such as the roof structure, supporting pillars, floor patterns, calligraphic ornaments, and other related features. Primary data were also collected through in-depth interviews with mosque administrators. Meanwhile, secondary data were obtained from various documents, journals, and literature related to ethnomathematics and Islamic architecture (Kusuma, 2020).

The data collection techniques included observation, interviews, and documentation. Observation was used to identify geometric forms and symmetries found within the mosque's architectural structure (Sugiyono, 2018). Interviews were conducted to understand the philosophical and cultural meanings embedded in the architecture. Documentation was utilized to support visual data and information throughout the research process (Creswell, 2018). Data analysis was conducted descriptively using qualitative methods through the stages of data reduction, data presentation, and conclusion drawing. The validity of the data was strengthened

through source and technique triangulation methods to ensure consistency among the results of observations, interviews, and documentation (Moleong, 2019).

3. RESULT AND DISCUSSION

3.1 Ethnomathematical Elements in Mosque Architecture

Masjid Agung Al-Jami' Pekalongan reflects the development of the Islamic community in *Pekalongan* from the 19th century to the modern era. This mosque functions not only as a place of worship but also as a symbol of identity, a center of socio-religious life, and an important part of the traditional urban spatial arrangement influenced by the spatial pattern of the Mataram Sultanate. During the growth of the Muslim population and the intensification of Islamic preaching, the need for a large mosque became increasingly urgent. Therefore, the mosque was strategically located on the western side of the town square, following the Mataram tradition that positioned the pendopo in the east, the prison in the northeast, and the mosque in the west.

Masjid Jami' Pekalongan was established on Tuesday Kliwon, 9 *Rabiul Awwal* 1270 H or December 26, 1852 by Resident *Raden Aryowiryo Tumenggung Adinegoro*. The original building measured 25 × 25 meters and featured nine large doors, twelve windows, one mihrab, and a small dome. This structure became the core of the mosque building for the following periods. The mosque architecture underwent several stages of development without eliminating the distinctive characteristics of its main structure. In addition to functioning as a place of worship, the mosque also possesses historical, aesthetic, and cultural values reflected in its various architectural elements.

Masjid Agung Al-Jami' Pekalongan is also one of the historical mosques located in *Pekalongan* City that possesses high aesthetic and philosophical values. One of the most interesting parts that can be studied is its minaret, which has a height of 27 meters and consists of 99 steps. These two elements function not only as parts of the architectural structure but also contain profound symbolic meanings. The 27-meter height of the minaret symbolizes the 27 degrees of reward that Muslims will receive when performing congregational prayers. Meanwhile, the 99 steps symbolize the 99 *Asmaul Husna*, which are the beautiful names of Allah SWT. This meaning indicates that each step taken while ascending the stairs toward the top of the minaret symbolizes the spiritual journey of a servant toward God.

From an aesthetic perspective, the proportionally designed minaret becomes the visual focal point that emphasizes the grandeur of the mosque building. The repetitive arrangement of the stairs creates rhythm and visual balance while simultaneously conveying the philosophical meaning that true beauty is reflected not only in physical form but also in the meaning behind every created element. Therefore, the design of the minaret of *Masjid Agung Al-Jami' Pekalongan* demonstrates a harmonious integration of mathematical elements, religious symbolism, and aesthetic values, reflecting ethnomathematics in Islamic architecture.

3.2 Ethnomathematical Exploration

Based on the results of the exploration, *Masjid Agung Al-Jami' Pekalongan* contains ethnomathematical objects that can be applied in mathematics learning activities. The following section discusses the results of the ethnomathematical exploration conducted at *Masjid Agung Al-Jami' Pekalongan*.

a. Rectangular Prism

A rectangular prism is geometrically defined as a three-dimensional shape composed of three pairs of rectangular or square faces that are opposite and parallel to each other (Arina Manasikana, 2023). The use of rectangular prism structures in traditional artifacts or architecture indicates that communities have long understood the function of load distribution through the precise utilization of twelve edges and eight vertices to ensure structural stability. Philosophically, the harmony among identical diagonal planes reflects the values of balance and order highly upheld in local wisdom. Therefore, integrating this object into mathematics learning becomes highly relevant. By exploring the meaning and function behind its form, students not only learn to calculate volume or surface area but also

appreciate ethnomathematical values as evidence of the application of spatial knowledge in addressing functional and aesthetic challenges in real life. Several applications of rectangular prism forms in *Masjid Agung Al-Jami' Pekalongan* are as follows.

a) Grand Mosque Pillars

Figure 1. Grand Mosque Pillars

b) Wall Speakers

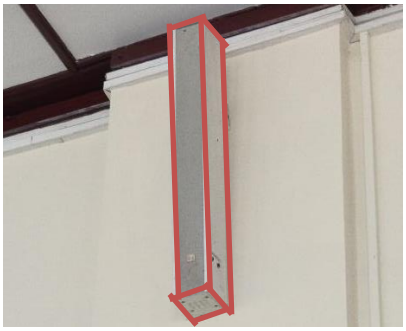

Figure 2. Speakers

Rectangular prism forms can be found in several architectural elements of *Masjid Agung Al-Jami' Pekalongan*, such as the mosque pillars and wall speakers. The rectangular prism shape demonstrates the application of solid geometry concepts with flat surfaces consisting of three pairs of parallel rectangular faces. The use of this shape reflects spatial efficiency and structural stability. In mathematics learning, these rectangular prism-shaped objects can be utilized as contextual media in solid geometry topics. Teachers may ask students to identify the elements of a rectangular prism, such as edges, vertices, and faces on the mosque pillars. In addition, students can also calculate the volume and surface area based on the actual dimensions of objects in their surrounding environment. Through this approach, geometric concepts can be connected to the students' culture and real-life environment.

b. Cylinder

Geometrically, a cylinder is defined as a three-dimensional shape formed by two identical and parallel circles serving as the base and the top, connected by a curved surface (Arina Manasikana, 2023). In *Masjid Agung Al-Jami' Pekalongan*, this concept is clearly represented in the *Bedug* instrument, although its meaning extends beyond merely representing a curved surface and circular faces. Functionally, the hollow space within the cylindrical volume serves as a resonance chamber that is crucial for producing strong and stable sound waves. In the context of ethnomathematics, this demonstrates a traditional understanding of acoustics in which local communities utilized the geometric properties of cylinders to achieve a wide sound range as a medium of social and religious communication.

Philosophically, the circular shapes on both sides of the *Bedug* connected by a curved surface without angles symbolize continuity and infinity in the relationship between humans and the Creator, as well as among fellow worshippers. The relevance of this object in

mathematics learning is highly significant because it provides a real context for students to understand that the formulas for the volume and surface area of a cylinder have practical applications in determining sound quality and structural durability.

Figure 3. Grand Mosque *Bedug*

In mathematics learning, the *Bedug* can be utilized as a contextual learning medium for the topic of curved-surface solid geometry, particularly cylinders. Teachers can guide students to identify the elements of a cylinder, such as radius, diameter, height, base, top, and curved surface based on the actual shape of the *Bedug*. In addition, students can also perform activities involving the calculation of the cylinder's volume and surface area using the real dimensions of the *Bedug*. This learning process enables students to understand geometric concepts more concretely because they are directly related to cultural objects found in their surrounding environment. By examining the *Bedug* through an ethnomathematical perspective, students not only identify the existence of three-dimensional shapes but also appreciate how geometric principles are integrated with local wisdom values to address traditional communication technology needs in the past (Pebriana et al., 2024).

c. Sphere

Geometrically, a sphere is defined as a three-dimensional shape that has only one curved surface without edges, formed by infinitely many circles centered at a single point (Arina Manasikana, 2023). In *Masjid Agung Al-Jami' Pekalongan*, this geometric principle is intelligently applied through the decorative lamps located in the front area of the mosque. The use of spherical forms in mosque elements contains profound philosophical values, as the perfectly round shape without beginning or end reflects the concept of *kamal* or perfection and the oneness of God in Islamic aesthetics. From an ethnomathematical perspective, this object becomes highly relevant in mathematics learning because it bridges the abstract concepts of center points and radii with physical realities that possess spiritual meaning. This contextual approach strengthens the argument that mathematics is not an isolated discipline, but rather an instrument embedded within the cultural and religious expressions of society (Pebriana et al., 2024).

Figure 4. Courtyard Lamps

In mathematics learning, spherical decorative lamps can be utilized as contextual media for the topic of curved-surface solid geometry. Teachers can guide students to identify the elements of a sphere, such as the center point, radius, and diameter based on real objects in the surrounding environment. In addition, students can also engage in activities involving the

calculation of the surface area and volume of a sphere using the dimensions of the decorative lamps observed directly. These activities help students understand geometric concepts more concretely rather than relying solely on abstract illustrations in textbooks.

d. Square Pyramid

A pyramid is a three-dimensional geometric shape consisting of a polygonal base and triangular lateral faces that meet at a single vertex (Meirida, 2021). Functionally, the upward-tapering pyramid shape is highly effective for tropical climate management, such as facilitating rapid rainwater drainage and supporting proper air circulation within the mosque interior. From an ethnomathematical perspective, the use of this pyramid form demonstrates local intelligence in applying principles of aerodynamics and gravitational load distribution centered at a single highest point, reflecting an applicative understanding of geometry.

Philosophically, the pyramid shape, with its broad base narrowing toward a single apex, symbolizes the concept of *hablum minannas* (human relationships) at the base and *hablum minallah* (the relationship with God) at the single highest point. This represents a spiritual journey toward the oneness of God. By exploring the pyramid structures in this mosque, students are encouraged to understand that mathematics is a cultural communication tool used to express divine values and the harmony of life, making learning more humanistic and less rigid (Pebriana et al., 2024; D'Ambrosio, 1985).

a) Mosque Dome

Figure 5. Grand Mosque Dome

b) Fence Wall

Figure 6. Mosque Fence Wall

In mathematics learning, pyramid forms found in mosque architecture can be utilized as contextual media for the topic of polyhedral solid geometry. Teachers can guide students to identify the elements of a pyramid, such as the apex, edges, lateral faces, and base through direct observation of mosque domes or ornaments. In addition, students can also engage in activities involving the calculation of the surface area and volume of pyramids based on the dimensions of the observed objects. The application of pyramid forms in mosque buildings can also be developed in contextual problem-solving learning. For example, students may be asked to estimate the amount of building materials required for pyramid-shaped roofs or analyze the relationship between pyramid forms and structural stability. These activities help

students understand that mathematical concepts are not only studied theoretically but are also applied in architectural planning and construction in real life.

e. Square

A square is a two-dimensional geometric shape characterized by four equal sides and four right angles, as well as a high degree of symmetry through four lines of symmetry and rotational symmetry (Manasikana, 2023). In *Masjid Agung Al-Jami' Pekalongan*, the application of square forms can be found in various elements, ranging from tile patterns and wall decorations to spatial layouts. In the context of ethnomathematics, the precision of the square is not merely a technical matter, but also a manifestation of the value of *nizham* (orderliness) and justice, in which each side has an equal position, symbolizing balance in social and spiritual life. Several applications of square forms in *Masjid Agung Al-Jami' Pekalongan* are as follows.

a) Mosque Floor

Figure 7. Mosque Floor

b) Mosque Ceiling

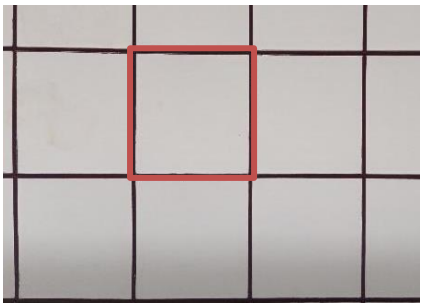

Figure 8. Mosque Ceiling

c) Courtyard Lamp Base

Figure 9. Lamp Base

d) Calligraphy in the Hall

Figure 10. Calligraphy

e) Side Door

Figure 11. Side Door

In mathematics learning, square forms found in mosque architecture can be utilized as contextual media for the topic of plane geometry. Teachers can guide students to identify the properties of squares, such as side lengths, diagonals, lines of symmetry, and rotational symmetry through direct observation of mosque floor or ceiling patterns. In addition, students can also engage in activities involving the calculation of the perimeter and area of squares based on the actual dimensions of the observed objects. Repetitive square patterns found on floor tiles can also be developed into learning activities related to tessellation and geometric transformations, such as translation and reflection. Teachers may ask students to analyze tile repetition patterns to understand the concepts of shifting and symmetry in plane figures. Thus, mathematics learning becomes more concrete and helps students understand the relationship between geometric concepts and the cultural environment around them.

By observing square patterns in mosque architecture, students can understand that symmetry is not merely an abstract topic, but also an instrument used to create visual harmony and structural stability. This argument is reinforced by the fact that culture-based learning (ethnomathematics) has been proven to improve students' abstraction abilities because they learn from objects that possess emotional and religious values within their environment (Pebriana et al., 2024).

f. Triangle

A triangle is defined as a two-dimensional geometric figure formed by three vertices and three sides, which can be classified based on side lengths and angle measurements (Manasikana, 2023). Philosophically, triangles in Islamic architecture are often interpreted as symbols of balance among the three main pillars: *Iman* (faith), *Islam*, and *Ihsan*. In addition, the upward-pointing apex represents human aspiration toward God. The relevance of this object in mathematics learning is highly significant because it provides a bridge for students

to explore the concepts of geometric rigidity and basic trigonometry through real objects. By analyzing the use of triangles in calligraphy or mosque structures, students are encouraged to observe how mathematics is intelligently utilized to solve spatial problems while simultaneously conveying theological messages. This approach strengthens the argument that ethnomathematics-based geometry learning can enhance students' cognitive engagement because the material being studied possesses practical applications and cultural values closely related to their daily lives (Pebriana et al., 2024; D'Ambrosio, 1985) Several applications of triangular forms in *Masjid Agung Al-Jami' Pekalongan* are as follows.

a) Mosque Parking Roof Supports

Figure 12. Parking Roof Supports

b) Side Roof Supports of the Mosque

Figure 13. Mosque Roof Supports

In mathematics learning, triangular forms found in mosque architectural structures can be integrated as representative learning resources for geometry topics. Teachers can guide students to examine the fundamental characteristics of triangles, ranging from proving the sum of interior angles (180°), identifying types of triangles based on side lengths and angle measurements, to understanding special lines such as altitudes, angle bisectors, and medians. Through direct observation of decorative elements, students can also be challenged to solve contextual problems involving estimations of ornament surface areas and perimeters.

The phenomenon of roof inclinations or interlocking triangular geometric patterns also has strong potential for constructing students' understanding of congruence, similarity, and the Pythagorean theorem. Through analysis of these visual patterns, teachers can guide students to understand how the concepts of side and angle relationships function harmoniously within a physical design. Therefore, the process of mathematical knowledge construction becomes more meaningful because it is based on real cultural artifacts closely connected to students' lives.

g. Rectangle

A rectangle is a plane geometric figure that has four sides with two pairs of parallel sides of equal length, as well as four identical right angles measuring 90° (Manasikana, 2023). In *Masjid Agung Al-Jami' Pekalongan*, the application of rectangular forms is dominantly found in window frames, doors, and calligraphy panels. In the context of ethnomathematics, the

ratio between length and width in mosque panels often reflects harmonious proportions, which are used to balance structural strength and visual aesthetics.

In Islamic aesthetics in *Pekalongan*, this shape symbolizes tranquility and stability, where the long horizontal lines represent worldly peace, while the vertical lines symbolize spiritual relationships. The relevance of this object in mathematics learning is highly significant because it helps students explore the concepts of perimeter, area, and symmetry through media that possess socio-religious functions. By examining rectangles in mosque architecture, students can understand that mathematics is not merely about numerical calculations, but also an instrument for creating order (*nizham*) that supports the solemnity of worship. This approach strengthens the argument that contextual learning based on cultural objects can improve students' spatial awareness while also fostering appreciation for their local identity (Pebriana et al., 2024). Several applications of rectangular forms in *Masjid Agung Al-Jami' Pekalongan* are as follows.

a) Signboard of *Masjid Agung Al-Jami' Pekalongan*

Figure 14. Mosque Signboard

b) Main Door

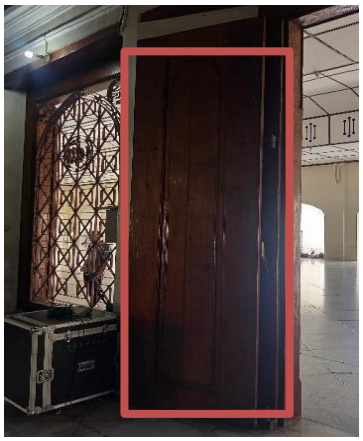

Figure 15. Main Mosque Door

In mathematics learning, the visualization of rectangular forms in these physical elements of the mosque can be transformed into instructional instruments rich in contextual value. Teachers can guide students to construct an understanding of basic concepts through proving the properties of rectangles, such as analyzing the equality of the two pairs of opposite sides, the identical nature of right angles, and the characteristics of the two diagonals that intersect at equal lengths. This process can be deepened by challenging students to solve mathematical estimation problems, such as calculating the surface area of the main door or determining the perimeter of the calligraphy panel frames using real measurement units. In addition, the proportional ratios between the length and width of mosque architectural panels have strong potential to bridge students' understanding of scale, direct proportion, and the concept of similarity between two-dimensional figures. Through activities involving the comparison of geometric dimensions among windows or ornamental panels, students are taught to observe how mathematical principles of order operate precisely within real architectural works. Therefore, the process of internalizing geometric

knowledge no longer feels monotonous, but instead becomes more inclusive and meaningful because it is grounded in cultural artifacts that exist within their community.

h. Hexagon

A hexagon is a plane geometric figure that has six sides and six angles, which geometrically can be viewed as a composition of six equilateral triangles meeting at a single central point (Prastika DB, 2025). In *Masjid Agung Al-Jami' Pekalongan*, this hexagonal form is applied to the structure of the date palm tree pots located in the mosque courtyard. In geometry, the hexagonal tessellation pattern is the most optimal shape for filling a plane without gaps and possesses high mechanical strength in resisting soil pressure within the pot. This represents local intelligence in adopting the principles of natural efficiency, similar to the honeycomb pattern mentioned in the Qur'an (QS. An-Nahl: 68–69), into human architectural works.

Philosophically, the hexagonal form contains values of togetherness, orderliness, and productivity. The symmetrical interconnectedness among its sides symbolizes synergy and harmony in communal life. The relevance of this object in mathematics learning is highly significant because it provides a real context for students to explore concepts such as central angles, rotational symmetry, and tessellation. By analyzing the date palm tree pots, students are encouraged to understand that the concept of 360° precisely divided into 60° angles within each composing triangle is not merely numerical theory, but also the basis for creating structures that are both stable and aesthetically pleasing. This argument reinforces that the use of ethnomathematical objects within mosque environments can help students appreciate the relationship between natural laws (*ayat kauniyah*) and mathematical principles, thereby fostering critical and appreciative attitudes toward local wisdom (Pebriana et al., 2024; D'Ambrosio, 1985).

Figure 16. Pot

In the context of mathematics learning in the classroom, the visualization of hexagon-shaped date palm tree pots can serve as a geometry learning activity based on guided discovery. Teachers can guide students to investigate the structural characteristics of regular hexagons, such as analyzing the relationship between the outer side lengths and the distance from the center point (circumradius), as well as proving that the interior angles of a regular hexagon measure 120°. This activity can be further developed by challenging students to solve practical problems, such as calculating the total surface area of the pot walls through the decomposition of the figure into six equilateral triangles or estimating the perimeter capacity of the pot using actual field measurements. Furthermore, the characteristic of the pots being able to fit together without leaving empty spaces can be applicatively integrated into tessellation and transformational geometry topics, particularly rotations of 60° around the central point. Through mathematical exploration of this mosque courtyard artifact, students are guided to understand how principles of spatial efficiency function geometrically to support structural strength. Therefore, the process of constructing mathematical knowledge no longer feels purely theoretical, but instead becomes more vivid and meaningful because it is grounded in real cultural objects existing within their environment.

i. Parallelogram

A parallelogram is a quadrilateral that can geometrically be understood as the result of a 180° rotation of a triangle around the midpoint of one of its sides (Harun, 2025). In *Masjid Agung Al-Jami' Pekalongan*, the parallelogram form is intelligently applied to the staircase handrail structure. Functionally, the use of parallelogram shapes in staircase elements serves as a geometric solution to elevation inclinations. The slanted parallel sides allow the structure to consistently follow the slope of the stairs, providing stability for worshippers who rely on it, while also demonstrating the community's understanding of the principles of slope (gradient) and translation in physical building construction.

Philosophically, the parallelogram form in the mosque staircase conveys impressions of movement, continuity, and progression that align with the values of humanity's spiritual journey. Its slanted yet parallel shape symbolizes a dynamic spiritual ascent, where every step toward a higher place must remain grounded in the principle of balance. The relevance of this object in mathematics learning is highly significant because it serves as a real model for teaching concepts such as supplementary angles, rotational symmetry, and area through contextual approaches. By observing this staircase handrail, students not only calculate formulas on paper but also explore how geometry is used to adapt building structures to human mobility needs. This strengthens the argument that ethnomathematics-based learning can improve students' sensitivity toward the practical and aesthetic functions of mathematics in religious architecture (Pebriana et al., 2024).

Figure 17. Staircase Fence

In mathematics learning, the parallelogram-shaped staircase handrail structure can serve as a learning design based on exploratory discovery activities. Teachers can guide students to empirically prove the properties of parallelograms, such as investigating the relationship between two pairs of opposite angles of equal measure, analyzing adjacent angles that sum to 180°, and examining the property of diagonals bisecting each other equally. This activity can be strengthened by providing problem-solving challenges involving the reconstruction of the area formula, where students are invited to perform "cut-and-shift" activities on triangular components at the ends of the handrail to form functional rectangles. Furthermore, the constant slope found in the handrail support structure is highly suitable to be integrated as a concrete stimulus for understanding linear equations, particularly the concepts of gradients (slopes), parallel lines, and translation vectors. Through mathematical analysis of this mosque staircase element, students are guided to observe how pure mathematics is precisely applied to support human mobility and comfort. Therefore, the transfer of mathematical knowledge no longer feels merely theoretical, but instead becomes more relevant and meaningful because it is directly grounded in real cultural objects.

j. Rhombus

A rhombus is geometrically defined as a two-dimensional plane figure that has four equal sides and two pairs of non-right angles equal to their opposite angles. A rhombus is a special form of a parallelogram in which all sides are equal in length (Sinulingga, 2025). In *Masjid Agung Al-Jami' Pekalongan*, rhombus shapes are frequently found in decorative window

patterns, ventilations, and wood carvings. Functionally, the use of rhombus shapes as ventilation elements demonstrates local architectural intelligence in regulating lighting and air circulation. The rhombus-shaped openings allow air to flow dynamically while also providing privacy protection for the interior areas of the mosque, indicating that the selection of this form is based on considerations of environmental efficiency and worshippers' comfort.

Philosophically, the rhombus shape, which resembles two triangles reflected along their bases, symbolizes the balance between the physical and spiritual aspects of human life. The equal lengths of its four sides reflect the principles of justice and steadfastness in practicing Islamic teachings. The relevance of this object in mathematics learning is highly significant because it provides a concrete bridge for students to explore relationships among plane figures, such as the concept of perpendicular diagonals and the high degree of line symmetry. This ethnomathematical approach strengthens the argument that learning connected to local cultural heritage can increase students' motivation and critical thinking in understanding the practical applications of geometry in real life (Pebriana et al., 2024; D'Ambrosio, 1985). Several applications of rhombus shapes in *Masjid Agung Al-Jami' Pekalongan* are as follows.

a) Minaret Door

Figure 18. Minaret Door

b) Air Ventilation

Figure 19. Ventilation

In mathematics learning, the rhombus-shaped ventilation shown in the figure can become a geometry learning design based on spatial reasoning. Teachers can guide students to investigate the main properties of rhombuses through direct observation, such as proving that the diagonals always intersect perpendicularly at 90° and bisect each other equally, as well as examining the existence of two lines of symmetry. This activity can be deepened through contextual problem-solving tasks, in which students are challenged to reconstruct the calculation of the ventilation area not by memorizing formulas, but by dividing the rhombus along its diagonals to form two congruent isosceles triangles. The neatly arranged rhombus ventilation structures on the mosque walls are highly suitable to be integrated as real media for understanding transformational geometry concepts, particularly reflection across diagonal lines and two-dimensional congruence. Through mathematical exploration of these local ornamental elements, students are guided to observe how principles of symmetry and geometric order function practically in traditional architecture. Therefore,

mathematics learning no longer feels merely theoretical, but instead becomes more vivid because it is grounded in the beauty of the cultural heritage surrounding them.

k. Similarity and Congruence

The concepts of similarity and congruence in the architecture of *Masjid Agung Al-Jami' Pekalongan* represent manifestations of geometric principles that maintain proportionality and uniformity of form with precision. Similarity can clearly be observed in the repetition of elements such as rhombus-shaped ventilations that appear in various scales while maintaining identical diagonal ratios and angles. Functionally, this serves to regulate light intensity and air circulation at different points of the building without disrupting the overall harmony of the design. Meanwhile, congruence is evident in the rows of windows and doors that possess exactly the same shape and size. This uniformity is not merely physical repetition, but also a technical solution to ensure structural stability and ease of building maintenance (Faturrahman & Soro, 2021). Functionally, similar ventilations help regulate lighting and air circulation in various parts of the building while preserving the harmony of the architectural design. Meanwhile, the use of congruent doors and windows creates a symmetrical and orderly appearance while simplifying the construction process. In the context of ethnomathematics, these repetitive patterns demonstrate the relationship between mathematical concepts and aesthetic as well as cultural values in Islamic architecture.

From an ethnomathematical perspective, these repetitive patterns contain profound philosophical meanings related to the values of order (*nizham*) and unity (*tauhid*). Similarity, which preserves proportions despite differences in size, symbolizes hierarchy and harmony in life, whereas congruence reflects the value of equality before the Creator. The relevance of these concepts in mathematics learning is highly significant, providing concrete models for students to understand that geometric transformations such as dilation (in similarity) and translation (in congruence) are important instruments in creating meaningful spatial aesthetics. By observing mosque structures, students are encouraged to perceive mathematics as a living discipline utilized by traditional architects to convey theological messages through consistency of form.

In mathematics learning, the concepts of similarity and congruence found in mosque architecture can be utilized as contextual media in geometry topics. Teachers can guide students to identify similar and congruent figures through direct observation of the mosque's ventilations, doors, and windows. Students can also compare side lengths, angles, and ratios between figures to understand the characteristics of similarity and congruence more concretely. In addition, ventilation patterns with different sizes but similar forms can be developed into learning activities related to dilation in transformational geometry. Teachers may ask students to determine the scale factors of several observed ventilations. Meanwhile, congruent door and window patterns can be used to study the concepts of translation and symmetry in plane geometry. These activities help students understand that geometric concepts are not only studied abstractly but are also applied in architectural design in real life. This approach strengthens the argument that ethnomathematics can improve students' critical thinking abilities in connecting mathematical ratios with beauty and spiritual values within their environment (Pebriana et al., 2024; D'Ambrosio, 1985).

l. Transformation Geometry

It is very important to introduce mathematical concepts, particularly transformational geometry, through cultural approaches that are familiar to students (Novianti, 2025). In addition to demonstrating the existence of mathematical concepts in architecture, transformational geometry in *Masjid Agung Al-Jami' Pekalongan* also represents aesthetic, religious, and educational values that can be utilized in contextual learning. The results of this study indicate that the architectural elements and ornaments of the mosque contain transformational geometry concepts in the form of reflection, translation, rotation, and dilation. These findings strengthen the view of Ubiratan D'Ambrosio (2006), which states that mathematics cannot be separated from the cultural activities of society, but rather develops

and exists within daily life practices, including architectural and religious artistic works. Therefore, the mosque functions not only as a place of worship but also as a representation of cultural values containing mathematical concepts.

Reflection can be observed in the calligraphic patterns in the hall, which are symmetrically arranged between the left and right sides. These symmetrical patterns symbolize balance and harmony within Islamic values. This finding is consistent with the study conducted by Rachmawati (2021), which states that symmetry in mosque calligraphy represents a symbol of perfection. Reflection is also visible in the iron fences and rhombus-shaped ventilations arranged proportionally on the northern and southern sides of the building. In the context of mathematics learning, these reflection patterns can be used as concrete media to help students understand the concept of reflection visually and contextually. Meanwhile, rotation and dilation in the ornaments demonstrate the creativity of the community in developing aesthetics based on geometric patterns.

The concept of translation is found in the floor tile patterns and window arrangements that repeat at constant intervals. This repetitive pattern demonstrates order and visual rhythm, creating a harmonious impression within the mosque building. From an educational perspective, these objects can be utilized to introduce the concept of plane figure translation in transformational geometry through cultural environments familiar to students' daily lives.

Rotation can be observed in the decorative ornaments on the hall ceiling and the calligraphic frames that form rotating patterns at certain angles, such as 90° and 180°. These rotational patterns demonstrate the creativity of Islamic art in constructing geometric beauty. Meanwhile, dilation appears in the variation of calligraphy sizes, where smaller forms are located in the center and gradually enlarge outward. These differences in scale indicate the application of enlargement concepts that maintain the original form of the figure.

Through these various elements, *Masjid Agung Al-Jami' Pekalongan* can serve as a source of ethnomathematics learning that connects abstract mathematical concepts with local culture. This approach has the potential to improve students' conceptual understanding because learning materials are associated with environments that are familiar and meaningful to them. Compared to previous studies, which generally only identified mathematical concepts in cultural buildings, this study specifically highlights transformational geometry in the architectural elements of *Masjid Agung Al-Jami' Pekalongan*. This demonstrates that transformational geometry concepts can be found concretely within local cultural environments that are closely connected to students' lives.

The findings of this study have implications for mathematics learning, particularly in transformational geometry topics in schools. Teachers can utilize photographs of mosque ornaments as contextual learning media to help students understand the concepts of reflection, translation, rotation, and dilation of geometric figures. For example, students may be asked to identify axes of symmetry in mosque calligraphy, determine translation patterns in floor tiles, or analyze rotation angles in ceiling ornaments. These activities enable students to learn mathematics through familiar cultural objects, making learning more meaningful and contextual.

In addition to being used as visual media, the findings of this study can also be integrated into project-based learning models or local cultural exploration activities. Students can conduct direct observations of cultural buildings in their surrounding environment to identify mathematical concepts contained within them. This approach aligns with ethnomathematics learning, which emphasizes the relationship between mathematics, culture, and students' real-life experiences.

4. CONCLUSION

The results of the exploration of *Masjid Agung Al-Jami' Pekalongan* indicate that the mosque building contains various geometric forms that reflect ethnomathematical practices in Islamic architecture. Various three-dimensional shapes such as cylinders, rectangular prisms, spheres, and pyramids, as well as two-dimensional figures such as squares, rectangles, triangles,

trapezoids, parallelograms, rhombuses, and hexagons, were found in both the structural elements and ornaments of the mosque. In addition, the use of certain numbers, such as the height of the minaret and the number of stairs, indicates the application of numerical concepts in the building design process.

This study also demonstrates that the ornaments and architectural elements of *Masjid Agung Al-Jami' Pekalongan* contain transformational geometry concepts in the form of reflection, translation, rotation, and dilation. These concepts are visible in the patterns of calligraphy, ventilation designs, floor tiles, windows, and decorative ornaments of the mosque. These findings indicate that mathematics is closely related to local culture and has the potential to be utilized as a source of ethnomathematics learning in transformational geometry instruction.

This study has several limitations because it only focuses on identifying transformational geometry concepts in several architectural elements of the mosque without directly testing their implementation in the learning process. In addition, this study has not explored students' responses to the use of cultural objects as mathematics learning media. Therefore, future studies may develop ethnomathematics-based learning media or instructional designs and examine their effectiveness in improving students' understanding of transformational geometry concepts.

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