Ethnomathematical exploration of the Al-Akbar National Mosque Surabaya in picture pattern material for fourth grade elementary mathematics

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Abstract: The Al-Akbar National Mosque in Surabaya was constructed with various forms of buildings and ornaments where ethnomathematics can be studied, particularly for drawing pattern material in fourth-grade elementary school. The objectives of this study are to describe: (1) the ethnomathematical links in the architecture of the Al-Akbar National Mosque, Surabaya, and (2) the material of image patterns for fourth-grade elementary school found in parts of the Al-Akbar National Mosque. This research utilizes qualitative methods with an ethnographic approach and was conducted at the Al-Akbar National Mosque in the Pagesangan area of Surabaya City. The objects studied include parts of the buildings and decorations of the Al-Akbar Mosque. Data collection methods included observation, interviews, and documentation. The results of the study show that (1) the Al-Akbar National Mosque has ethnomathematical relationships evident in its architecture, layout, and decorations. The concept of image patterns at the Al-Akbar National Mosque is found in the main dome, both outer and inner, as well as the outer pyramid dome. These structures demonstrate the concept of enlarged and smaller image patterns. (2) There are mathematical concepts, especially the pattern of enlarging and shrinking images, present in the Al-Akbar National Mosque, Surabaya. In conclusion, this study underscores the significance of ethnomathematics in architectural design and its potential educational applications in elementary school settings.

Keywords: Al-Akbar Mosque Surabaya, Ethnomathematics, Image patterns


INTRODUCTION

In today's modern era, culture has become a crucial element in human life and society. Culture is the result of human actions, emotions, and creations, encompassing a complex way of life that includes knowledge, beliefs, art, morals, customary law, and all other skills and habits acquired by humans as members of society (Syakhrani & Kamil, 2022). Culture is also a way of life that is passed down from one generation to the next in social life. It is formed from a combination of various elements such as politics, language, religion, customs, clothing, artworks, and buildings. Culture and education are inseparable, as education is an aspect of culture related to human life, and both support and strengthen each other (Puspitasari & Putra, 2022). Generally, culture is a characteristic of a country. Thus, culture must be deeply ingrained in every individual in society. Education plays an important role in encouraging individuals to uphold the values of local cultural wisdom. As Ki Hadjar Dewantara stated, the essence of education is to integrate culture into children and children into culture so that they become complete human beings (Tarigan et al., 2022).
According to Maryati and Prahmana (2018), culture can serve as the context and starting point in the mathematics learning process. This connection between mathematics and culture is known as ethnomathematics, which is defined as cultural practices within communities that incorporate mathematical concepts (Krismonita et al., 2021). First introduced by Ubiratan D’Ambrosio in 1985, ethnomathematics is a strategy for teaching mathematics that integrates local cultural knowledge. Lusiana et al. (2019) describe ethnomathematics as the study of mathematics or mathematical ideas in relation to the broader social culture. Susanto et al. (2022) suggest that ethnomathematics bridges culture and mathematical concepts, serving as a medium for conveying these concepts to students. Maulida (2020) notes that ethnomathematics involves mathematical learning derived from cultural traditions, interpreting it as methods used by specific cultural groups for activities like sorting, sequencing, calculation, and measurement. Hence, ethnomathematics is not a new concept but something practiced and transmitted across generations. Various cultural groups or tribes have inherently used mathematics in their daily activities, often without realizing it. This aligns with Sianturi et al. (2022), who state that people have indirectly applied mathematics in everyday life, though many do not recognize it. The outcomes of these cultural practices are historical artifacts imbued with mathematical elements, such as handicrafts, music, and architecture, with mosques serving as one example of culturally significant buildings.

According to Sidi Gazalba (as cited in Putra & Rumondor, 2019), a mosque serves as a place for teaching, speaking, and encompassing all aspects of Islamic life. While mosques around the world function as places of worship for Muslims, their names and architectural styles vary across different countries. In Indonesia, mosques exhibit a wide range of shapes and designs that reflect the local community’s tastes and culture. This diversity in form and design makes mosques a fascinating subject for observation and research. One example of a mosque with an intriguing design that incorporates mathematical elements is the Al-Akbar Surabaya mosque.

Based on research by Ana and Mariana (2022), a connection was found between the Al-Akbar National Mosque Surabaya and geometric concepts. The mosque’s architecture features numerous flat geometric shapes, including rectangles and squares, as well as three-dimensional forms like cubes, beams, pyramids, cylinders, hemispheres, and cones. Additionally, the Al-Akbar National Mosque Surabaya functions as a hub for various educational and religious activities in Surabaya, housing schools of different educational levels in its basement. The researchers also identified other mathematical elements in the mosque's architecture, such as pattern drawing, where specific patterns are formed.

The primary issue in elementary schools is the lack of student engagement in mathematics. Research on ethnomathematics at the Al-Akbar Mosque aims to increase student activity in math subjects. Ethnomathematics in elementary schools serves as a tool for students to learn mathematics by connecting it with their socio-cultural environment (Fajriyah, 2018). This approach emphasizes the direct application and practice of culture in the students’ surroundings. In teaching ethnomathematics, elementary students are encouraged to observe and draw various cultural objects in their environment, such as traditional houses, buildings,
and places of worship. For instance, students might observe a traditional house and identify geometric shapes within the structure, noting them in their notebooks.

This method shows that ethnomathematics is crucial at the elementary level, providing a foundation for learning (Kencanawaty et al., 2020). Integrating ethnomathematics into math education makes learning enjoyable and contextual, shifting the perception of mathematics from being difficult and abstract to being fun and relevant to everyday life (Soebagyo et al., 2021). Using ethnomathematical materials not only introduces the relationship between math and local culture to students but also enhances their understanding and motivates them to learn math in a more enjoyable and contextual way (Wulandari et al., 2024). This aligns with the findings of Putra and Mahmudah (2021), which demonstrate that applying ethnomathematical concepts innovatively can improve students' critical thinking and make learning more accessible.

Mathematics is a science involving interconnected concepts (Sari et al., 2021). It encompasses various materials, all related to the science of calculation. In elementary school, mathematics education focuses on introducing basic concepts such as geometry, algebra, measurement, numbers, and data analysis, including probability. Among these topics, elementary school mathematics includes material on patterns, particularly picture patterns, which are typically covered in 4th grade. Picture patterns are sequences of images that follow specific shapes and arrangements or can be defined as a series of images with regular patterns from one image to the next. According to the competencies in the independent curriculum, students must grasp the concept of picture patterns. With ethnomathematics providing concrete examples, students find it easier to understand these patterns and their applications in daily life.

Researchers will investigate the ethnomathematics of image pattern materials in the Al-Akbar National Mosque in Surabaya. The goal is to describe the ethnomathematics connected to the drawing patterns found in the mosque's architecture, specifically tailored for grade 4 elementary school material. This research aims to provide a useful reference for teachers who wish to show students real-world examples of drawing patterns in mosque buildings.

METHOD

Type Of Research

According to Abdussamad (2021), qualitative research methods investigate natural object conditions, with the researcher as the key instrument. Data collection is performed through triangulation, analysis is inductive, and the results focus on meaning rather than generalization. Ethnography, a qualitative research approach, is a branch of anthropology that describes, explains, and analyzes cultural elements of a society or ethnic group (Sari et al., 2023). Surayya (2018) supports this by stating that ethnography involves descriptive research on culture and society. The researcher selected the ethnographic approach because it involves detailed descriptions of societal behaviors and thinking patterns, expressed through writing, photographs, paintings, films, and more. This aligns with the research aim of describing the ethnomathematics present in the Al-Akbar mosque.

Based on the research questions and understanding outlined above, this study employs a qualitative research methodology with an ethnographic approach. Researchers gather information through observation, interviews, and documentation. To ensure data validity, triangulation techniques are utilized. The aim of this study is to elucidate the ethnomathematical findings related to the Al-Akbar National Mosque in Surabaya, specifically within the context of elementary school drawing pattern materials.

Data Collection Techniques

In this study, a comprehensive approach was employed to gather data through three distinct methods: observation, interviews, and documentation. Each method was meticulously
designed to capture different aspects of the Al-Akbar National Mosque in Surabaya, focusing on the ethnomathematics of image pattern materials. This multi-faceted approach ensured a robust and holistic understanding of the research subject, enabling a detailed exploration of the architectural elements and their educational implications for elementary school curriculum. The following sections describe the specific procedures and instruments used for each data collection method.

**Observation Method**

The researcher conducted direct observations at the Al-Akbar National Mosque in Surabaya, focusing on parts of the building related to the image pattern material, specifically the enlargement and reduction of patterns. An observation sheet was used as the instrument. The protocol for observations involved preparing a sheet noting which parts of the mosque's architecture might contain image patterns pertinent to the research focus. The researcher then recorded the architectural elements that indeed exhibited these image patterns.

**Interview Method**

For the interview method, the researcher prepared questions about the mosque buildings relevant to the research focus. These questions were documented on a question sheet, along with spaces for interview answers. The questions were posed to the management staff of the Al-Akbar Mosque, chosen as resource persons because of their extensive knowledge of the mosque's structure, ornaments, and history.

**Documentation Method**

The documentation method involved collecting data related to the research focus on ethnomathematics at the Al-Akbar National Mosque, particularly the image pattern material. Photographs were taken of the mosque's buildings, motifs, and architecture that were relevant to the ethnomathematics of drawing patterns. These visual records supported the steps taken by the researchers.

**Data Analysis Technique**

Data analysis is a process that involves systematically examining data from observations, documentation, practical results, and other sources to facilitate understanding and effectively communicate findings. The techniques used in data analysis depend on the type of data collected. This study adopts the data analysis techniques proposed by Miles et al., (2014), which consist of three components:

**Data Condensation**

Data condensation varies based on the data collection technique. For observations at the Al-Akbar National Mosque in Surabaya, data was condensed through note-taking and photography of the mosque's architecture. For interviews, audio recordings were made during the interview sessions. These recordings were then repeatedly listened to, transcribed, and coded, with "P" for the researcher and "S" for the subject or source.

**Data Display**

The presentation of data involved organizing the results of observations, interviews, and documentation into descriptive texts and interview transcripts. These documents included expressions from observations, interview excerpts, and documentation gathered during the research process. The descriptive text and transcripts served as guidelines for assessing image patterns in relation to mathematics learning outcomes based on the ethnomathematics found in the dome architecture of the Al-Akbar National Mosque.
Drawing Conclusions

Conclusions were drawn after the data presentation stage, addressing the predetermined research questions. This involved synthesizing the results of the data analysis to clearly understand the ethnomathematics of the Al-Akbar National Mosque concerning image pattern material in elementary schools. The findings were then correlated with learning outcomes and objectives in elementary school mathematics education.

![Data Analysis Flow](image)

**Figure 2. Data Analysis Flow**

The structured approach of data condensation, display, and conclusion drawing ensures a thorough and coherent analysis, providing valuable insights into the ethnomathematical elements present in the Al-Akbar National Mosque and their implications for elementary school education. The data analysis flow can be seen in Figure 2.

RESULTS AND DISCUSSION

Results

The findings aim to describe the ethnomathematics related to drawing pattern material for grade 4 elementary school students, as found in the architecture of the Al-Akbar Mosque in Surabaya. The research on ethnomathematics at the Al-Akbar National Mosque in Surabaya regarding image pattern material yielded two significant results. The following is an explanation of these two results.

Ethnomathematics of Al-Akbar National Mosque Surabaya

The Al-Akbar National Mosque in Surabaya is located at Al-Akbar Timur Street No.1, Pagesangan, Jambangan district, Surabaya City, East Java Province. The mosque's establishment began in 1995, inspired by Mr. Soenarto Soemprawiro, who was the Mayor of Surabaya at the time. The construction officially started with the ceremonial laying of the first stone by Mr. Try Sutrisno, who was then the Vice President of Indonesia. However, the project faced financial difficulties shortly after commencement, leading to a halt in construction for about a year. In 1996, the central government took over the project, and construction resumed in 1997. The mosque was finally completed in mid-2000 and officially inaugurated on November 10, 2000, by President KH Abdurrahman Wahid. The Al-Akbar National Mosque stands as a significant cultural and religious landmark in Surabaya, embodying the community's dedication and resilience in overcoming obstacles to complete this grand architectural endeavor.

After its inauguration, the Al-Akbar National Mosque in Surabaya, which incorporates elements of Arabic culture, began serving as a central hub for religious activities. These activities include marriage ceremonies, recitations, prayers, and the celebration of Islamic holidays. Beyond its religious functions, the mosque has evolved into an educational center over time. The transformation into an educational hub began with frequent seminars and was further solidified by the establishment of Madrasah Ibtidaiyah Al-Akbar on May 19, 2014,
located in the mosque's basement. As the institution grew, the mosque's management expanded its educational offerings to include Madrasah Tsanawiyah (MTs) and Madrasah Aliyah (MA). This expansion culminated on May 22, 2019, with the founding of Al-Akbar Islamic College Surabaya. Today, the Al-Akbar National Mosque stands as a pillar of social activities for Indonesians, particularly the people of Surabaya. It frequently hosts community events, fulfilling the vision of former President KH Abdurrahman Wahid for the mosque to serve as a national landmark.

From an interview with the management of the Al-Akbar National Mosque regarding its history and various related matters, it was revealed that the mosque serves not only as a place for religious activities but also as an educational facility for the community and students, particularly elementary school students. The researcher also inquired about the motifs in the Al-Akbar National Mosque in Surabaya. Here are the findings from the observations and interviews:

1. **Main Dome motifs of the Outer Mosque**

   ![Figure 3. Main Dome Motifs of the Outer Mosque](image)

   Based on Figure 3, which depicts the motifs of the outer main dome, it was observed that the dome is adorned with neatly arranged blue rhomboid shapes, extending from top to bottom. The arrangement of these motifs follows a specific pattern, where each set includes an additional rhomboid, creating an image that appears enlarged. This pattern is evident from the increasing number of rhomboid motifs as they descend the dome, starting with 7 at the top and increasing to 8, 9, and so forth.

   P: Regarding this outer dome motif, it seems like there are more motifs as you go down. Is that correct?

   S: Yes, the motif is indeed designed that way. The pattern adjusts to the shape of the dome, so the motifs increase as they go down.

   Interviews with the subjects revealed that the outer mosque dome motif incorporates mathematical elements in the form of enlarged image patterns. The number of motifs increases as they descend, creating a pattern that can also appear as smaller image patterns when viewed from different angles. From below, the pattern appears to diminish as it ascends.

2. **Main Dome Motifs of the Inner Mosque**

   ![Figure 4. Main Dome Motifs of the Inner Mosque](image)
Based on Figure 4, which shows the motifs of the inner main dome, it was found that these motifs, like those of the outer dome, are related to an enlarged image pattern. The inner dome motifs follow a similar pattern, with an additional motif in each group. This can be seen in the green rhombus motifs, where the number of motifs increases from top to bottom. However, the motifs in this section are more crowded and include various colors and shapes, making it challenging to fit all motifs into a single image pattern.

P: For the inner main dome, is the pattern the same as the outer dome?
S: Yes, the pattern is the same, with the number of motifs increasing as you go down. However, the shape of the motifs is slightly different, with more variety in shape and color on the inside.

Interviews with the subjects revealed that the inner dome motif also incorporates mathematical elements of image patterns. Despite the variation in shapes at the bottom, this does not impact the overall pattern, as the minimum number of image patterns is maintained.

3. Mosque Pyramid Dome Motifs

In the pyramid dome motifs, researchers discovered a similar relationship between the image pattern material and other dome motifs, specifically an enlarged image pattern with an additional motif in each group. As depicted in the figure, the pyramid dome motifs share the same rhombus shape as the other domes, though the pyramid dome has fewer rhombic motifs due to its smaller size.

P: What about the pyramid dome, does it also have the same pattern as the other domes?
S: Yes, the pattern is the same. All motifs related to the dome must follow this pattern. However, other motifs here are numerous but have fixed patterns and do not increase or decrease.

From the interview transcript, it was found that the pyramid dome of Al-Akbar Mosque also contains mathematical elements of image patterns. Based on observations and interviews, the Al-Akbar Mosque in Surabaya features mathematical elements of image patterns in specific parts, namely the main dome and pyramid dome. These image patterns involve both shrinking and enlarging motifs.

**Mathematical Concept of Picture Pattern at Al-Akbar Mosque Surabaya**

Based on the observations at Al-Akbar Mosque in Surabaya, it is evident that the mosque incorporates the concept of image patterns, specifically those that involve enlarging and shrinking. This architectural approach is evident in the intricate tile work, geometric designs, and the overall layout of the mosque. The dome, for instance, showcases a pattern that appears to expand and contract, creating a visual illusion of movement and depth. Similarly, the windows and arches feature designs that use repeated shapes in varying sizes, further emphasizing the concept of enlargement and reduction. These elements not only enhance the aesthetic appeal of the mosque but also reflect a sophisticated understanding of mathematical principles in design. The detailed results of these observations, which delve deeper into the
specific techniques and patterns used to achieve this effect, will be presented below, offering a comprehensive insight into the architectural ingenuity of Al-Akbar Mosque.

1. Main Dome Motifs of the Outer Mosque

![Figure 6. Main Dome Motifs of the Outer Mosque](image)

The results of observations about the outer main dome motifs of the Al-Akbar Mosque revealed that the rhombus-shaped dome motifs follow the concept of an enlarged image pattern when viewed from above. This conclusion is drawn from the characteristics of the motifs, which meet the criteria for an enlarged drawing pattern: each set has the same shape, there are at least three sets, and the number of rhombic motifs increases in each set. The specific formula for this pattern can be found in Table 1.

<table>
<thead>
<tr>
<th>Group</th>
<th>Number Of Motive</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>1+1</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>2+1</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>3+1</td>
</tr>
</tbody>
</table>

From the description in the table above, it can be explained that the first set contains 1 rhombus motif, the second set contains 2 rhombic motifs, and the third set contains 3 rhombic motifs. These three groups illustrate a pattern of adding 1 rhombic motif in each subsequent set. To determine the next set, simply add 1 rhombic motif to the previous set. Therefore, the fourth set would have 1+1+1+1 = 4 rhombic motifs.

2. Main Dome Motifs of the Inner Mosque

![Figure 7. Main Dome Motifs of the Inner Mosque](image)

The observations of the inner main dome motifs of the Al-Akbar Mosque revealed that the rhombus-shaped motifs adhere to the concept of an enlarged image pattern. This conclusion is based on the characteristics that qualify the motifs as an enlarged drawing pattern, including maintaining the same shape in each set, forming at least three sets, and experiencing an increase in the number of rhombic motifs per set. The specific formula for this pattern is presented in Table 2.
From the description in the table above, it can be explained that the first set contains 3 rhombic motifs, the second set contains 4 rhombic motifs, and the third set contains 5 rhombic motifs. These three groups illustrate a pattern of adding 1 rhombic motif in each subsequent set. To determine the next set, simply add 1 rhombic motif to the previous set. Therefore, the fourth set would have 3+1+1+1 = 6 rhombic motifs.

3. Mosque Pyramid Dome Motifs

Based on the description in Table 3, the first set contains 4 rhombic motifs, the second set contains 5, and the fourth set contains 6. This pattern reveals that each subsequent set increases by 1 motif. To find the number of motifs in the next set, we simply add 1 motif to the previous set. Therefore, the next set would contain 7 rhombic motifs, following the sequence of 3+1+1+1+1 = 7.

Discussion

Researchers, through detailed observations and interviews with the management of the Al-Akbar National Mosque in Surabaya, uncovered various ethnomathematical elements and mathematical concepts intricately woven into the mosque’s design. These elements manifest in the mosque’s geometric patterns, structural symmetry, and decorative motifs, all of which reflect a deep understanding of mathematical principles. By focusing on picture patterns relevant to 4th-grade elementary school curricula, the researchers were able to identify specific examples that illustrate concepts such as symmetry, repetition, and scaling. These
findings not only highlight the practical application of mathematics in cultural and religious architecture but also provide an engaging and relatable context for teaching young students. The discussion of these elements and concepts will offer insights into how traditional designs can be used as effective educational tools, bridging cultural heritage and modern education.

**Ethnomathematics of Al-Akbar National Mosque Surabaya**

The ethnomathematical findings in this study explain that ethnomathematics is the study of mathematics related to cultural values. This aligns with the opinion of Bahagia et al. (2022), which states that ethnomathematics is connected to culture, where communities practice mathematical values in daily life. Similarly, Agustini et al., (2019) describe ethnomathematics as a science used to understand how mathematics is adapted from culture. Jayanti and Puspasari (2020) also support this view, noting that ethnomathematics recognizes various ways of applying mathematics in life.

In the case of the Al-Akbar National Mosque in Surabaya, the mosque’s design can be seen as a cultural expression of the surrounding community, exemplified through mathematical structures. This ethnomathematical research at the Al-Akbar Mosque has identified image patterns in specific parts of the mosque, particularly in the motifs of the main and pyramid-shaped domes. These domes symbolize the 5 pillars of Islam, reflecting Islamic cultural values and practices.

On the exterior of the main dome, an image pattern is found that can change into two types: enlarged and reduced. The main dome motif qualifies as both an enlarged and reduced image pattern because it meets the requirements: having at least 3 sets of the same image and showing an increase or decrease in the pattern. The lower collection of the main dome motifs increases in number, while the upper collection decreases, demonstrating both patterns. Inside the main dome, an enlarged image pattern is evident. The collection of rhombus-shaped motifs increases with each set, qualifying it as an enlarged image pattern. However, the inner dome does not exhibit a shrinking image pattern because the motif at the bottom is different from the rest.

The outer pyramid dome also features an enlarged image pattern, with the number of motifs increasing downward. This dome can also exhibit a shrinking image pattern if the pattern is counted from bottom to top. The reason the pyramid dome motif is only classified as an image pattern on the outside is that there is no discernible pattern on the inside. These findings highlight the ethnomathematical elements in the architecture of the Al-Akbar Mosque, providing valuable examples for teachers. Educators can use these patterns to help students observe the application of mathematical patterns in real life. These findings can be connected to the learning outcomes of algebraic material on drawing patterns in 4th-grade elementary school.

**Mathematical Concept of Picture Pattern at Al-Akbar Mosque Surabaya**

In this study, mathematical concepts of image patterns were identified, specifically focusing on enlarged and smaller image patterns. These patterns are associated with the motifs or images in the Al-Akbar Mosque, which display certain recurring patterns. The assessment of these image patterns was based on the mathematical learning outcomes expected in elementary schools, particularly in terms of recognizing changes in image patterns. The primary patterns observed were those that either enlarged or diminished.

The concept of enlarged and smaller image patterns is significant for mathematics learning in 4th grade. Teachers can utilize these patterns to relate and develop materials for discussions or implement them in lessons by conducting observation activities at the Al-Akbar Mosque in Surabaya. During these activities, students can be engaged with questions about the addition and subtraction of image patterns. This aligns with the guidelines from Datadikdasmen (2022), which state that elements of algebra and learning achievements in 4th grade, phase B, should
involve identifying, imitating, and developing simple drawing patterns or objects, as well as patterns of enlarging and decreasing numbers involving addition and subtraction up to 100.

According to these guidelines, by the end of Phase B, students should be able to identify, imitate, and develop simple image or object patterns, as well as patterns of enlarging and decreasing numbers up to 100 through addition and subtraction. However, the findings in this study are specifically limited to the 4th-grade drawing pattern material. Future research is recommended to delve deeper into the ethnomathematical aspects of the Al-Akbar Mosque's architecture, particularly within the main room of the mosque.

CONCLUSION

Based on the discussion and data analysis, the researcher concludes that ethnomathematics is present in the Al-Akbar National Mosque in Surabaya, specifically in the concept of picture patterns. These patterns are found in the main dome (both outer and inner) and the outer dome of the pyramid. The mosque exhibits both enlarged and shrinking image patterns. Additionally, a mathematical concept, particularly the picture pattern concept, is evident in the Al-Akbar Mosque. The exploration activities conducted at the mosque have been analyzed and matched with the learning outcomes, objectives, and flow that align with the 4th-grade elementary school curriculum. The findings of this research can be used by teachers to enhance and develop materials related to the discussion of picture patterns. Teachers can implement these concepts in mathematics lessons by organizing observation activities at the Al-Akbar Mosque. During these activities, students can engage with questions about the addition and subtraction of the image patterns found in the mosque's architecture.

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