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ETHNOMATHEMATICS: EXPLORATION OF GEOMETRY CONCEPTS IN TIBAN MOSQUE ARCHITECTURE

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Abstract: This study aims to explore the geometric and cultural concepts embedded within the architecture of the Tiban Mosque in Malang regency, assessing their potential as an ethnomathematical learning medium. Through a qualitative ethnographic approach, this research gathered descriptive data from key informants including residents visiting students, mosque officials, and an ornaments craftsman. The study reveals that the Tiban Mosque, a prominent religious tourism site, embodies rich cultural and mathematical concepts. Its architectural elements reflect a blend of Chinese, Indian, and Arabic cultural influences, while the mathematical aspects encompass various geometric principles, including flat shapes, spatial forms, and geometric transformations. These findings suggest that the Tiban Mosque offers a valuable ethnomathematical learning medium, particularly for geometry concepts relevant to secondary education levels. Furthermore, this study highlights how exploring ethnomathematics can cultivate appreciation and foster cultural preservation in the Malang regency.

Keywords: ethnomathematics, geometry, Tiban Mosque

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INTRODUCTION

Mathematics is a fundamental and compulsory subject taught from from elementary to university levels (Juliasari & Kusmanto, 2016). However, it is often perceived as a challenging subject by many students (Azizah & Masrurotullaily, 2023; Ferdiani, Farida, & Murniasih, 2019; Novita *et al*., 2018). To address these learning difficulties, integrating relevant learning contexts is crucial (Fanany, Isnani, & Ahmadi, 2019). One effective approach is connecting school curricula with societal culture (Maryati & Priatna, 2017), as merging mathematics with culture elements can enhance students' understanding of the material (Soebagyo & Haya, 2023).

Ethnomathematics serves as a vital bride between culture, education, and mathematics. In Indonesia, with its predominantly Muslim population, mosques are ubiquitous and often feature unique architectural designs. The Tiban Mosque in Malang Regency, a prominent religious tourism destination, is an exemplary site rich in cultural and mathematical concepts, offering significant potential for ethnomathematical study. This approach is particularly valuable for cultivating an appreciation for local culture and fostering its preservation. Ethnomathematics is recognized as a unique interdisciplinary field connecting mathematics with culture (Sanyoto, Setiana, & Agustito, 2021). It encompasses the mathematical practice developed within specific cultural groups, involving activities such as counting, measuring, classifying, ordering, explaining, and modeling (Rachmawati, 2012). This approach highlights how mathematical concepts are embedded in daily life experiences and cultural contexts, bridging formal school mathematics with real-world applications and cultural heritage.

Despite its recognized benefits, the impelementation of ethnomathematics in school learning remains underexplored in practice. This limited integration may be partly attributed to the rapid advancement of technology, which often exposes students to diverse global cultures, sometimes overshadowing local traditions (Setyoningrum, Supriyono, & Pangestika, 2022). The situation underscores a potential challenge to cultural preservation among Indonesian students. Therefore, the effective implementation of of ethnomathematics in schools is crucial for safeguarding Indonesia's cultural heritage (Amalia, Syamsuri, & Ihsanudin, 2021; Bitin, Amsikan, & Ahzan, 2023; Blegur, 2023).

To explore these connections and contribute to the ethnomathematics discourse, this study focuses on the Tiban Mosque, a renowned religious tourism destination in Turen District, Malang Regency, East Java. Tiban Mosque is an integral part of the Bihaar Bahri Asal Fadlaailir Rahmah Islamic boarding school (Pesantren), founded by KH. Ahmad Bahru Mafdhaluddin Shaleh bin Al Mahbub Rahmat Alam and his family. Spanning an area of approximately 8 hectares, with the building itself occupying about 2 hectares, the mosque's development began in 1963 as a small house and prayer room. Formal permission for its establishment was submitted to the government in 1978. The first phase of construction (1987-1992) primarily utilized red bricks, sand, and cement, while the second phase (starting in 1998) involved more permanent materials, guided by KH. Ahmad Bahru Mafdlaluddin Shaleh's spiritual insights. Notably, the construction process has largely been carried out by students and congregants from various regions (Basyar, 2022).

The architectural designs and ornamental motifs within the Tiban Mosque, numbering around 600, were meticulously crafted by students from the Bihaaru Bahri Asal Fadlaailir Rahmah Islamic boarding school. These intricate ornaments were made by hand, utilizing only chisels, reflecting the students' remarkable creativity. A closer examination suggests the presence of distinct geometric principles embedded within both the mosque's structure and its elaborate decorations. Geometry is a crucial component of mathematics, widely recognized for its relevance to daily life. However, it is often considered one of the more challenging areas for students to grasp (Nur'aini *et al*., 2017). Therefore, investigating the Tiban Mosque's architecture offers a valuable resource for enriching geometry learning and addressing these difficulties. This research aims to examine the various geometric concepts embedded in the Tiban Mosque's architecture, assessing their potential as a learning medium for mathematics and their role in cultural preservation efforts.

Previous studies have explored ethnomathematics within mosque architecture, including research on the Aschabul Kahfi Mosque in Tuban (Nurhalisa, Alghofiati, & Fadiana, 2022), he visualization of geometric concepts in mosque constructions(Nisa *et al*., 2023), and geometric aspects of the Gedhe Kauman Mosque in Yogyakarta (Putri & Putri, 2024). his current study distinguishes itself by specifically focusing on the Tiban Mosque in Turen. Its unique architectural design offers a distinct context for exploring and utilizing its embedded geometric principles, particularly flat and transformation geometry, as a valuable learning resource.

METHOD

This research was use a qualitative exploratory method, employing an ethnographic approach, was conducted in Malang Regency, East Java. This method generated descriptive data in word descriptions of the phenomena studied, emphasizing the meaning, characteristics, and symbols of an events (Wahyudi *et al*., 2021). Consistent with qualitative research, the researchers served as the primary instrument for data collection and direct engagement with study (Lusiana *et al*., 2019).

Data was collected using literature review, observations, interviews, and documentation (Soebagyo & Amalia, 2022). Observations focused on the buildings and ornaments of the Tiban Mosque. Interviews were conducted to gather information regarding the history and architectural details from key informants, including a resident of the Tiban Mosque area, a student who was also an information officer, and an ornament craftsman. Documentation involved taking photographs of the mosque's building and

ornaments. To ensure data validity, triangulation was performed after data collection. Subsequently, the obtained data were analyzed using domain and taxonomic analysis to compile the research findings.

RESULTS AND DISCUSSION

The results of the ethnomathematics exploration conducted at the Tiban Mosque through literature study, observation, interviews, and documentation show several cultural and mathematical concepts in the building and ornaments of the Tiban Mosque. The following is a discussion of the results of the exploration at the Tiban Mosque.

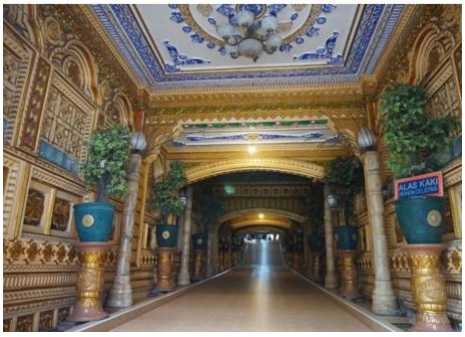
Cultural Analysis at the Tiban Mosque

The Tiban Mosque, an architectural marvel in Sananrejo Village, Turen, Malang Regency, East Java, is imbued with both spiritual and profound cultural significance. It originated from the expansion of the Salafiah Bihaaru Bahri Asali Fadlaailir Rahmah Islamic Boarding School, established in 1963 by Romo Kiai Ahmad. Due to growing student numbers and facility demands, the pesantren was relocated to a more strategic and spacious site between 1987 and 1992. This move not only boosted capacity but also reinforced its role as a key educational and spiritual hub. As an integral part of the pesantren complex, the Tiban Mosque has become a symbol of community identity and pride, embodying moderate religious values and a dedication to enduring Islamic education.

The construction of the Tiban Mosque, which commenced years after the pesantren's founding, famously involved the active participation of students in tasks such as brick-making, cement-mixing, and interior decoration. This intensive, manual labor, combined with the rapid, seemingly sudden appearance of the complex, fueled a local myth that the mosque was built by mythical beings, particularly because the community did not directly witness every stage of its construction. However, documented facts confirm that the Tiban Mosque was constructed manually without heavy machinery. Its intricate designs and architectural integrity are a testament to the guidance of Romo Kiai Ahmad Bahru Mafdlaluddin Shaleh and the dedication of students, many of whom lacked formal construction training. The main building stands at 10 stories, each serving a distinct purpose: Floors 1-4 are dedicated to worship and student activities, floors 5-6 house family quarters, and floors 7-8 contain shops managed by female students, catering to student needs. While the 9th floor remains under construction, the 10th floor features an open-air roof, with accessibility to all floors provided by both elevators and stairs. The

following are the results of the cultural analysis of the Tiban mosque which will be shown in Table 1.

Table 1. Architectural and Cultural Analysis of Tiban Mosque

No.	Mosque Section	Ornaments/Calligraphy	Description
1	Front Section 	   	The front of the Tiban Mosque is decorated with various ornaments and calligraphy made of blue and white ceramics. These colors make it strike and more like an eccentric Chinese vase, combining Arabic, European, Chinese, and Indian architectural styles.
2	Interior Section 	  	The interior of the mosque is made of ceramics and calligraphy in a Middle Eastern architectural style. Some areas of the mosque are also decorated with cement carvings that look like caves.

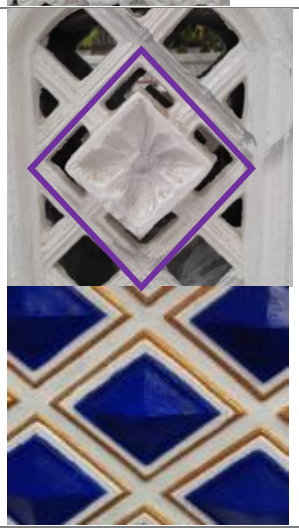
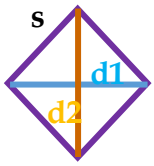
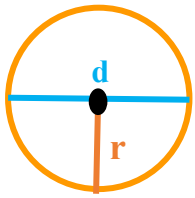
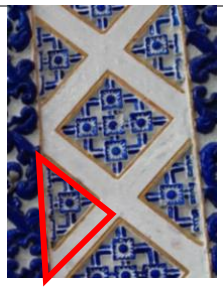
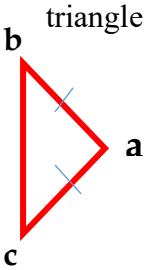
No.	Mosque Section	Ornaments/Calligraphy	Description
			
			
3	Roof Section 		The roof has Arabic, Indian, and Chinese architectural styles

Geometric concept analysis of Tiban Mosque

Table 2, Table 3, and Table 4 presents the results of the ethnomathematics exploration conducted at the Tiban Mosque, which is the result of the cultural analysis of the Tiban Mosque

Table 2. Concept Geometry Get up FlatFlat Building at Tiban Mosque

No	Items containing draft geometry	Material	Aspects that can be learned
1		Rectangle 	Properties: Has four sides, The same long Has four corners, The same big (90^0) Area and Perimeter Rectangle L = $s \times s$ K = $s + s + s + s = 4s$

No	Items containing draft geometry	Material	Aspects that can be learned
2		Rectangle  	Properties: Has four sides On the opposite side, the same long Has four corners, The same big (90^0) Area and circumference rectangle long L = p x l K = 2 (p + l)
3		Cut the rice cake  	Properties: Has four sides, The same long Has four corners Opposite angles, the same big Area and circumference cut the rice cake. L = $\frac{d1 \times d2}{2}$ K = $s + s + s + s = 4s$
4		Circle  	Properties: Own One-point center The point distance from the center to the edge of the line is always the same {radius (r)} Does it have a diameter (d) that divides the circle into two equals big? Area and circumference circle L = $\pi \times r \times r$ K = $2 \times \pi \times r$
5		Equilateral triangle  	Properties: Has three corners Has three sides (2 sides are the same long) Area and circumference triangle L = $\frac{1}{2}(a \times t)$ K = $ab + bc + ac$
6		Right angle trapezoid	Properties: Has four sides (2 sides each other parallel) Has two right angles

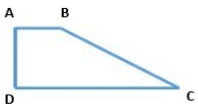
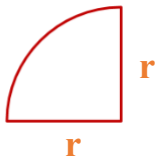
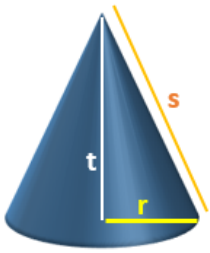
No	Items containing draft geometry	Material	Aspects that can be learned
			Area and circumference trapezoid right angle L = $\frac{jumlah\ sisi\ sejajar \times tinggi}{2}$ K = AB+BC+CD+AB
7		Quarter Circle 	Properties: Own 90^0 angle The extent is the same with a quarter-wide circle Area and circumference L=$\frac{1}{4} \times \pi \times r \times r$ K =$2r + (\frac{1}{2} \times \pi \times r)$
8		Semicircle 	Properties: Own angle 180^0 The extent is the same with a wide circle Area and circumference L=$\frac{1}{2} \times \pi \times r \times r$ K =$2r + (\pi \times r)$

Table 3. Concept Geometry Spatial Structure of Tiban Mosque

No	Items containing draft geometry	Material	Aspects that can be learned
1		Cone 	Properties: Has two sides, a shaped circle, and a curve. Has a base-shaped circle. Own blanket (s). Own One corner at the end cone. Surface area and volume L.blanket =$\pi \times r \times s$ L.surface =$\pi \times r(r + s)$ V =$\frac{1}{3} \times \pi \times r \times r \times t$
2		Tube 	Properties: Base and lid sides in the form of a circle. Has three sides, namely two circles and one curved (blanket). Surface area and volume L.blanket =$2 \times \pi \times r \times t$ L.surface =$2 \times \pi \times r(r + t)$ V =$\pi \times r \times r \times t$

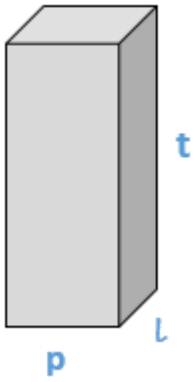
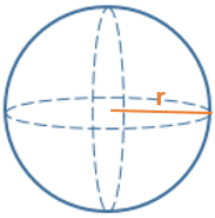
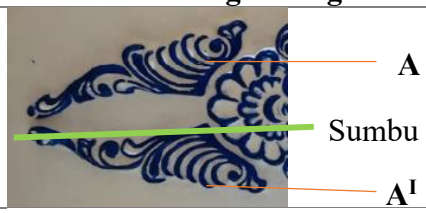
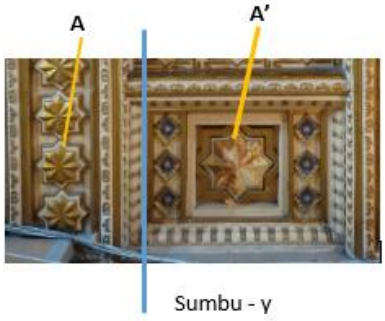
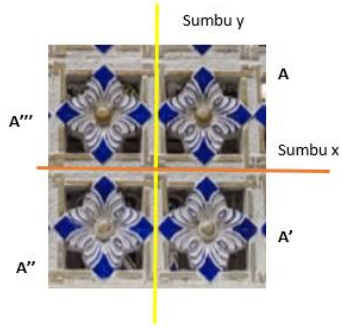
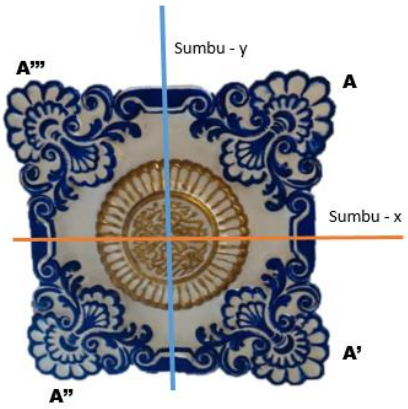
No	Items containing draft geometry	Material	Aspects that can be learned
			
3		Beam 	Properties: Has six sides Has 12 ribs Has eight angles measuring 90^0 On opposite sides of the same large/congruent Surface area and volume: L.surface $=2(pl + pt + lt)$ V $=p \times l \times t$
4		Ball 	Properties: Own One side. No own corner. Own One-point center. Own distance point center to side edge the same length (fingers). Surface area and volume: L.surface $=4 \times \pi \times r \times r$ V $=\frac{4}{3} \times \pi \times r \times r \times r$

Table 4. Concept Transformation of Space Building at Tiban Mosque

No	Items containing draft geometry	Material	Aspects that can be learned
1		Reflection (reflection)	Draft reflection can be seen from ornamental motifs. Part A is mirrored to x- the x-axis and produces ornament. Part A [I]
2		Dilation	Draft dilation can be seen from the shape of motif A, which is dilated enlarged) against the y-axis, which becomes motif A.'

3		Translation (shift)	The draft translation is in Ornamental Motifs Part A. If shifted along the x-axis, it produces motif A'.
4		Rotation (turnover)	Draft rotation can be seen from ornamental motifs: When rotated as much as 90^0 one-way clockwise on the x-axis, part A produces part A'.

Several previous studies have explored ethnomathematics within mosque architecture. For instance, research on the Aschabul Kahfi Mosque in Tuban (Nurhalisa *et al*., 2022) identified both flat shapes (circles, semicircles, squares) and spatial shapes (cones, cylinders). Another study on the Cikini Al-Ma'mur Grand Mosque in Jakarta (Soebagyo & Haya, 2023) similarly revealed diverse geometric principles, including various flat and spatial shapes, as well as geometric transformations (translation, rotation, dilation, reflection). Janan *et al*. (2022) also found numerous geometric elements in the buildings and ornaments of the Grand Mosque of Bandung, such as rectangles, circles, squares, triangles, parallelograms, pentagons, kites, spheres, cuboids, and cylinders. Furthermore, Rofiq *et al*., (2022) explored the ethnomathematical aspects of the Grand Mosque of Probolinggo City, highlighting geometric patterns like triangles, hexagons, squares, rectangles, circles, cuboids, and cylinders.

These previous studies demonstrate that each mosque possesses a unique architectural design, reflecting its local cultural characteristics. Consistent with this, the Tiban Mosque in Malang exhibits distinctive architectural characteristics, particularly a fusion of Middle Eastern, Chinese, and Indian influences. Our exploration of the Tiban Mosque complements these findings by specifically identifying a comprehensive set of geometric concepts embedded within its structure and ornaments. These include: a) flat shapes (such as squares, rectangles, circles, rhombuses, right-angled trapezoids,

equilateral triangles, quarter circles, and semicircles); b) spatial shapes (including cones, cuboids, cylinders, and spheres); and c) geometric transformations (reflection, dilation, translation, and rotation). The distinct architectural fusion of the Tiban Mosque, combined with this detailed identification of geometric elements, offers a unique case study that enriches the existing body of ethnomathematical literature on mosque buildings.

CONCLUSION

Based on the results of the research, it can be concluded that: (1) The Tiban Mosque, recognized as a significant religious tourism site, embodies rich cultural and mathematical concepts. Its architecture reflects a unique fusion of Chinese, Indian, and Arabic cultures. From a mathematical perspective, the mosque's design clearly demonstrates various geometric principles, including a comprehensive array of flat shapes, spatial forms, and geometric transformations; (2) These findings suggest that the Tiban Mosque serves as a valuable ethnomathematical learning medium, particularly for teaching geometry concepts relevant to various secondary education levels. Furthermore, this study underscores how the exploration of ethnomathematics can cultivate a deeper appreciation for local culture and foster its preservation in Malang; (3) Suggestions for further researchers, it is recommended to develop ethnomathematics-based learning media, teaching materials, or modules specifically tailored for the Turen area in Malang. Such materials could be effectively implemented through digital platforms, such as computer or Android applications, to enhance accessibility and flexibility for students' learning experiences.

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