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Ethnomathematics in religious tourism architecture: mathematical concepts and islamic geometric ornaments at Alun-Alun Cililin

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Abstract

Meaningful learning is a key objective of the contemporary Indonesian curriculum, emphasizing conceptual understanding rather than the mere memorization of mathematical formulas. However, the integration of cultural and spiritual dimensions into mathematics instruction remains limited. Ethnomathematics offers a valuable approach to addressing this gap by exploring mathematical ideas embedded in cultural artifacts. This study investigates the philosophical meanings reflected in the Islamic geometric patterns of Alun-Alun Cililin Park, West Bandung Regency, Indonesia, and examines their relationship with mathematical concepts. An exploratory qualitative design with a semiotic approach was employed. Data were collected through observation and documentation and analyzed using Charles Sanders Peirce's semiotic framework, consisting of representamen, object, and interpretant. The analysis identified various mathematical concepts embedded in the geometric patterns, including plane geometry (quadrilaterals, pentagons, and circles), solid geometry (rectangular prisms, trapezoidal prisms, cylinders, and truncated cones), and transformational geometry (rotation, dilation, and reflection). The patterns also embody philosophical values related to mutual cooperation, cultural preservation, social solidarity, spiritual preparedness, and the pursuit of a meaningful life. These findings highlight the potential of Islamic geometric patterns as culturally grounded resources for connecting mathematical learning with cultural and spiritual values, thereby contributing to the development of more meaningful and contextually relevant mathematics education.

Keywords: Alun-alun cililin park; Ethnomathematics; Islamic geometric patterns; mathematical concepts; Meaningful learning

Introduction

Indonesia is widely recognized for its rich cultural diversity, encompassing numerous ethnic groups, languages, traditions, and social communities. This diversity constitutes a fundamental aspect of national identity and plays an important role in fostering social cohesion and unity. Beyond its sociocultural significance, Indonesia's cultural heritage also offers considerable potential for educational development. Abdullah (2017) argues that the nation's cultural richness provides opportunities to transform mathematics education by connecting mathematical learning with students lived experiences and cultural backgrounds. At the same time, preserving both tangible and intangible cultural heritage has become increasingly important amid globalization and the growing challenges to local cultural identities (Turnip, 2022). As noted by Setinawati et al. (2025), Indonesia's diversity of ethnicities, religions, and traditions represents a valuable national asset that contributes to social harmony and collective identity. Similarly, Rizapoor (2023) emphasizes that this diversity underpins the national philosophy of *Bhinneka Tunggal Ika* (Unity in Diversity), highlighting the importance of cultural preservation in maintaining national integration. Consequently, cultural heritage should be viewed not only as a social asset but also as a valuable educational resource capable of supporting meaningful and contextualized learning.

Within mathematics education, ethnomathematics has emerged as an influential theoretical and pedagogical perspective for examining the relationships between mathematics and culture. Challenging the view of mathematics as culturally neutral, ethnomathematics emphasizes that mathematical ideas are generated, interpreted, and practiced within particular sociocultural contexts. According to Siregar (2025), ethnomathematics involves identifying and applying mathematical concepts embedded in everyday cultural activities, including traditional measurement systems, indigenous timekeeping practices, architectural designs, and artistic patterns. Likewise, Mumu et al. (2026) contend that ethnomathematics promotes culturally responsive learning by integrating mathematical practices rooted in local traditions, while Marlina et al. (2026) argue that different cultural communities develop distinctive mathematical understandings reflected in their social practices and material culture. Through this perspective, mathematics learning becomes more meaningful because students are encouraged to recognize mathematical ideas within their own cultural environments. Despite its educational potential, however, the implementation of ethnomathematics-based learning remains limited in many Indonesian mathematics classrooms (Muthia & Maulani, 2025).

One cultural setting that offers considerable potential for ethnomathematical investigation is Cililin, a district in West Bandung Regency, Indonesia. The region is commonly known as the "City of Santri" because of the prominent role of Islamic boarding schools known as *pesantren* in shaping its religious and cultural identity. Among its most notable landmarks is Alun-Alun Cililin, a public space developed under the concept of "Little Madinah." The site features monumental umbrella structures inspired by those of Al-Masjid an-Nabawi, a miniature Qur'an monument, and various Islamic geometric ornaments. These architectural elements not only reinforce the site's religious character but also embody cultural, spiritual, and philosophical meanings expressed through their visual forms (Risdiyanti et al., 2023).

Furthermore, their geometric configurations suggest the presence of diverse mathematical ideas that can be explored through an ethnomathematical lens. Accordingly, Alun-Alun Cililin represents a culturally rich environment with potential as a contextual resource for mathematics learning while simultaneously supporting cultural preservation and religious tourism.

The educational value of contextual and culturally relevant learning environments has been widely acknowledged in mathematics education research. Contextual learning experiences enable students to connect mathematical concepts with authentic situations, thereby enhancing relevance, engagement, and conceptual understanding (Awalia et al., 2021; Febrianti et al., 2024). Similarly, Supriatna et al. (2017) argue that mathematics learning becomes more meaningful when linked to learners' everyday experiences, allowing students to construct understanding through direct engagement with familiar phenomena rather than through procedural memorization alone. Nevertheless, mathematics education in Indonesia continues to face persistent challenges, particularly in geometry learning. Research indicates that many students experience difficulties in understanding fundamental geometric concepts (Stevani et al., 2025), demonstrate low levels of engagement during mathematics lessons (Anggraeni et al., 2020), and exhibit limited interest in learning due to instructional approaches that insufficiently accommodate their educational needs and sociocultural backgrounds (Naldi et al., 2023). These challenges suggest the need for alternative instructional approaches capable of making mathematics more meaningful and relevant to students' experiences.

Ethnomathematics offers one such approach by connecting mathematical learning with cultural artifacts, traditions, and social practices familiar to learners. Rosa et al. (2016) define ethnomathematics as the study and integration of mathematical ideas, methods, and techniques developed by diverse sociocultural groups. Similarly, Risdiyanti and Prahmana (2017) argue that mathematics is inseparable from the cultural contexts in which it is produced and applied. From a broader perspective, D'Ambrosio (2016) contends that ethnomathematics seeks to reposition mathematics within diverse cultural settings by recognizing multiple forms of knowledge, promoting critical reflection, and fostering democratic and tolerant dispositions among learners. Consequently, integrating cultural contexts into mathematics education may contribute not only to deeper conceptual understanding but also to the preservation of cultural heritage and the development of cultural awareness.

Although a growing body of ethnomathematics research has examined mathematical concepts embedded in cultural artifacts, limited attention has been devoted to Islamic geometric patterns within contemporary public spaces, particularly those that combine religious symbolism, cultural identity, and educational potential. Moreover, few studies have explored how the philosophical meanings represented in such patterns can be interpreted alongside their mathematical structures. Addressing this gap, the present study investigates the Islamic geometric patterns embedded in the architectural and ornamental structures of Alun-Alun Cililin. Specifically, the study examines the mathematical concepts represented in these patterns and explores their associated philosophical meanings through an ethnomathematical perspective. By doing so, the study contributes to the expanding body of ethnomathematics literature and demonstrates how local cultural environments can serve as meaningful resources

for culturally responsive mathematics education while supporting efforts toward cultural preservation and appreciation.

Methods

This study employed a qualitative descriptive-exploratory design informed by a semiotic perspective to investigate the ethnomathematical elements embedded in the Islamic geometric patterns and architectural ornaments of Alun-Alun Cililin, West Bandung Regency, Indonesia. A qualitative approach was considered appropriate because the study sought to explore and interpret the meanings, symbols, and cultural representations associated with mathematical concepts situated within a specific sociocultural context. Rather than focusing on the measurement of observable phenomena, the study aimed to understand how mathematical ideas are represented, communicated, and culturally constructed through architectural and ornamental forms.

Semiotics served as the primary analytical framework because it provides a systematic means of examining signs and symbols as carriers of meaning. According to Kevinia et al. (2022), semiotic analysis enables the interpretation of signs that represent objects, ideas, emotions, situations, and cultural values. From this perspective, signs are not merely visual representations but meaningful entities that refer to concepts and realities beyond themselves (Septiani & Sari, 2023). Their meanings are therefore socially and culturally constructed rather than fixed or universal. Drawing on this framework, the present study sought to identify mathematical concepts represented in the geometric ornaments and architectural structures of Alun-Alun Cililin and to interpret the philosophical and cultural meanings embedded within these visual forms.

Research Site and Data Collection

The study was conducted at Alun-Alun Cililin, a public cultural and religious space located in West Bandung Regency, Indonesia. The site was selected because of its distinctive architectural features, particularly its Islamic geometric ornaments and symbolic structures, which potentially embody both mathematical concepts and cultural values. Developed under the concept of a “Little Madinah,” Alun-Alun Cililin provides a rich setting for exploring the interrelationships among mathematics, culture, and religious symbolism.

Data were collected through observation, documentation, and literature review. Field observations were conducted to examine the architectural structures, geometric designs, and ornamental patterns distributed throughout the site. Particular attention was given to visual elements that could be associated with mathematical concepts, including plane geometry, solid geometry, symmetry, and transformational geometry. In addition to identifying mathematical structures, observations focused on understanding the cultural, historical, and philosophical significance of the observed artifacts.

Documentation consisted of photographic records, field notes, and descriptive accounts of relevant architectural and ornamental features. These materials served as the primary

empirical data and supported the credibility and dependability of the analysis. To complement the field data, a literature review was undertaken to provide historical and cultural context for Alun-Alun Cililin and to establish a theoretical basis for interpreting the identified ethnomathematical elements. The reviewed sources included studies on ethnomathematics, Islamic geometric art, semiotics, cultural symbolism, and culturally responsive mathematics education.

Data Analysis

Data analysis followed the interactive model proposed by Miles and Huberman (1994), consisting of data collection, data reduction, data display, and conclusion drawing and verification. These stages were conducted iteratively throughout the research process. The first stage involved organizing observational records, photographic documentation, and relevant literature. Subsequently, data reduction was carried out through the selection, categorization, simplification, and abstraction of information relevant to the research objectives. This process facilitated the identification of architectural and ornamental features that reflected mathematical concepts and cultural meanings.

The reduced data were then systematically displayed to support interpretation and pattern identification. Visual and descriptive representations of the geometric forms were examined to determine their mathematical characteristics and ethnomathematical significance. Particular attention was directed toward identifying relationships among geometric structures, mathematical concepts, and the cultural meanings associated with the observed artifacts.

Semiotic interpretation was consisting of the representamen, object, and interpretant. The representamen refers to the visual sign represented by a geometric pattern or architectural element; the object denotes the mathematical concept or cultural referent represented by the sign; and the interpretant corresponds to the meaning generated through the interpretation of the relationship between the sign and its referent. Through this analytical framework, the identified mathematical forms were interpreted not only as geometric structures but also as cultural symbols expressing religious values, philosophical principles, and local cultural identity.

Finally, conclusions were developed through an iterative verification process in which emerging interpretations were continuously compared with observational evidence, documentation records, and relevant theoretical literature. This process enhanced the credibility and consistency of the findings and enabled the formulation of theoretically grounded conclusions regarding both the mathematical concepts and the philosophical meanings embedded in the architectural and ornamental designs of Alun-Alun Cililin.

Results and Discussion

This study investigates the mathematical concepts embedded within Alun-Alun Cililin, a public park covering approximately 4,000 m². The site provides a strategic context for identifying mathematical ideas that may serve as realistic and contextual learning resources for students in

the surrounding community. Moreover, Alun-Alun Cililin has developed into an iconic destination for religious tourism in West Bandung. Architecturally, the park adopts the concept of "Little Madinah," characterized by Islamic design elements, including large umbrella structures inspired by those of Al-Masjid an-Nabawi and a miniature replica of the Qur'an that strengthens the Islamic atmosphere of the site.

Pentagon Concept in the Rehal Structure

The exploration of mathematical elements embedded in Alun-Alun Cililin provides opportunities to examine the intersections among mathematics, culture, religion, and local identity. Beyond its function as a public recreational and religious space, the site contains architectural and ornamental features that reflect both mathematical structures and cultural meanings. One such feature is presented in Figure 1.

Figure 1. A *Rehal* with a Pentagon-Shaped Base

One of the Islamic ornamental structures identified at Alun-Alun Cililin is a rehal (Qur'an stand) whose base exhibits a pentagonal form. From a mathematical perspective, the pentagon is a five-sided polygon that represents a fundamental concept in plane geometry. The pentagonal configuration observed in the rehal provides a contextual example through which geometric properties of polygons can be explored within culturally meaningful learning environments. The perimeter of the pentagon is determined by the sum of its five sides:

$$K = a + b + c + d + e$$

The pentagonal structure functions as a representamen that refers to the mathematical concept of a pentagon as its object. At the level of the interpretant, the geometric form conveys cultural and religious meanings associated with Islamic teachings. Thus, the pentagon operates simultaneously as a mathematical representation and a cultural symbol.

As illustrated in Figure 1, the *rehal* supports a miniature Qur'an and serves not only a practical function but also a symbolic one. Ridwan et al. (2022) argue that the *rehal* embodies

cultural and spiritual values associated with devotion to God. Similarly, Darmalaksana (2021) explains that the *rehal* symbolizes a vessel or boat that metaphorically carries the reader toward paradise, while the *tuding* (a pointer used during Qur'anic recitation) represents the paddle that guides this spiritual journey. Through these symbolic interpretations, the *rehal* becomes a material expression of religious commitment and spiritual aspiration.

Philosophically, the pentagonal form represents a strong and interconnected foundation for Muslim life. Its five sides may be interpreted as symbolizing the Five Pillars of Islam, namely the *shahada* (profession of faith), *salat* (prayer), *zakat* (almsgiving), *sawm* (fasting during Ramadan), and *hajj* (pilgrimage to Mecca). These pillars constitute the fundamental principles that guide individual conduct and shape harmonious relationships with both God and society. From an ethnomathematical perspective, the pentagonal structure demonstrates how a geometric form can simultaneously embody mathematical knowledge, religious symbolism, and cultural values. Consequently, the *rehal* may serve as a meaningful contextual resource for geometry instruction by enabling students to connect abstract mathematical concepts with cultural artifacts that are familiar within their sociocultural environment.

Rectangle Concept in the Gate Structure

Figure 2 illustrates the entrance gate of Alun-Alun Cililin, which features the inscription Bismillāhirraḥmānirraḥīm accompanied by four rectangular ornaments. From a mathematical perspective, the ornament represents the concept of a rectangle, a quadrilateral characterized by four right angles and two pairs of equal opposite sides. The area and perimeter of a rectangle are determined using the following formulas:

$$L = p \times l$$
$$K = 2 \times (p + l)$$

where p denotes length and l denotes width.

Figure 2. Right-Side Gate in the Form of a Rectangle

The rectangular ornament functions as a representamen that refers to the mathematical concept of a rectangle as its object. At the level of the interpretant, the geometric form conveys cultural and philosophical meanings associated with order, balance, and stability. Delfi et al. (2020) argue that rectangular forms are frequently interpreted as symbols of honesty, harmony, solidarity, security, and equality. Similarly, Efendi et al. (2025) suggest that rectangular structures represent social order and organization, reflecting the importance of maintaining balance within communal life.

The inscription Bismillāhirraḥmānirraḥīm ("In the name of Allah, the Most Gracious, the Most Merciful") further enriches the symbolic meaning of the architectural composition. Within Islamic tradition, the phrase signifies the recognition of Allah as the ultimate source of guidance, blessing, and meaning in human life. It also reflects the interconnectedness of physical, psychological, and spiritual dimensions of existence. Contemporary studies have shown that spiritual practices, including prayer and meditation, contribute positively to emotional resilience and psychological well-being (Mustapa et al., 2023).

As the opening verse of Surah Al-Fātiḥah, the Basmalah encourages Muslims to begin every action with sincere intentions and moral awareness. Khusniyah (2023) interprets this principle through the Javanese expression ing mbun mbun mami dhohir ing rasaning wong, emphasizing the importance of commencing activities with the remembrance of God. The term mbun mbun (forehead) symbolically refers to the location of the brain, which is regarded as the center of knowledge, reasoning, and understanding.

The inscriptions "Allah" and "Muhammad" further reinforce the ethical and spiritual message communicated through the gate. Together, they encourage believers to worship Allah sincerely and to emulate the exemplary character of Prophet Muhammad SAW. From an ethnomathematical perspective, the rectangular ornament demonstrates how a geometric form may simultaneously function as a mathematical object and a cultural symbol. Consequently, the gate provides a meaningful contextual resource through which students can explore geometric concepts while reflecting on the cultural and spiritual values embedded within their local environment.

Semicircle Concept in the Gate Roof Ornament

Another mathematical concept identified in the architectural design of Alun-Alun Cililin is the semicircle, which appears in the decorative elements of the entrance gate roof (Figure 3). A semicircle represents half of a circle and possesses distinctive geometric properties related to area and perimeter.

Figure 3. Gate Roof Featuring Semicircular Ornaments

The area and perimeter of a semicircle are expressed as follows:

$$L = \frac{1}{2}\pi r^2$$
$$K = \frac{1}{2}\pi d + 2r$$
$$K = \frac{1}{2}\pi d + d$$

where L denotes area, K denotes perimeter, r denotes radius, and d denotes diameter.

From a semiotic perspective, the semicircular ornament serves as a representamen that refers to the mathematical concept of a semicircle as its object. The interpretant emerges through the cultural and philosophical meanings attributed to the form. The repeated semicircular motifs contribute to the visual harmony of the entrance gate while simultaneously communicating symbolic ideas related to balance, order, and continuity.

The semicircular ornament also possesses considerable educational value. In mathematics classrooms, students frequently experience misconceptions regarding the perimeter of a semicircle. A common misunderstanding is the assumption that the perimeter consists solely of half the circumference of a circle, expressed as $K = \frac{1}{2}\pi d$. However, the perimeter must also include the diameter because the semicircle contains a straight boundary in addition to its curved arc. Hidayat and Fauzi (2023) emphasize that such misconceptions should be addressed early because they may influence students' understanding of subsequent mathematical concepts. The ornament depicted in Figure 3 therefore provides a culturally relevant and visually accessible context through which students can explore, and correct misconceptions related to semicircular geometry.

Beyond its mathematical significance, the semicircle embodies philosophical meanings associated with Islamic thought. Liesandra (2022) suggests that semicircular forms symbolize balance and order within the universe. Similarly, Alfisyahr et al. (2026) argue that the semicircle reflects the incompleteness of human beings and their dependence on divine perfection. Although individuals possess both strengths and limitations, they remain reliant upon God's guidance and provision throughout their lives. Accordingly, the semicircular ornament may be interpreted not only as a geometric structure but also as a symbolic representation of the relationship between human existence and divine transcendence.

Taken together, these findings demonstrate how the semicircular ornament integrates mathematical, cultural, and spiritual dimensions within a single architectural form. Such integration highlights the potential of ethnomathematical approaches to connect formal geometric concepts with meaningful cultural experiences, thereby supporting more contextualized and culturally responsive mathematics learning.

Rhombus Concept in Pillar Ornamentation

The analysis identified rhombus-shaped ornaments embedded within the pillar structures of Alun-Alun Cililin (Figure 4). From a mathematical perspective, a rhombus is a quadrilateral

with four equal sides and opposite angles of equal measure. The area and perimeter of a rhombus are determined by the following formulas:

$$L = \frac{1}{2} \times d_1 \times d_2$$
$$K = 4 \times s$$

where d_1 and d_2 represent the diagonals and s represents the side length.

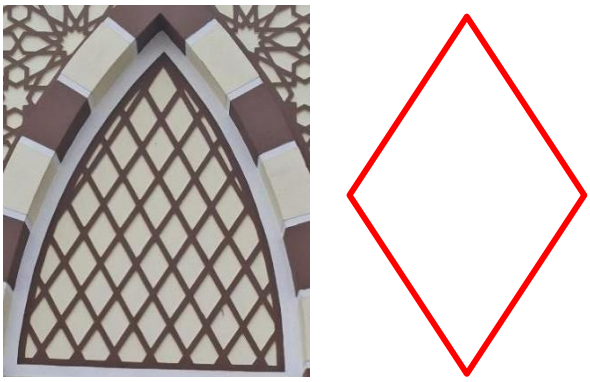

Figure 4. Pillar Ornamentation in the Form of a Rhombus

The rhombus patterns are formed through the intersection of parallel lines, producing repetitive geometric arrangements characteristic of Islamic architectural ornamentation. The rhombus motif functions as a representamen that refers to the mathematical concept of a rhombus as its object. At the level of the interpretant, the geometric form communicates cultural meanings associated with social harmony and interpersonal relationships.

Similar rhombus patterns have been identified in the dome structure of the Keuchiek Leumiek Mosque, where they serve both decorative and functional purposes, including water drainage (Nirmala et al., 2019). In addition, Dewi et al. (2019) argue that the rhombus motif symbolizes the strengthening of silaturahmi (social relationships), encouraging mutual respect, generosity, and positive interactions within the community. The repetitive arrangement of the rhombus pattern may therefore be interpreted as representing interconnectedness and social cohesion among individuals.

From an ethnomathematical perspective, the rhombus ornament demonstrates how geometric structures can simultaneously function as mathematical representations and cultural symbols. Consequently, the ornament offers a meaningful context through which students may explore geometric properties while reflecting on the social and cultural values embedded in local architectural heritage.

Trapezoid Concept in Supporting Structures

Another geometric concept identified in Alun-Alun Cililin is the trapezoid, which appears in both the supporting pillars and the plaza structures shown in Figure 5. Mathematically, a trapezoid is a quadrilateral with one pair of parallel sides. The area and perimeter of a trapezoid are expressed as follows:

$$L = \frac{1}{2} \times (a + b) \times t$$

$$K = ab + bc + cd + ad$$

where a and b denote the parallel sides and t denotes height.

The trapezoidal forms contribute to the visual organization of the site through their symmetrical arrangement, creating an environment that appears structured, balanced, and accessible to visitors. Within the semiotic framework, the trapezoid serves as a representamen corresponding to the mathematical concept of a trapezoid as its object. The interpretant emerges through the cultural and philosophical meanings attributed to the form.

Figure 5. Supporting Pillars and Plaza Structures in the Form of a Trapezoid

According to Efendi et al. (2025), the pointed upper section of a trapezoid symbolizes humility, whereas its wider lower section represents stability and a strong foundation. This symbolism reflects an important philosophical principle in which personal growth is grounded in humility and supported by a firm moral foundation. Such interpretations resonate with broader educational values that emphasize the importance of confidence, critical thinking, perseverance, and openness to learning.

From an ethnomathematical perspective, the trapezoidal structures illustrate how architectural forms may communicate both mathematical and philosophical ideas. Their presence within a public cultural space provides opportunities for students to connect geometric concepts with values that are meaningful within their sociocultural environment.

Kite Concept in Umbrella Ornamentation

The umbrella structures of Alun-Alun Cililin contain ornaments exhibiting kite-shaped geometric forms (Figure 6). A kite is a quadrilateral characterized by two pairs of adjacent sides of equal length and diagonals that intersect at right angles. The area and perimeter of a kite are given by:

$$L = \frac{1}{2} \times d_1 \times d_2$$
$$K = a + b + c + d$$

where d_1 and d_2 denote the diagonals.

The kite motif forms part of the decorative elements supporting the monumental umbrella structures inspired by the architecture of Al-Masjid an-Nabawi. The kite ornament functions as a representamen that refers to the mathematical concept of a kite as its object. At the interpretive level, the ornament conveys symbolic meanings associated with aspiration, freedom, and joy.

Figure 6. Kite-Shaped Ornamentation in the Umbrella Structure

Efendi and Susanti (2025) explain that kite motifs are often interpreted as representations of hope, optimism, and the pursuit of higher goals. In the context of Alun-Alun Cililin, the interconnected pillars supporting the umbrella structures further reinforce the idea that individual strength is developed through cooperation and mutual support. The geometric arrangement therefore symbolizes collective unity and interdependence within the community.

From an ethnomathematical perspective, the kite ornament exemplifies the integration of mathematical concepts, architectural aesthetics, and cultural symbolism. As a contextual learning resource, the ornament enables students to investigate geometric properties while simultaneously engaging with the cultural meanings embedded in the architectural environment. Such connections may contribute to more meaningful mathematics learning by linking abstract geometric ideas to students lived cultural experiences.

Square Concept in Entrance Wall Ornamentation

Figure 7 illustrates a square-shaped ornament located on the right entrance wall of Alun-Alun Cililin. From a mathematical perspective, a square is a two-dimensional geometric figure

characterized by four equal sides and four right angles. The area and perimeter of a square are determined by the following formulas:

$$L = s \times s$$
$$K = 4 \times s$$

where s denotes the side length.

The square ornament functions as a representamen that refers to the mathematical concept of a square as its object. At the level of the interpretant, the geometric form conveys symbolic meanings that extend beyond its mathematical properties. The ornament represents ideas of stability, balance, and order, values that are frequently associated with both architectural design and social organization.

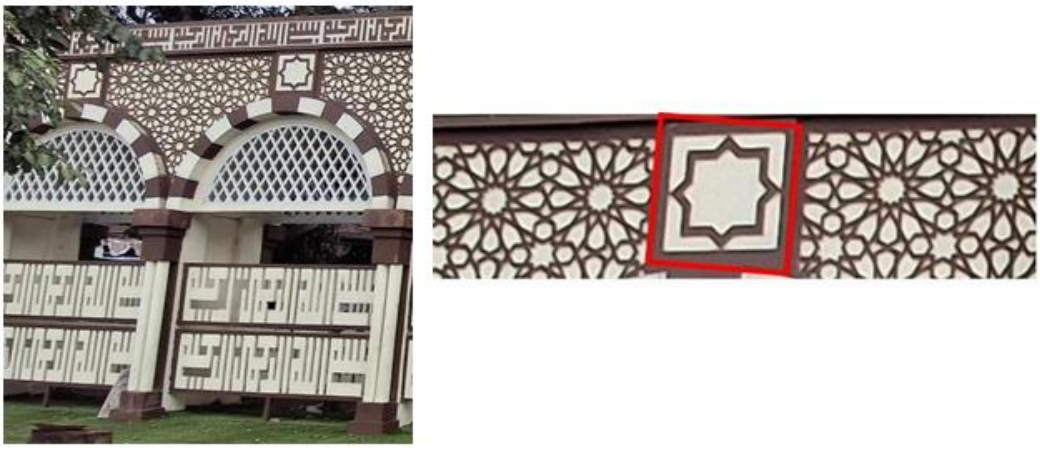

Figure 7. Right Entrance Wall Ornament in the Form of a Square

Dewi et al. (2019) argue that square ornaments symbolize institutional perfection supported by individuals who contribute expertise within their respective domains. Similarly, Burckhardt (2009) explains that the square traditionally represents stability, order, and the material dimension of existence, whereas the circle symbolizes unity, perfection, and the divine realm. The ornament observed in Alun-Alun Cililin combines these geometric traditions, producing an octagonal pattern that may be interpreted as a symbolic transition between earthly and spiritual realities. Critchlow (1976) suggests that the octagon functions as an intermediary form linking the square and the circle, thereby representing the relationship between the physical and spiritual dimensions of human existence.

Furthermore, the number eight possesses particular significance within Islamic symbolism because it is frequently associated with the eight gates of paradise. In this sense, the ornament may be interpreted as representing humanity's spiritual journey toward God through a life characterized by faith, moral conduct, and devotion. From an ethnomathematical perspective, the square ornament demonstrates how geometric forms can simultaneously communicate mathematical ideas and religious meanings. As a contextual learning resource, the ornament provides opportunities for students to explore geometric concepts while engaging with the cultural and spiritual values embedded within local architectural heritage.

Prism Concept in the Main Gate Structure

Another mathematical concept identified at Alun-Alun Cililin is the prism, which appears in the architectural composition of the main gate structure (Figure 8). A prism is a three-dimensional geometric solid characterized by two congruent and parallel polygonal bases connected by lateral faces. The general formula for prism volume is expressed as:

$$V = L_a \times t$$

where L_a denotes the area of the base and t represents the height of the prism.

In the observed structure, the upper and middle sections form rectangular prisms, while the lower section forms a trapezoidal prism. The corresponding volume formulas are:

$$V = p \times l \times t$$

for a rectangular prism, and

$$V = \left(\frac{a+b}{2} \times t_p\right) \times t$$

for a trapezoidal prism.

Figure 8 presents a structure commonly referred to as a leader head, which traditionally functions as a component of a drainage system by directing rainwater from roof gutters to underground channels. In the context of Alun-Alun Cililin, however, the structure also serves an ornamental purpose, framing cylindrical elements positioned above and below it. Through semiotic analysis, the prism-based structure functions as a representamen corresponding to the mathematical concept of a prism as its object.

Figure 8. Main Gate Ornamentation in the Form of Rectangular and Trapezoidal Prisms

Beyond its geometric characteristics, the prism structure reflects the integration of functional and aesthetic considerations within Islamic architectural design. Its layered composition demonstrates how mathematical forms are employed not only to satisfy practical needs but also to create visual harmony and structural balance. From an ethnomathematical perspective, the prism-based ornament illustrates how three-dimensional geometric concepts can be identified within everyday architectural environments, thereby providing meaningful contexts for the teaching and learning of spatial geometry.

Cylinder Concept in Supporting Pillars

The analysis also identified cylindrical forms integrated into the decorative gateway structures of Alun-Alun Cililin (Figure 9). A cylinder is a three-dimensional solid bounded by two congruent and parallel circular bases connected by a curved lateral surface. The volume and surface area of a cylinder are determined using the following formulas:

$$V = \pi r^2 t$$
$$L_p = 2\pi r(r + t)$$

where r denotes the radius and t represents the height of the cylinder.

The cylindrical structures are positioned within ornamental compositions framed by leader head elements, contributing to the visual identity of the entrance gateway. The cylinder functions as a representamen that refers to the mathematical concept of a cylinder as its object. At the interpretive level, the geometric form conveys meanings associated with strength, stability, and continuity.

Figure 9. Cylindrical Supporting Pillar

Rizqiyah and Khoiri (2025) argue that cylindrical forms symbolize resilience and steadfastness, while Nalim et al. (2024) associate them with consistency in practicing Islamic teachings, particularly the observance of the five daily prayers. The continuous curved surface of the cylinder may therefore be interpreted as representing persistence and unwavering commitment in the face of life's challenges. Such symbolism aligns with broader Islamic values emphasizing discipline, perseverance, and spiritual constancy.

From an ethnomathematical perspective, the cylindrical ornament demonstrates how mathematical forms may acquire cultural and religious significance within a particular sociocultural setting. The structure provides a concrete representation of spatial geometry while simultaneously communicating values that are meaningful to the local community. Consequently, the cylindrical pillar has the potential to function as a contextual learning resource through which students can investigate geometric concepts while appreciating the cultural meanings embedded within architectural artifacts.

Rectangular Prism Concept in Gabion Structures

The analysis identified rectangular prism forms within the gabion structures surrounding the Qur'anic monument at Alun-Alun Cililin (Figure 10). A rectangular prism is a three-dimensional solid bounded by six rectangular faces arranged in three congruent pairs. The volume and surface area of a rectangular prism are determined using the following formulas:

$$V = p \times l \times t$$
$$L = 2(pl + pt + lt)$$

where p, l, and t denote the length, width, and height of the prism, respectively.

Figure 10 illustrates stacks of stones enclosed within gabion structures arranged in rectangular prism forms. Eight prisms are positioned symmetrically on either side of the Qur'anic monument, creating visual balance within the architectural composition. The gabion structure functions as a representamen that refers to the mathematical concept of a rectangular prism as its object. At the interpretive level, the structure may be understood as symbolizing stability, order, and protection, qualities commonly associated with both architectural and educational foundations.

Figure 10. Gabion Fence in the Form of a Rectangular Prism

The symmetrical arrangement of the gabions reinforces the principles of balance and organization that characterize many Islamic architectural designs. Beyond their functional role as retaining structures, the gabions contribute to the aesthetic coherence of the site while

illustrating the application of spatial geometry in everyday environments. From an ethnomathematical perspective, the rectangular prism structures demonstrate how three-dimensional mathematical concepts are embedded within cultural artifacts and public spaces. Consequently, they may serve as contextual resources for supporting students' understanding of volume, surface area, spatial reasoning, and geometric visualization.

Truncated Cone Concept in Umbrella Ornamentation

Another prominent mathematical concept identified at Alun-Alun Cililin is the truncated cone, which appears in the monumental umbrella structures inspired by the architecture of Al-Masjid an-Nabawi (Figure 11). A truncated cone is formed when a cone is intersected by a plane parallel to its base, removing the upper portion of the original cone. The volume and surface area of a truncated cone are expressed as follows:

$$V = \frac{1}{3}\pi r_B^2 t_B - \frac{1}{3}\pi r_k^2 t_k$$
$$V = \frac{1}{3}\pi(r_B^2 t_B - r_k^2 t_k)$$
$$L = \pi r_B^2 + \pi r_k^2 + \pi r_B s_B - \pi r_k s_k$$
$$L = \pi(r_B^2 + r_k^2 + r_B s_B - r_k s_k)$$

where r_B and r_k denote the radii of the larger and smaller circular bases, t_B and t_k represent their corresponding heights, and S_B and S_k denote the slant heights.

The umbrella structures constitute one of the most distinctive architectural features of Alun-Alun Cililin. Within the semiotic framework, the truncated cone serves as a representamen corresponding to the mathematical concept of a three-dimensional geometric solid as its object. The interpretant emerges through the cultural and spiritual meanings associated with the form.

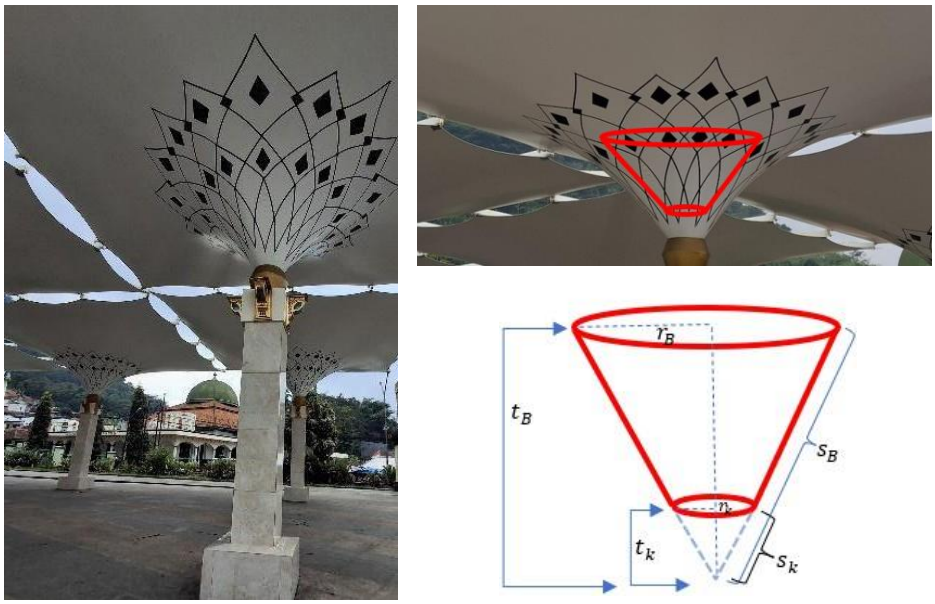

Figure 11. Umbrella Structure in the Form of a Truncated Cone

Jamaludin (2021) explains that the cone combines circular and triangular elements, symbolizing both spatial perfection and spiritual completeness. In the context of Alun-Alun Cililin, the truncated cone may therefore be interpreted as representing the integration of worldly and spiritual dimensions of life. The broad lower section provides a sense of stability and protection, whereas the upward orientation of the structure symbolizes spiritual aspiration and transcendence. Consequently, the ornament communicates the importance of maintaining balance between material responsibilities and spiritual development.

From an ethnomathematical perspective, the umbrella structures demonstrate how sophisticated geometric concepts can be embodied within culturally significant architectural forms. Their presence provides opportunities for students to explore three-dimensional geometry while simultaneously engaging with the cultural and religious meanings embedded within Islamic architectural traditions.

Reflection Concept in Tower Ornamentation

The analysis also identified reflection as a transformational geometry concept embedded within the tower ornamentation of Alun-Alun Cililin (Figure 12). Reflection is a geometric transformation that maps an object onto its mirror image across a line or point of symmetry. The reflection of a point can be expressed as:

$$Ref_p(a) = 2p - a$$

where a represents the original point, p denotes the center of reflection, and $Ref_p(a)$ represents the reflected image.

The ornament shown in Figure 12 is derived from circular geometric forms arranged symmetrically around a central point. The symmetrical pattern functions as a representamen that refers to the mathematical concept of reflection as its object. At the interpretive level, the ornament communicates broader cultural and spiritual meanings associated with harmony, balance, and unity.

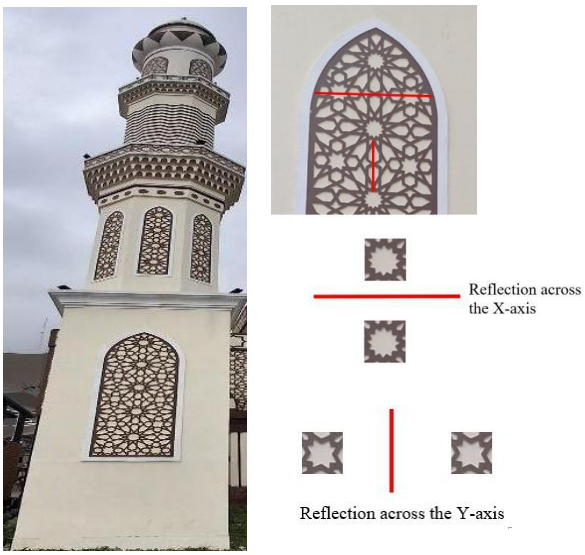

Figure 12. Tower Ornamentation Exhibiting Reflection Symmetry

According to Abdullahi and Embi (2013), the circle and its center constitute the fundamental basis of Islamic geometric design. The circle symbolizes divine unity and reflects the central spiritual significance of Mecca within Islamic tradition. Dewi et al. (2019) further argue that symmetrical arrangements represent social harmony, religious values, and communal balance. Consequently, the reflected patterns observed in the ornament may be interpreted as visual representations of equilibrium between individual, social, and spiritual dimensions of life.

From an educational perspective, the ornament provides a meaningful context for introducing transformational geometry concepts. By examining reflection within culturally familiar architectural forms, students may develop a deeper understanding of symmetry while simultaneously recognizing the presence of mathematics within their cultural environment.

Rotation Concept in Hexagonal Ornamentation

Rotation was identified as another transformational geometry concept embedded within the decorative patterns of Alun-Alun Cililin. Figure 13 presents a floral motif constructed around a regular hexagonal structure and organized symmetrically around a central point. Rotation is defined as the movement of a point through a specific angle around a fixed center. The ornament demonstrates reflections across the X-axis, the Y-axis, and the origin $(0, 0)$. The rotational movement of the regular hexagon may be interpreted analogously to clock positions: 90° corresponds to 3 o'clock, 180° to 6 o'clock, 270° to 9 o'clock, and 360° to 12 o'clock.

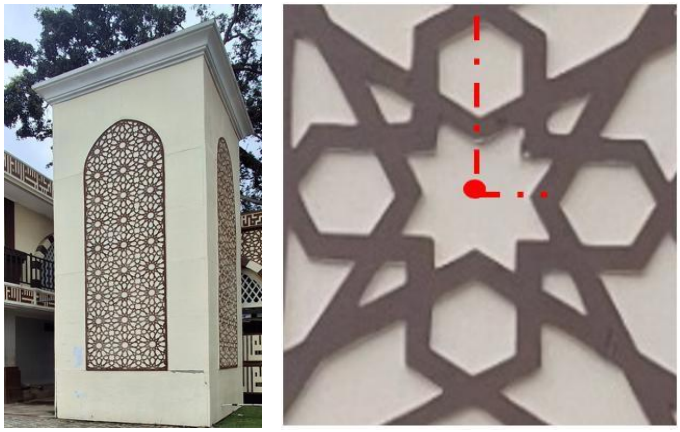

Figure 13. Rotational Symmetry in a Regular Hexagonal Ornament

Mathematically, rotation refers to the movement of a geometric object through a specified angle around a fixed center. The ornament exhibits rotational symmetry through the repeated arrangement of floral motifs around the center of the hexagon. In addition, the design demonstrates reflectional symmetry across the horizontal axis, vertical axis, and the origin, illustrating the integration of multiple transformational concepts within a single ornamental pattern.

Within the semiotic framework, the ornament functions as a representamen that refers to the mathematical concept of rotation as its object. The interpretant emerges through the symbolic meanings associated with repetition, continuity, and harmony. The rotational

arrangement creates a sense of visual balance that is characteristic of Islamic geometric art, where mathematical precision and aesthetic beauty are closely interconnected.

From an ethnomathematical perspective, the hexagonal ornament demonstrates how transformational geometry is embedded within cultural and religious artistic traditions. The repeated rotational patterns reveal the intentional use of mathematical principles to create aesthetically harmonious designs. Such patterns provide rich opportunities for exploring concepts of rotational symmetry, angle measurement, and geometric transformations in culturally meaningful contexts.

Educational Implications of the Findings

The findings indicate that Alun-Alun Cililin contains a rich variety of Islamic geometric forms that may serve as contextual resources for mathematics education, particularly in the domains of plane geometry, solid geometry, and geometric transformations. The identified mathematical concepts are not isolated abstractions; rather, they are embedded within architectural and cultural artifacts that carry religious, philosophical, and social meanings. This integration supports the ethnomathematical perspective that mathematical knowledge is inseparable from the cultural contexts in which it is developed and practiced.

Consistent with the findings of Purniati et al. (2021), the present study demonstrates that Islamic artistic and architectural forms provide meaningful contexts for exploring geometric concepts and transformations. Furthermore, the integration of cultural contexts into mathematics learning aligns with the principle that meaningful learning occurs when students are able to connect new mathematical ideas with their prior experiences and sociocultural environments (Nursanti & Febrianti, 2025).

The results also suggest that local Islamic architecture can support the development of culturally responsive mathematics instruction. By incorporating architectural elements and geometric patterns familiar to students, teachers may design learning experiences that are more relevant, engaging, and accessible while fostering deeper conceptual understanding of geometry (Hidayati & Habibi, 2025). Such an approach may help students recognize mathematics as a living body of knowledge embedded within everyday life rather than as a collection of abstract rules and procedures.

More broadly, this study contributes to the growing body of ethnomathematics research in Indonesia by demonstrating the educational potential of religious tourism sites as sources of mathematical knowledge. The architectural features of Alun-Alun Cililin illustrate how mathematical concepts, cultural heritage, and religious values can be integrated within a single learning environment. Consequently, the findings may inform the development of culturally responsive teaching materials and contextualized geometry learning activities that simultaneously support mathematical understanding, cultural appreciation, and heritage preservation. Through such efforts, mathematics education may contribute not only to students' academic development but also to the cultivation of cultural identity and awareness within increasingly diverse educational settings.

Conclusion

This study demonstrates that the architectural structures and Islamic geometric ornaments of Alun-Alun Cililin embody a diverse range of mathematical concepts that can serve as meaningful resources for mathematics education. Through a semiotic and ethnomathematical analysis, the study identified concepts of plane geometry, including squares, rectangles, trapezoids, rhombuses, circles, kites, and pentagons; solid geometry concepts, including rectangular prisms, trapezoidal prisms, cylinders, and truncated cones; and transformational geometry concepts, particularly reflection and rotation. These findings indicate that mathematical ideas are embedded within cultural artifacts and architectural forms, illustrating the interconnectedness of mathematics, culture, and religious symbolism.

Beyond their mathematical significance, the identified geometric patterns convey philosophical meanings associated with moral responsibility, spiritual preparedness, social solidarity (silaturahmi), historical preservation, mutual cooperation, and the pursuit of personal and spiritual excellence. Through Peirce's semiotic framework, these ornaments can be understood not merely as decorative elements but as cultural signs that communicate religious, social, and philosophical values. The findings therefore support the ethnomathematical perspective that mathematical knowledge is inseparable from the cultural contexts in which it is created, represented, and interpreted.

From an educational perspective, this study highlights the potential of Alun-Alun Cililin as a culturally responsive and contextually meaningful learning environment for geometry instruction. Integrating local Islamic geometric patterns into mathematics education may enable students to connect formal mathematical concepts with their sociocultural experiences, thereby fostering deeper conceptual understanding and greater appreciation of the relationships among mathematics, culture, and everyday life. The findings also provide a foundation for the development of ethnomathematics-based teaching materials and learning activities grounded in local cultural heritage.

This study is subject to several limitations. First, the analysis was confined to a specific cultural site, which may limit the transferability of the findings to other contexts. Second, the interpretation of cultural and philosophical meanings is inherently situated and may be influenced by the perspectives adopted during the analytical process. Future research may extend this work by developing and implementing ethnomathematics-based instructional materials derived from the Islamic geometric patterns of Alun-Alun Cililin and by examining their impact on students' geometric reasoning, cultural awareness, mathematical engagement, and meaningful learning. Such investigations would further contribute to the development of culturally responsive mathematics education and to the growing body of ethnomathematics research.

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