SCIENTIFIC CULTURE
www.sci-cult.com

SCIENTIFIC CULTURE, Vol. 12, No. 2.1, (2026), pp. 11821-11827
Open Access. Online & Print

DOI: 10.5281/zenodo.20241588

EXPLORATION OF GEOMETRY CONCEPT IN YOGYAKARTA PALACE ORNAMENTS

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Received: 07/04/2026
Accepted: 08/05/2026

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ABSTRACT

This research uses an ethnomathematics approach to study the concept of geometry found in ornaments in the Yogyakarta Palace. The methods used by cultural groups in daily mathematical activities, such as categorizing, counting, and measuring, are called ethnomathematics. The purpose of this research is to discover and understand how geometry concepts such as square, rectangle, circle, triangle, trapezoid, and rhombus are used in ornaments made in the Yogyakarta Palace. Data were collected through interviews, observations, and literature studies; then, data reduction, mapping, and interpretation methods were used. The results showed that the ornaments have high cultural and aesthetic values, as well as complex mathematical principles. It is hoped that by incorporating geometry concepts from these ornaments into the educational curriculum, students will gain a better understanding of geometry.

KEYWORDS: Ethnomathematics, Geometry, Yogyakarta Palace Ornaments, Culture, Kurikulum Merdeka Belajar.

1. INTRODUCTION

Against the backdrop of technological advancement, the education curriculum requires the integration of culture in the process of education with the aim of forming a generation with character and being able to preserve culture (Fajriyah, E, 2018). Mathematics is a field that investigates concepts, shapes, and relationships. According to Destrianti, *et al*. (2019), this relationship is related to culture and other fields of science. Culture and math are two things that cannot be avoided in everyday life. Mathematics helps us solve everyday problems, and culture is a permanent, inherent, and applicable unity in society (Putri, 2017). According to Pinxten (1944) (Pertiwi & Budiarto, 2020), mathematics is basically a symbolic technique based on cultural skills or environmental activities.

Ethnomathematics refers to certain methods used by certain cultural groups or communities for mathematical activities. These mathematical activities are activities that involve the process of abstracting practical experiences in everyday life into mathematics, or vice versa, such as classifying, counting, measuring, designing buildings and tools, making patterns, counting, and others (Rachmawati, I, 2012).

Ethnomathematics is a science used to understand how mathematics is adapted from a culture and serves to show the relationship between culture and mathematics (Marsigit, *et al.*, 2019). Ethnomathematics includes mathematical ideas, thoughts, and practices developed by all cultures. Ethnomathematics can also be seen as a program that aims to study how students can understand, express, process and ultimately use mathematical ideas, concepts, and practices to solve problems related to their daily activities (Barton, 1996). In this case, the purpose of ethnomathematics research is to understand the belief system, thinking and behavior of a group, which can then be used as a basis for providing meaningful mathematics learning for students. The same thing is also emphasized by Freudenthal (Putrawangsa, 2017), learning should start from what students can imagine, close to students, and related to students' lives.

Geometry is a branch of mathematics that studies the shape, size, and position of objects (Muhammad, AFN, *et al.*, 2019; Muhammad, AFN, 2023). Geometry has an important role in everyday life, from building design, art, to technology. Geometry material in the realm of elementary school, especially the lower grades, is only limited to introducing flat shapes, calculating the area and perimeter of a flat shape and calculating side lengths. In addition, students are also introduced to various flat shapes that are located or applied to the surrounding environment, such as houses /buildings, historical sites, and so on.

The development of ethnomathematics-based learning can begin by identifying several ethnomathematics objects. One of the learning resources that can be explored from an ethnomathematics point of view that is interesting to study is the Yogyakarta Palace. Kraton Yogyakarta is a kingdom founded by Sri Sultan Hamengkubuwono I a few months after the Giyanti Agreement in 1755. The museum, which was founded on February 13, 1755, which during the reign of Sri Sultan Hamengkubuwono I, has various important monuments where monuments or valuable items left over from the time of Sri Sultan Hamengkubuwono I are still neatly stored and cared for. And also, the existence of several important buildings from the previous era in which there are shapes and ornaments that implement mathematics at that time. On the one hand, the Yogyakarta Palace is one of the cultural heritages that has unique ornaments and is rich in meaning (Wijayanto, Z, 2017; Pratikno, 2018). These ornaments not only have aesthetic value, but also contain cultural and philosophical values. The Yogyakarta Palace itself is located on Jl. Rotowijayan Blok No. 1, Panembahan, Keraton District, Yogyakarta City, Yogyakarta Special Region. Until now, Yogyakarta Palace is still visited by local and foreign tourists.

This research aims to explore the concept of geometry in Yogyakarta Palace ornaments. This research is expected to provide a deeper understanding of the concept of geometry contained in the Yogyakarta Palace ornaments.

2. MATERIAL AND METHODS

This study employs a qualitative method with an ethnographic approach to systematically explore and document the geometric concepts embedded within the Keraton Yogyakarta (Yogyakarta Palace) ornaments. Ethnography was specifically chosen to capture the intricate relationship between mathematical structures and their underlying cultural philosophies in a naturalistic setting.

2.1. Participants And Data Sources

To ensure depth of analysis, data were gathered through a purposive sampling strategy. Key participants included:

a. Cultural Experts (Abdi Dalem): Three senior experts specialized in palace architecture and philosophy to provide context on the symbolic meanings of the ornaments.

b. Mathematicians: Two academics specializing in ethnomathematics to validate the geometric modeling.
c. Physical Artifacts: Primary observations focused on specific high-relief and low-relief ornaments across the Keben and Sri Manganti wards.

2..2 Data Collection Procedures

The data collection was executed in three synchronized phases:

a. Direct Observation: Using a structured observation field note, the researcher documented geometric patterns, symmetry, and tessellations. High-resolution photography was utilized to capture details for subsequent digital geometric mapping.
b. Semi-Structured Interviews: In-depth interviews were conducted to uncover the "ethno" aspect—specifically how the makers and the royal community perceive these shapes. Questions focused on the philosophical symbolism (e.g., Sangkan Paraning Dumadi) and how it dictates specific spatial proportions.
c. Literature Review: Analysis of historical manuscripts (Serat) and architectural archives to triangulate oral testimonies with historical design principles.

2.3. Data Analysis and Interpretation

Beyond descriptive mapping, the analysis employed an iterative process of Ethno-Mathematical Modeling. The data were processed through:

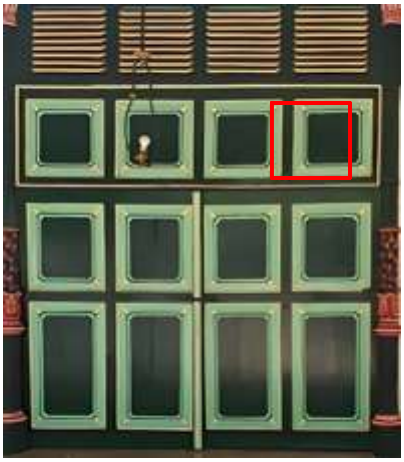
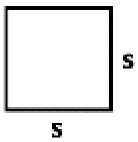
a. Data Reduction: Filtering complex visual data into core geometric motifs.
b. Pattern Mapping: Utilizing geometric software to overlay Euclidean and transformational geometry principles onto the photographic data.
c. Cultural-Mathematical Synthesis: A deep analytical stage where cultural meanings (the "why") were linked with mathematical properties (the "how"). For instance, analyzing how the concept of "balance" in Javanese philosophy manifests as specific bilateral symmetry in the ornaments.

2.4. Trustworthiness And Validation

To ensure the credibility and reliability of the findings, this study implemented triangulation of sources and methods. The findings were further subjected to member checking, where the initial geometric interpretations were presented back to the cultural experts and mathematicians for verification. This process ensured that the mathematical abstraction did not deviate from the intended cultural significance of the Keraton Yogyakarta heritage.

3. RESULT AND DISCUSSION

Table 1: Square-Shaped Ethnomathematics of Yogyakarta Palace.

Parts that contain mathematical elements.	Aspects of math that need to be learned at school.
	One of the square-shaped sections of the palace wall.  **The shape of the building can be used as learning material for elementary school students in grade one (recognizing shapes), grade two (geometric shapes and shapes), grade three (elements of flat shapes), grade four (measuring area and volume) and grade five (perimeter and area of flat shapes).**

A two-dimensional flat shape with equal side lengths is called a square. A square is made up of four equal-length sides and its four corners are right angles. The material on the area and perimeter of a square flat can be found at the fifth grade elementary school level.

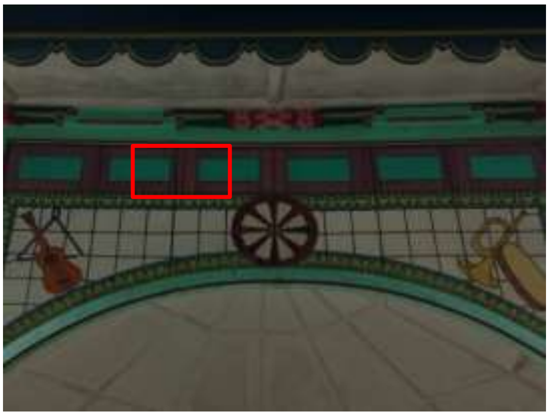
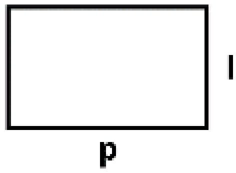
Area of a square

Perimeter of a square

L = s x s
L is the area, and **s** is the length of each side.

K = 4 x s
K is the perimeter of the square, and **s** is the length of each side of the square

Table 2: Ethnomathematics Of The Yogyakarta Palace In The Shape Of A Rectangle.

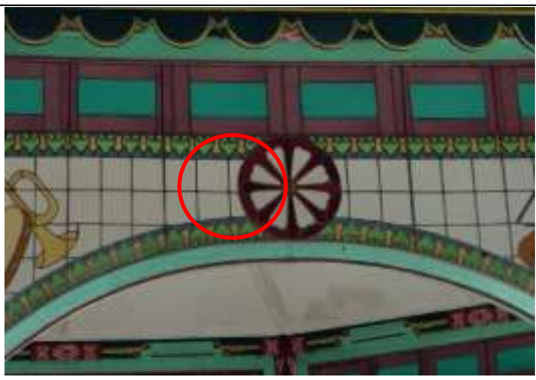
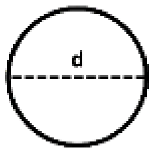
Parts that contain mathematical elements.	Aspects of math that need to be learned at school.
	One part of the palace's rectangular gate:  **The shape of the building can be used as learning material for first grade students (recognizing shapes), second grade (shapes and geometry), third grade (elements of flat buildings), fourth grade (measuring area and volume) and fifth grade (perimeter and area of flat buildings).**

A two-dimensional flat shape that has 4 sides with 2 pairs of sides facing the same length and has 4 angles that are all right-angled is called a rectangle. The material on the area and perimeter of rectangular flat shapes can be found at the fifth-grade elementary school level.

The area of the rectangle.
L = p x l
L is area, **p** is length, and **l** is width.

Perimeter of a Rectangle.
K = 2 x (p + l)
K is the perimeter, **p** is the length, and **l** is the width

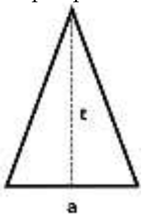
Table 3: Circle-Shaped Ethnomathematics Of Yogyakarta Palace.

Parts that contain mathematical elements.	Aspects of math that need to be learned at school.
	One of the circular parts of the palace ornament.  **The shape of the building can be used as learning material for first grade students (recognizing shapes), second grade (shapes and geometry), third grade (elements of flat buildings), fourth grade (measuring area and volume) and fifth grade (perimeter and area of flat buildings).**

A two-dimensional flat shape formed from curved lines whose two ends meet at the same distance from a center point is called a circle. The material on the area of a circular flat shape can be found at the fifth-grade elementary school level.
The area of the circle.
$L = \pi r^2$
L is the area, **π** is 3,14 or $\frac{22}{7}$, and **r** is the length of the radius.
Circumference of a circle.
$K = \pi \times d$
K is the circumference, **π** is 3.14 or $\frac{22}{7}$, and **d** is the length of the diameter.

Table 4: Ethnomathematics Of Yogyakarta Palace In The Shape Of A Triangle.

Parts that contain mathematical elements.	Aspects of math that need to be learned at school.

	One of the triangular-shaped parts of the palace ornament.  **The shape of the building can be used as learning material for first grade students (recognizing shapes), second grade (shapes and geometry), third grade (elements of flat buildings), fourth grade (measuring area and volume) and fifth grade (perimeter and area of flat buildings).**

A two-dimensional flat shape that has 3 sides and 3 angles is called a triangle. The material on the area of a triangle can be found at the fifth grade elementary school level.
The area of a triangle.
$\boldsymbol{L = \frac{a\ x\ t}{2}}$

L is the area, **a** is the base length, and **t** is the height length.
If there are 2 congruent triangles, a rectangle will be formed. The formula for the area of a rectangle is ***p x l (a x t in a triangle)***. So, to calculate the area of 1 triangle the formula becomes $\frac{a\ x\ t}{2}$.

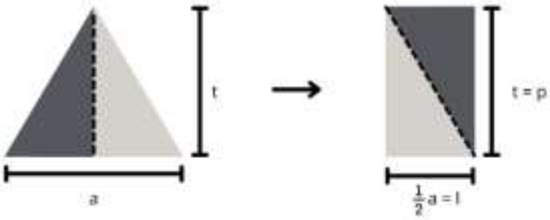
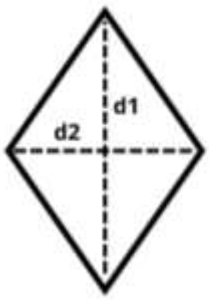


Figure 1: The Origin Of The Triangle Area Formula.

Perimeter of a triangle.
K = side 1 + side 2 + side 3

K is the perimeter, and **sides 1,2,3** are the lengths of each side.

Table 5: Ethnomathematics Of The Yogyakarta Palace In The Shape Of A Rhombus.

Parts that contain mathematical elements.	**Aspects of math that need to be learned at school.**
	One of the rhombus-shaped parts of the palace ornament.  **The shape of the building can be used as learning material for first grade students (recognizing shapes), second grade (shapes and geometry), third grade (elements of flat shapes), fourth grade (measuring area and volume) and fifth grade (perimeter and area of flat shapes).**

Two-dimensional flat shapes with equal side lengths and perpendicular diagonals are called rhombuses.

The area and perimeter of the rhombus can be found at the fifth grade elementary school level.
The area of a rhombus.
$L = \frac{d1\ x\ d2}{2}$
L is the area, **d1** and **d2** are the lengths of each diagonal.
The area of a rhombus is a derivative of the area of a rectangle. The formula for the area of a rectangle is **p x l**. Therefore, the formula for the area of a rhombus is $\frac{d1\ x\ d2}{2}$.

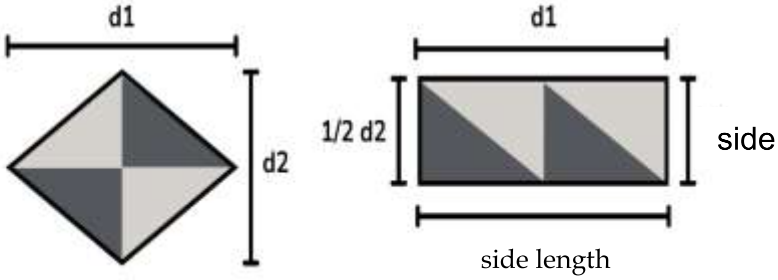
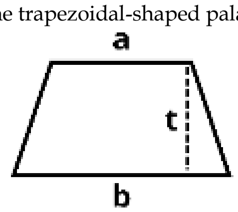


Figure 2: The Origin Of The Rhombus Formula.

Perimeter of a rhombus.
$K = 4\ x\ s$
K is the perimeter, and **s** is the length of each side.

Table 5: Trapezoidal Ethnomathematics Of Yogyakarta Palace.

Parts that contain mathematical elements.	Aspects of math that need to be learned at school.
	One part of the trapezoidal-shaped palace ornament.  **The shape of the building can be used as learning material for first grade students (recognizing shapes), second grade (shapes and geometry), third grade (elements of flat shapes), fourth grade (measuring area and volume) and fifth grade (perimeter and area of flat shapes).**

A two-dimensional flat shape with 4 ribs, 2 of which are parallel but of different lengths, is called a trapezoid. The material on the area and perimeter of trapezoidal flat shapes can be found at the fifth grade elementary school level.

Trapezoid area.
$L = \frac{1}{2}\ (number\ of\ parallel\ sides\ \times t\ )$
L is the area, and **t** is the height.
The area of a trapezoid is also a derivative of the area of a rectangle.

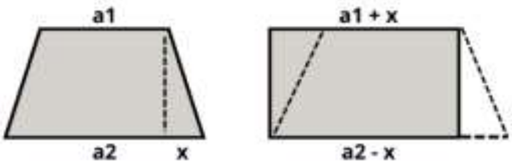


Figure 3: Origin Of The Trapezoid Formula.

Perimeter of a trapezoid.
$K = side\ 1 + side\ 2 + side\ 3 + side\ 4$

4. CONCLUSSION

This article discusses how mathematical concepts, especially geometry such as the area of flat shapes that exist in the ornaments in the Yogyakarta Palace. These ornaments not only have high aesthetic and cultural value, but also contain complex mathematical principles. Through the study of ethnomathematics, we can see that the artists and architects of the Yogyakarta Palace have consciously or unconsciously applied mathematical knowledge in their designs. Many geometry concepts can be found in the Yogyakarta Palace, such as the area and perimeter of a square, rectangle, circle, triangle, rhombus, and trapezoid. This shows that mathematics is an integral part of cultural heritage and traditional art that can provide new insights into how local cultures understand and use mathematical concepts in everyday life. Geometry concepts found in Yogyakarta Palace ornaments can be integrated in the curriculum that focuses on fun learning through ethnomathematics. It is hoped that by learning with this method, students can better understand geometry concepts that are relevant to their culture as an implementation of an independent learning curriculum.

Author Contributions: Azamul Fadhly Noor Muhammad: Conceptualization, Methodology, Formal analysis, Investigation, Writing - Original Draft, Project administration. Luluk Mauluah: Formal analysis, Validation, Writing - Review & Editing. Eka Cahya Sari Putra: Resources, Data Curation, Investigation. Ahmad Agung Yuwono Putro: Investigation, Resources, Writing - Review & Editing. Heru Purnomo: Validation, Supervision. Nency Hardini: Data Curation, Formal analysis.

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