

Ethnomathematical Analysis on Geometric Transformation Patterns in Cultural Artifacts at the Banten Museum

Rio Tri Hartanto¹, Putri Puspita Sari², Ratu Ummu Salmah³, Jaka Wijaya Kusuma⁴

^{1,2,3,4}Mathematica Education, Universitas Bina Bangsa, Serang, Indonesia

jakawijayak@gmail.com

Abstract: The scientific study of size, shape, change, and relationships between abstract objects is known as mathematics. Mathematics is used in everyday life, especially in the cultural history of a society, in addition to serving as a foundation for science and technology. Ethnomathematics is one of the fields of mathematics that studies the relationship between mathematics and culture. This study examines the idea of ethnomathematics about geometric transformation patterns found in cultural objects in the Banten Museum. By associating it with cultural historical objects, this study seeks to recognize and analyze the use of geometric transformation in translation, reflection, rotation, and dilation. The three main objects studied were an antique cannon, which was examined to illustrate dilation; flower-shaped and spiral grain fragments connected with translation and rotation; and a nine-plate glaze sambel container, which symbolizes reflection. The descriptive study of these artifacts' shapes and transformation patterns is part of the qualitative research methodology. The study results show that geometric transformation patterns are not only present in the design of artifacts, but also reflect the local philosophy and wisdom that develops in the culture of the Banten people. This study enriches the understanding of the relationship between mathematics and culture and can be a reference in developing ethnomathematics-based learning.

Keywords: Ethnomathematics, Geometric Transformation, Cultural Artifacts, Banten Museum.

Article History:

Received: 01-04-2025

Online : 28-04-2025



This is an open access article under the [CC-BY-SA](https://creativecommons.org/licenses/by-sa/4.0/) license

— — — — — ◆ — — — — —

A. INTRODUCTION

Mathematics is often considered a universal and objective science; in fact, its development and application is greatly influenced by culture in a society. The concept of mathematics is not only found in books or formal institutions, but also daily life, such as in art, traditional games, or weaving and batik patterns. (Ode & Jazuli, 2020), some explain about mathematics that mathematics is considered a human creation. The existence of mathematical concepts depends on human invention and creation. Mathematics is a product of human activities and thoughts (Shofi Mubarak, 2022).

This phenomenon led to the emergence of a field of study known as ethnomathematics. The term ethnomathematics was first introduced by a Brazilian mathematician, Ubiratan D'Ambrosio, in 1977. He describes ethnomathematics as a form of mathematics related to culture, which develops in specific communities such as rural or urban communities, working groups, children of a certain age, and indigenous peoples (Nuryami & Apriosa, 2024). Some experts argue that Ethnomathematics is an approach to mathematics learning designed to facilitate the understanding of the community by connecting mathematics with various activities, traditions and cultures in the surrounding environment (Ramadhani et al., 2023). By understanding ethnomathematics we can see that mathematics is dynamic and

diverse, depending on the cultural context in which it develops. Where we can know that culture or can be called culture is a lifestyle that develops in a community group, is owned collectively, and is inherited from one generation to the next. Culture is formed from various complex elements, such as belief systems and government, traditions, language, and other aspects (supiani et al., 2021).

Mathematical values are hidden in many traditional objects that are part of Indonesia's rich cultural heritage. Cultural objects such as fine arts such as ceramics, textiles, and kitchenware often exhibit visual patterns that represent people's perceptions of geometric symmetry, shape, and transformation. Geometry itself can be interpreted as a field or branch in mathematics that explicitly studies various shapes and structures, two-dimensional, flat buildings, and three-dimensional ones, spatial ones (Satriawati et al., 2023). In addition to serving as a witness to history, cultural artifacts preserve the intellectual heritage of previous societies, such as spatial abilities and orderly forms. The meaning of the word artifact is a relic object or archaeological findings created, altered, or modified by humans and have properties that can be moved from one place to another. In addition, another view states that artifacts are artificial objects that have important value in culture and history because they can provide information about past life, culture, and technological developments (Fateh Ahmad et al., 2023). In this regard, ethnomathematics is a valuable instrument for reconstructing these cognitive values and showing how local cultures influence the evolution of mathematical thought.

Indonesia as an archipelagic country that has a vibrant cultural diversity. With more than 17,000 islands and hundreds of ethnic groups, Indonesia has a variety of traditions, languages, arts, customs, and belief systems that have evolved from generation to generation. It is also included in the province of Banten. Banten is one of the administrative areas located on the island of Java. Previously, this area was part of West Java Province. However, based on the legal provisions of the Law of the Republic of Indonesia Number 23 of 2000, Banten was officially separated and designated as an independent province since 2000 (Hady Hartanto et al., n.d.). The cultural diversity in this area is inseparable from various tribes that settle and interact in the region, such as the Baduy, Sundanese, and Javanese tribes, each of which has distinctive customs, traditions, and arts. Geographically, the Banten area is divided into three main parts. First, North Banten includes Serang Regency and Cilegon City, where most of the population comes from the Javanese and Cirebon tribes. Second, East Banten, which includes Lebak and Pandeglang Regencies, is dominated by people from the Sundanese tribe. Finally, West Banten, which consists of Tangerang Regency and Tangerang City, has a diverse or heterogeneous population, due to the large number of immigrants from various regions who settle in the region.

One of the institutions that exhibits various kinds of art with significant ethnomathematical potential is the Banten Museum. This museum exhibits many artifacts from the Banten era that include art, symbols, and distinctive decorative patterns. The museum itself can be interpreted as an institution that acts as a place to preserve and store cultural heritage from the past, which has historical and civilizational value. This cultural heritage is a historical relic of humanity that serves as authentic evidence of the development

of past life and culture. The role of this museum is in line with the views of some experts who state that museums are essentially used as an important source of information in understanding the dynamics of people's lives in the past. (Nuhiyah & Wawan Darmawan, 2021) Through silent observations, it was concluded that many works of art depict visual elements that mathematically illustrate the concept of geometric transformation, such as translation, rotation, reflection, and dilation. These patterns do not appear suddenly but result from aesthetic and cultural values presented throughout the day.

This research was conducted to analyze the elements of geometric transformation found in cultural artifacts in the Banten Museum and explore the cultural meaning behind them. The approach used is qualitative descriptive with a focus on analyzing the visual form of artifacts through documentation, cultural interpretation, and visualization using geometry software. Three artifacts were chosen as the primary focus of the research: fragments of pottery with a ceplok pattern, a container with nine glazed plates, and ancient bullet objects (cannon balls). These three artifacts were chosen because they contain visual forms rich in meaning and relevant to be studied mathematically. This research aims to show that geometric transformation is not only an idea found in textbooks, but also a component of the visual cultural expression of society transmitted through traditional artifacts.

B. METHOD

This research was conducted at the Banten museum using a qualitative descriptive method. Because this research wants to discover the relationship between artifacts in the Banten museum, it can be illustrated in mathematics lessons by taking geometry transformation material. The qualitative descriptive method is a research approach used to examine the conditions of society (human groups), objects, and situations or circumstances that are currently taking place. This study aims to describe or describe systematically, factually, and accurately the existing facts and explore the relationship between the studied phenomenon and its characteristics. In addition, some argue that the process of identifying a descriptive research is an important step that aims to obtain a deeper picture and to draw clear and comprehensive conclusions about the phenomenon or problem being studied in the study. (Firdausa et al., 2021).

Data was collected by observing three cultural artifacts exhibited at the Banten Museum: pottery fragments with a ceplok pattern, a container with nine glazed plates, and cannon balls. Observations focus on visual shapes, decorative motifs, artifact arrangements, and geometric elements visible to the naked eye. In addition, the researcher also conducts visual documentation through image capture to be further analyzed using software such as GeoGebra to visualize the shape of the geometric transformation. Literature studies are also used to strengthen understanding each artifact's symbolic meaning and cultural value, based on local historical and cultural literature sources. According to (Yonantha et al., 2024), GeoGebra has several advantages, namely (1) dynamic display visualization, (2) Easy use and abundant features, (3) Authoring tool so that the learning that has been created can be interactive, (4) Available in multiple languages, and (5) Free access for non-profit users.

The data obtained from observation and visual documentation were analyzed descriptively through two stages. First, the **identification of geometric transformation elements** in the pattern or shape of the artifact, such as **translation, rotation, reflection, and dilation**, was carried out. Each artifact is analyzed based on the appearance of its geometric pattern and matched with the corresponding transformation principle. Second, **interpreting the cultural values** contained in the artifacts is based on relevant literature, so a complete understanding of the mathematical form and its cultural meaning is obtained. The results of these two analyses are presented as descriptive narratives and supporting visual illustrations.

C. RESULT AND DISCUSSIONS

The purpose of ethnomathematical research on specific cultural objects at the Banten Museum is to explain the relationship between contemporary mathematical ideas and regional cultural features, particularly those related to geometric transformations. This method shows artifacts as historical and artistic objects and symbols of earlier societies' mathematical thinking, expressed through arrangements, shapes, and decorative elements. Geometric transformations that include translation, rotation, reflection, and dilation can be observed implicitly in the structure and motifs of such traditional artifacts. This suggests that traditional societies have used mathematical concepts naturally in everyday life, especially in creating and arranging cultural artifacts, without studying mathematics formally as in the modern academic environment.

Some artifacts were analyzed visually and interpretively, and it was found that each artifact had a unique transformational geometry component in terms of size proportions, pattern repetition, and basic shape. This research shows how the history of local cultures can be a rich and significant source of scientific inquiry, in addition to supporting the role of ethnomathematics as a bridge between culture and mathematics. Some of the main findings from the observation and analysis results are as follows:

1. Translation Concept

The pottery fragment found in the Banten Museum has a flat lip decorated with a pattern of plain circles arranged repeatedly from top to bottom. In local culture, this symbol embodies simplicity and meaning. As an endless geometric shape, the circle symbolizes eternity, continuity, and unity. Symbols like these are often used in Banten ceramic and batik designs to symbolize harmony and the circle of life. The circular pattern of this artifact gives a dynamic yet stable impression by displaying repetitive visual regularity and rhythm and the presence of an interordered shape that can be imitated by **translation**. Along the side of the artifacts, the design appears uniform and evenly distributed.



Figure 1. Pottery Fragment Artifacts (Small Circle Pattern)

The visual form of pottery fragments found in the Banten Museum is shown in Figure 1. The small circles are repeated and stacked parallel to create a decorative design. This visual pattern shows how ancient artisans integrated interesting features with organized shapes. A mathematical depiction of such a pattern in the Cartesian coordinate plane system. A geometric object that undergoes translation—displacement with a specific vector without changing its size or orientation—is used to illustrate a circular pattern on an object.

2. Concept of Reflection

One of the classic tableware used by the people of Banten in the past is a nine-plate sambal container. This container is usually used for banquets together, especially during traditional rituals or family gatherings. The cultural ideals of the Banten people that prioritize peace, unity, and balance in social life are reflected in the appearance of two plates with the same decorative shape and design. Local customs also often use the symbolism of two complementary and similar elements to symbolize the relationship between humans and between nature and humans. Two glass-clad flat plates arranged parallel to each other and facing each other form the visual composition of the artifact. It looks as if one plate reflects the other plate because of the shape and arrangement similarity between the two plates' decorative patterns. With decorative lines or patterns that appear identical but are oriented in opposite directions, the arrangement creates a symmetrical and bouncing effect. Their location and similarity reinforce the impression of order and visual harmony of the objects.



Figure 2. Artifact of Blue and White Glazed Sambal Nine Plate Container from the Qing Dynasty

In Figure 2, two identical plates are arranged symmetrically facing each other. The shape and size of the two plates are the same, and the position of both shows a distinctive visual balance. This placement pattern reflects the principle of reflection in geometry. In Figure 3, two shapes reflecting each other concerning a given axis depict the composition of the two plates in the coordinate plane. Two vertically symmetrical plates can be found on the artifact of the Sambel Sembilan container. Both plates can undergo **reflection**, i.e. an object is reflected against the horizontal line $x = a$, where a is the value x where the reflection line is located, if placed on the coordinate plane. In addition, symmetry is created in the distance between the matching points on both shapes concerning the axis of reflection.

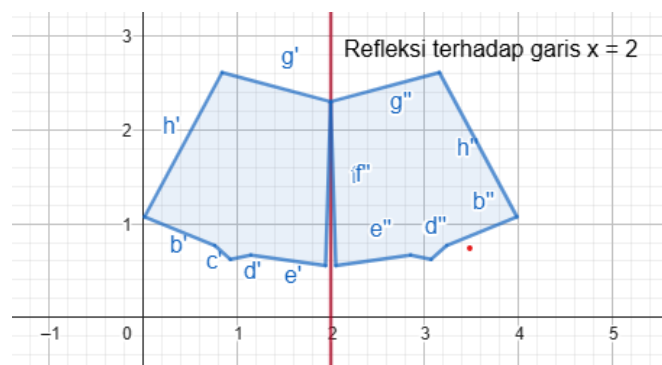


Figure 3. Reflection on 2 Sambal Nine Plates Blue and White Glaze from the Qing Dynasty in the Field of Coordinates (Geogebra)

3. Rotation Concept

The same pottery fragment has a flower-shaped decoration with petals resembling rhombus fragments arranged in a ceplok pattern. The floral motifs seen on the surface of the pottery fragments represent traditional aesthetic values highly upheld in local culture. This pattern is not only visually appealing, but also full of philosophical meaning. In appearance, the shape of the flowers is arranged symmetrically and crisscrossing, forming a pattern that seems to revolve around a central point. The arrangement creates a distinctive impression of order and harmony, which in a mathematical view reflects the concept of **rotational** transformation. This rotational pattern occurs when a shape is rotated against a specific center at a fixed angle, while retaining its shape and size. In this artifact, the flower's petals circled the central point with visual regularity, indicating an apparent repetitive rotation. Rotational motifs like this are often found in traditional art forms, such as batik, carving, and ceramic decorations, depicting the universe's life cycle, balance, and order. In Banten's own culture, flowers have a deep symbolic meaning. Flowers are often associated with purity, elegance, and harmony of life. Thus, the presence of a flower motif in the rotation pattern on this artifact not only strengthens the aesthetic value, but also shows the close relationship between cultural heritage and mathematical concepts, making the artifact a concrete form of ethnomathematics in the life of the people of Banten.



Figure 4. Pottery Fragment Artifacts (Flower Motif)

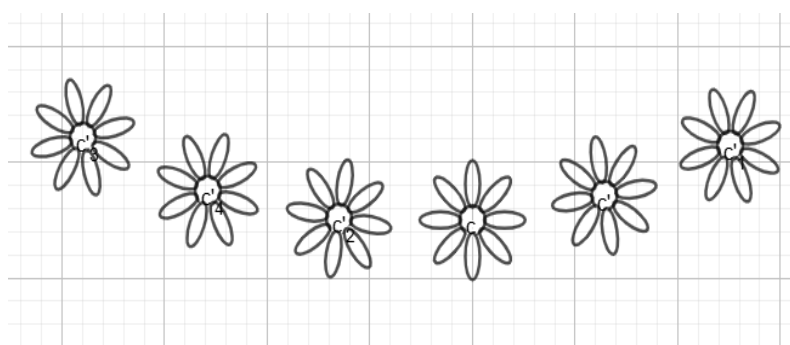


Figure 5. Rotation in the Flower Motif section in the Coordinate field (Geogebra)

The visual shape of the glassware found in the Banten Museum is shown in Figure 5. The surfaces of these objects are decorated with floral motifs that function as decorative patterns. This visual pattern shows how ancient artisans integrated interesting features with organized shapes. The flower motif is mathematically represented in Figure 5 as a **rotating object**, which is the rotation of a central point at a certain angle, for example 0° to 360° on the coordinate plane. This is indicated by the position of the object's shadow that follows the rotational transformation towards the point of origin or other specific point.

4. The Concept of Dilation

Cannon balls found in the Banten Museum are relics of the colonial period and the glory of the Sultanate of Banten as a trade and military center. These relics show how Banten's culture has considerable defensive power in addition to being involved in cultural and commercial efforts. Its cannons and bullets indicate the region's sophisticated military strategy and the importance of defending its territory from outside threats. These cannon bullets represent the strength, aggressiveness, and defense of regional values and territorial sovereignty in a cultural setting. These cannon balls look like metal balls ranging from very small to large. When artifacts are grouped in one perspective, the difference in size becomes noticeable and shows a continuous gradation. This variation implies methodical application, perhaps adapted to the intended firing range or type of gun. This arrangement of bullets of varying sizes also symbolizes a type of dilation, in which the size of one base-ball-shaped shape changes proportionally. It has a straightforward visual order but is structurally sound.



Figure 6. Cannon Balls of Ancient Times

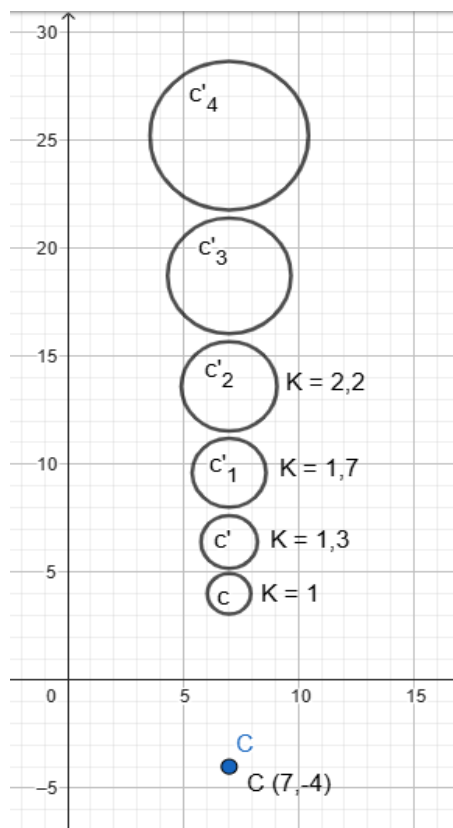


Figure 7. Dilation of the Ancient Cannon Balls in the Coordinate Field (Geogebra)

Artifacts in the form of historic cannonballs, varying in size from small to very large, are depicted in Figure 7. The shapes retain their perfect roundness despite their varying sizes, illustrating how the principle of proportional size is applied visually. The shape of the bullet in Figure 8 is depicted as a circle on a coordinate plane that has undergone a change in dilation, which is a transformation that makes an object larger or smaller than its center point according to a specific scale.

D. CONCLUSION AND SUGGESTIONS

This research uses an ethnomathematical approach to investigate the relationship between the mathematical idea of geometric transformation and the cultural components in traditional Banten Museum objects. This study shows that cultural values can be studied mathematically through the shapes, patterns, and visual arrangements of objects seen and found in historical and aesthetic characteristics. The study also shows that, mainly when used for geometric transformations, ethnomathematical approaches can be a link between exact science and culture. Two types of geometric transformations were found in the artifact of pottery fragments with a ceplok pattern: translation and rotation. The translation pattern, in which the same shape is repeated in a specific direction and distance, is indicated by a simple circular motif aligned at the top and bottom. The idea of rotation, in which the shape is rotated at a point without changing the size, is reflected in the floral motif that stretches around the central point in a symmetrical pattern. In addition to adding beauty to the object, these two designs convey the philosophical beliefs of the Banten people about harmony and balance in life.

The artifact of the nine-plate glaze sambel container represents a reflection transformation. When two plates of the same shape and size are positioned next and facing each other, the idea of reflecting the shadow line is shown. In addition to showing visual order, this reflection captures important social ideals in Banten's food culture, such as equality, togetherness, and cooperation. Furthermore, cannon balls artifacts show the concept of dilated transformation. A shift in scale comparable to a particular center is indicated by a change in the size of the bullet from small to large. These changes graphically illustrate how size changes in mathematics. This variation can be explained culturally by historical advances in military power and technology and the strategic use of each bullet size.

Overall, this study's findings show that the Banten people's cultural heritage undoubtedly contains aspects of geometric transformation. Ethnomathematical techniques can reveal the mathematical implications of artifacts only seen as historical objects. In addition to adding to scientific knowledge, this discovery also raises awareness of the practical applications of mathematics, including in cultural heritage that is centuries old. Therefore, from a broader scientific perspective, ethnomathematical approaches are a valuable substitute for investigating and preserving indigenous cultures.

REFERENCES

- Fateh Ahmad, Aris Rahmansyah, & Irfan Dwi Rahadianto. (2023). Perancangan Konsep Game Environment Pada Game "Garuda's Disciple." *E-Proceeding of Art & Design*, 10.
- Hady Hartanto, B., Dian Trisnasari, W., Chamalia Rochmah, E., Dicky Fauzan, M., Muhammadiyah Tangerang, U., & Bahasa Provinsi Banten, K. (n.d.). Kearifan Lokal dalam Cerita Rakyat Provinsi Banten Sebagai Upaya Mengembangkan Sejarah Kebudayaan Banten. In *Jurnal Bastrindo* | (Vol. 3).
- Nuhyah, & Wawan Darmawan. (2021). Kota Multietnis Surosowan Sebagai Living Museum: Upaya Pendidikan Multikultural Melalui Pembelajaran Sejarah Kreatif. *Candrasangkala: Jurnal Pendidikan Dan Sejarah*, 7(2).
- Nuryami, N., & Apriosa, K. D. (2024). Eksplorasi etnomatematika batik Probolinggo sebagai sumber belajar matematika sekolah. *JPMI (Jurnal Pembelajaran Matematika Inovatif)*, 7(1), 177–190. <https://doi.org/10.22460/jpmi.v7i1.20628>
- Ode, L., & Jazuli, A. (2020). Pengembangan Perangkat Pembelajaran Matematika Model Kooperatif dengan mengintegrasikan budaya Lokal Masyarakat Wakatobi. 22(2). <https://doi.org/10.21009/jtp.v22i2.1>
- Ramadhani, A., St.Nurul Mutmainna, Mirnawati, & Irmayanti. (2023). Peran Etnomatematika Dalam Pembelajaran Matematika Pada Kurikulum 2013. *COMPETITIVE: Journal of Education*, 2(1), 53–68. <https://doi.org/10.58355/competitive.v2i1.16>
- Satriawati, G., Kholis, N., Dwirahayu, G., & Sobiruddin, D. (2023). Pengembangan Bahan ajar transformasi geometri berbantuan website: Pendekatan Project-Based-Learning Mozaik Geometri. *JINoP (Jurnal Inovasi Pembelajaran)*, 9(1). <https://doi.org/10.22219/jinop.v9i1.23581>
- Shiffa Firdausa, T., Nurasih, N., Purwaningsih, Z., Nisa, K., Wijaya Kusuma, J., & Bina Bangsa, U. (n.d.). Etnomatematika batik khas Banten, nilai filosofis dan materi Transformasi Geometri bagi siswa SMA. In *Original Research*.
- Shofi Mubarak, M. (2022). Aksiologi Matematika Dan Implikasinya Dalam Pembelajaran Matematika. In *Implikasinya dalam Pembelajaran Matematika* (Vol. 9, Issue 1).
- Supiani, Fawza rahmat, & Fajar budiman. (2021). Pengaruh Budaya Dan Persepsi Masyarakat Terhadap Keputusan Menabung Di Bank Syariah. *Journal Islamic Banking and Finance*, 1.
- Yonantha, K., Pranata, F. B., & Nugraha, A. S. (2024). Pengembangan Bahan Ajar Berbasis Etnomatematika Siter Didukung Platform GeoGebra Materi Barisan Aritmatika. *EQUALS: Jurnal Ilmiah Pendidikan Matematika*, 7(2), 94–104. <https://doi.org/10.46918/equals.v7i2.2268>