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EXPLORING MATHEMATICAL CONCEPTS IN THE LEGACY OF THE BANTEN SULTANATE

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Abstract

Mathematics is a form of knowledge that is closely related to everyday life. Although many mathematical concepts are inherently connected to daily experiences, students' understanding of the material still often encounters various difficulties, particularly in topics such as geometry, graphs of linear equations, and quadratic functions. Based on this understanding, this study aims to identify the functions, symbolic meanings, and mathematical concepts found in Genta, Tengkuluk, and Panji, as well as how this knowledge can be utilized in ethnomathematics-based learning and local wisdom values as an effort to enrich contextual learning resources that are rooted in culture. This research employs a qualitative descriptive approach. The research subjects consist of two curators from the National Museum of Indonesia and one religious expert from the Banten community. Data were collected using instruments comprising observation sheets, interview guidelines, and documentation. The data were analyzed using the qualitative data analysis process proposed by Miles and Huberman. The data reduction process was carried out by simplifying the results of interviews, observations, and documentation according to aspects related to mathematical concepts as well as religious and cultural values found in the heritage of the Banten Sultanate. The data were then presented visually in the form of photographs, tables, and narrative descriptions illustrating the relationships between heritage objects, mathematical concepts, and cultural and religious values. The final stage involved drawing conclusions from the research findings. Overall, the findings indicate that the integration of mathematical concepts within cultural artifacts provides meaningful potential for developing contextual and culturally grounded ethnomathematics-based learning resources.

Keywords: Ethnomathematics, Banten Sultanate, Tengkuluk, Panji, Genta

Abstrak

Matematika merupakan pengetahuan yang sangat dekat dengan kehidupan sehari-hari. Meskipun berbagai konsep matematika sebenarnya dekat dengan kehidupan, pemahaman siswa terhadap materi masih sering menghadapi berbagai kendala, diantaranya pada materi geometri, grafik persamaan garis lurus dan fungsi kuadrat. Berdasarkan pemahaman tersebut, penelitian ini bertujuan untuk mengidentifikasi fungsi, makna simbolik, serta konsep-konsep matematika yang muncul pada Genta, Tengkuluk, dan Panji dan bagaimana pengetahuan tersebut dapat dimanfaatkan dalam pembelajaran berbasis etnomatematika dan nilai kearifan lokal, sebagai upaya memperkaya sumber belajar yang kontekstual dan berakar pada budaya. Penelitian ini menggunakan pendekatan deskriptif kualitatif. Subjek penelitian ini terdiri dari dua orang kurator Museum Nasional Indonesia dan satu ahli agama dari masyarakat asal Banten. Pengumpulan data menggunakan instrumen yang terdiri atas lembar observasi, pedoman wawancara, dan dokumentasi. Data dianalisis dengan menggunakan proses analisis data kualitatif model Miles dan Hubernam. Proses reduksi data dilakukan dengan menyederhanakan hasil wawancara, observasi, dan dokumentasi sesuai dengan hal-hal yang berkaitan dengan konsep matematika, serta nilai agama dan budaya pada peninggalan Kesultanan Banten. Kemudian data disajikan secara visual berupa foto, tabel dan deskripsi naratif yang menunjukkan hubungan antara objek peninggalan dengan konsep matematika serta nilai budaya dan agama. Tahap terakhir yaitu menyimpulkan hasil penelitian. Secara keseluruhan, temuan penelitian menunjukkan bahwa integrasi konsep matematika dalam artefak budaya memiliki potensi yang bermakna untuk pengembangan sumber belajar berbasis etnomatematika yang kontekstual dan berakar pada budaya.

Kata kunci: Etnomatematika, Kesultanan Banten, Tengkuluk, Panji, Genta

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INTRODUCTION

Mathematics is knowledge that is very close to everyday life, because many human activities involve measurement, calculation, and patterns (Isnaniah et al., 2022). In various contexts, mathematical concepts arise naturally in objects, tools, art, and cultural activities that have been passed down from generation to generation (Alanuari et al., 2025). This shows that mathematics is not only present in the classroom, but also embedded in real life, including various historical relics and cultural heritage.

Although various mathematical concepts are actually closely related to everyday life, students' understanding of the material still often faces various obstacles (Firda & Juandi, 2023; Saputri et al., 2022). Geometry, for example, is a branch of mathematics that studies the relationships and properties of points, lines, planes, and the shapes formed by these three elements (Hasratuddin, 2022). However, in practice, students often encounter obstacles in understanding basic concepts (Dinda Fitria & Maarif, 2021), for example, mistakes in solving geometric transformation problems (Maulani & Setiawan, 2021), proof of the Pythagorean theorem (Dinda Fitria & Maarif, 2021), as well as quadrilaterals (Fakhrudin et al., 2023; Juanti et al., 2021), whether due to limited conceptual information, incorrect use of formulas, poor visual, verbal, and logical skills, or unpreparedness for learning (Firda & Juandi, 2023; Juanti et al., 2021). In addition, students also experience difficulties in representing graphs, including graphs of linear equations and quadratic functions (Julaeha & Kadarisma, 2020; Juniantika et al., 2024; Rahmawati et al., 2022). Obstacles often arise from incomplete prerequisites, lack of conceptual understanding, errors in reading and processing information, and transforming problems into graphs (Astuti et al., 2023; Julaeha & Kadarisma, 2020; Kurniasari et al., 2021; Ningsih & Kadarisma, 2023; Rahayu et al., 2023; Utami et al., 2023). Therefore, contextual learning can be used as a relevant approach to help students understand mathematical concepts through real-life situations that are close to their experiences (Ekarini et al., 2024). This approach opens up opportunities to utilize cultural elements and the surrounding environment in mathematics learning, known as ethnomathematics.

According to (Rosa et al., 2017), ethnomathematics views mathematics as being composed of rich, diverse, and varied cultural traditions, so learning needs to relate mathematical concepts to the cultural realities that exist around students. According to (D’Ambrosio, 2001), Ethnomathematics is a term used to describe the relationship between culture and mathematics. Both perspectives show that ethnomathematics not only understands mathematics as a cultural product, but also as a practice that arises from the way of life, experiences, and identity of a community. Thus, ethnomathematics encourages the use of various local cultural heritages as contextual material in learning, including the Historical Heritage of the Banten Sultanate, which can be used as a learning resource.

Historical artifacts from the Banten Sultanate have great potential to be integrated into local culture-based learning because they reflect the local wisdom and Islamic identity of the community (Rifqiawati et al., 2023). Several aspects such as the architecture of the Surosowan Palace, the Great Mosque of Banten, and the traditional city layout of Old Banten can be used as contextual media to introduce the integration of religious, social, and aesthetic values to students (Saefullah, 2018). In addition, the multicultural social system that has developed in Banten, where various ethnic groups and religions coexist harmoniously, can be used as a concrete example of the values of tolerance, mutual cooperation, and openness to differences in character education (Hadi Wibowo, 2022).

From the perspective of mathematics and science education, cultural elements of Banten, such as geometric patterns in architectural ornaments and traditional batik motifs, have the potential to be developed as ethnomathematics teaching materials that link abstract concepts to the local cultural context (Pratiwi & Mandasari, 2025; Subekhi et al., 2021). The integration of these elements is in line with a learning approach that instills regional cultural values to strengthen students' national identity and historical awareness (Iswatiningsih, 2019). Through the application of the historical values of the Banten Sultanate in learning, students not only understand past events, but are also able to emulate the spirit of independence, tolerance, and progress that was once demonstrated by the people of Banten during its heyday (Rifqiawati et al., 2023).

Previous research on Banten ethnomathematics has generally focused on well-known cultural aspects such as the traditional houses of the Baduy tribe and the architecture of the Banten Sultanate, but has not explored artifacts such as Genta, Tengkuluk, and Panji, which also contain mathematical values. The study by Yulyani et al. (2023) focuses on the geometric and symbolic elements of traditional Baduy houses as a source of culture-based mathematics learning, while the study by Nirmalasari et al. (2021) examines the application of the Pythagorean Theorem in various Banten cultural artifacts such as house roofs, Baduy totopong, and Kasunyatan gateways. Furthemore, Subekhi et al. (2021) emphasize the connection between Banten's cultural architectural elements and contextual learning values through an ethnomathematics approach. Although these three studies show the integration of Banten culture in mathematics education, no study has specifically examined Genta, Tengkuluk, and Panji as cultural representations that contain elements of form, pattern, and philosophical values that have great potential to be used as sources of contextual learning based on local wisdom.

This study was conducted to analyze in greater depth the cultural heritage of the Banten Sultanate, such as Genta, Tengkuluk, and Panji. This study aims to identify the functions, symbolic meanings, and mathematical concepts such as geometric elements, symmetry, and patterns that appear in Genta, Tengkuluk, and Panji and how this knowledge can be utilized in ethnomathematics-based learning and local wisdom values, as an effort to enrich contextual learning resources rooted in culture. Thus, this research is expected to contribute to the development of a theory regarding the relationship between mathematical concepts and cultural artifacts. In addition, this research can also add to scientific references on how the cultural values of local wisdom and religious elements of the Banten Sultanate can be a source of contextual and meaningful mathematics learning for students.

METHODS

This study employed a qualitative descriptive approach. According to (Heriyanto, 2018), qualitative methods aim to explore phenomena based on informants' perspectives and to produce in-depth and meaningful descriptions. This approach was chosen because it was considered the most appropriate for exploring cultural values and the application of mathematical concepts within cultural artifacts in depth. Data were collected through interviews, observations, and documentation.

The informants of this study consisted of two curators from the Indonesian National Museum and one religious expert from the Banten community. The informants were selected using purposive sampling because museum curators have direct access to and in-depth knowledge of the Banten Sultanate's collection of artifacts. The information obtained from the museum curators and the religious expert provides insights into the cultural and religious values embedded in these artifacts.

The research instruments consisted of observation sheets, interview guidelines, and documentation. Observation sheets were used to record the forms and characteristics of the Banten Sultanate relics. Interview guidelines assisted the researcher in collecting information from museum curators regarding the history and significance of the relics. Documentation was used to collect photographs, archives, and museum records, as well as to support and clarify observation findings and provide concrete evidence of the application of mathematical concepts in the relics of the Banten Sultanate. Data validity was ensured through triangulation of data sources and techniques.

Data analysis in this study followed the qualitative data analysis model proposed by Miles and Huberman. According to Miles et al. (2014), qualitative data analysis is conducted continuously and interactively until data saturation is achieved. The analysis consisted of three stages: data reduction, data display, and conclusion drawing. Data reduction involved simplifying interview, observation, and documentation data related to mathematical concepts as well as cultural and religious values found in the relics of the Banten Sultanate. The data were then presented visually in the form of photographs, tables, and narrative descriptions illustrating the relationships between the artifacts, mathematical concepts, and cultural and religious values. The final stage involved drawing conclusions based on the analyzed data.

RESULTS AND DISCUSSION

The data in this study consist of three artifacts from the Banten Sultanate whose physical forms can still be observed, namely *tengkuluk*, *panji*, and *genta*. These three artifacts are described based on their observable visual characteristics without providing additional interpretation, in accordance with the principles of descriptive research, which focus solely on describing objects as they are (Sandelowski, 2000). The three artifacts were then visualized using the Desmos application to clarify the patterns, contours, and geometric regularity of the object forms.

A detailed description of each artifact is presented in the following section, beginning with the physical description, initial visual appearance, and concluding with the results of the visualization in Desmos.

1. **Tengkuluk**
   a. Description of Tengkuluk

Figure 1. Tengkuluk

Source: author's personal documentation

Based on the researcher’s documentation at the National Museum of Indonesia, *tengkuluk* is a cotton head covering originating from Banten in the early 20th century. This artifact takes the form of a sheet of cloth. Its surface is filled with Arabic script motifs arranged in a layered geometric pattern, ranging from a square frame on the outer section to diamond-shaped fields and small circles at the center. Along the edges of the cloth, there is a series of Arabic inscriptions that frame all sides of the artifact. According to information provided by the museum, the inscription is the *shahada*, which reads “Asyhadu an lā ilāha illallāh, Muḥammadan rasuluhu,” meaning “I bear witness that there is no god but Allah, and Muhammad is the Messenger of Allah.” The inscription is printed in a cream color, creating a contrast with the background fabric, forming a regular border line and becoming a prominent visual element of the *tengkuluk*.

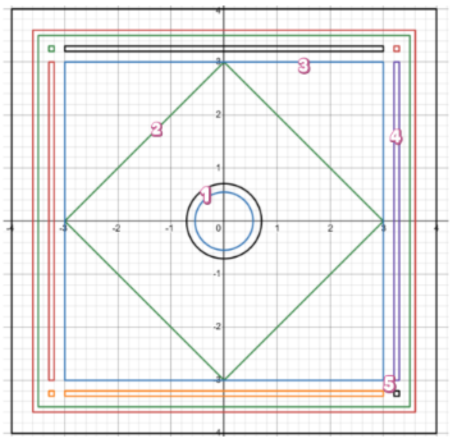
Based on interviews with a curator at the National Museum of Indonesia, *tengkuluk* is known as a head covering worn by *santri* and Islamic scholars within the pesantren environment. This artifact has a dual function, serving both as a head covering and as a form of protection due to the presence of Islamic phrases on its surface. This was further emphasized by the informant, who stated that:

Informant: *“According to catalog sources, tengkuluk was used in pesantren. In the past, head coverings were likely worn by santri or Islamic scholars. There are also Arabic inscriptions whose function, in addition to serving as a head covering, is as an amulet or protection, due to the presence of phrases referring to Allah”.*

When viewed from its visual structure, the presence of Arabic inscriptions arranged in layered patterns such as diamonds, squares, and circles indicates that the religious function of this artifact is expressed through an orderly geometric composition. These patterns not only reinforce the aesthetic value and spiritual meaning of the *tengkuluk*, but also demonstrate the integration of religious symbols and geometric principles, thereby possessing strong potential to be utilized as a contextual learning resource.

b. Mathematical Concepts in Tengkuluk

Table 1. Mathematical Concepts in Tengkuluk Based on Desmos Visualization

Visualization on Desmos	
	Based on the visualization analysis on Desmos, Tengkuluk consists of various mathematical elements, namely: 1. Two circles centered at the point (0,0) $x^2+y^2=0.3$ $x^2+y^2=0.5$ 2. Linear equations that form a rhombus $y=x+3\ \{-3\le y\le 3\}\{-3\le x\le 0\}$ $y=-x+3\ \{0\le y\le 3\}\{0\le x\le 3\}$ $y=x-3\ \{-3\le y\le 0\}\{0\le x\le 3\}$ $y=-x-3\ \{-3\le y\le 3\}\{-3\le x\le 0\}$

3. Horizontal and vertical line segments that form 4 squares (large size)

7. $y = 3\{-3 \le x \le 3\}$
8. $x = 3\{-3 \le y \le 3\}$
9. $y = -3\{-3 \le x \le 3\}$
10. $x = -3\{-3 \le y \le 3\}$
11. $y = 3.5\{-3.5 \le x \le 3.5\}$
12. $x = 3.5\{-3.5 \le y \le 3.5\}$
13. $y = -3.5\{-3.5 \le x \le 3.5\}$
14. $x = -3.5\{-3.5 \le y \le 3.5\}$

15. $y = 3.6\{-3.6 \le x \le 3.6\}$
16. $x = 3.6\{-3.6 \le y \le 3.6\}$
17. $y = -3.6\{-3.6 \le x \le 3.6\}$
18. $x = -3.6\{-3.6 \le y \le 3.6\}$
19. $y = 4\{-4 \le x \le 4\}$
20. $x = 4\{-4 \le y \le 4\}$
21. $y = -4\{-4 \le x \le 4\}$
22. $x = -4\{-4 \le y \le 4\}$

4. Vertical and horizontal line segments that form 4 rectangles

23. $y = 3\{3.2 \le x \le 3.3\}$
24. $x = 3.3\{-3 \le y \le 3\}$
25. $y = -3\{3.2 \le x \le 3.3\}$
26. $x = 3.2\{-3 \le y \le 3\}$
27. $y = -3.2\{-3 \le x \le 3\}$
28. $x = 3\{-3.3 \le y \le -3.2\}$
29. $y = -3.3\{-3 \le x \le 3\}$
30. $x = -3\{-3.3 \le y \le -3.2\}$

31. $y = 3\{-3.3 \le x \le -3.2\}$
32. $x = -3.2\{-3 \le y \le 3\}$
33. $y = -3\{-3.3 \le x \le -3.2\}$
34. $x = -3.3\{-3 \le y \le 3\}$
35. $y = 3.3\{-3 \le x \le 3\}$
36. $x = 3\{3.2 \le y \le 3.3\}$
37. $y = 3.2\{-3 \le x \le 3\}$
38. $x = -3\{3.2 \le y \le 3.3\}$

5. Horizontal and vertical line segments that form 4 squares (small in size)

39. $y = 3.3\{3.2 \le x \le 3.3\}$
40. $x = 3.3\{3.2 \le y \le 3.3\}$
41. $y = 3.2\{3.2 \le x \le 3.3\}$
42. $x = 3.2\{3.2 \le y \le 3.3\}$
43. $y = -3.2\{3.2 \le x \le 3.3\}$
44. $x = 3.3\{-3.3 \le y \le -3.2\}$
45. $y = -3.3\{3.2 \le x \le 3.3\}$
46. $x = 3.2\{-3.3 \le y \le -3.2\}$

47. $y = -3.2\{-3.3 \le x \le -3.2\}$
48. $x = -3.2\{-3.3 \le y \le -3.2\}$
49. $y = -3.3\{-3.3 \le x \le -3.2\}$
50. $x = -3.3\{-3.3 \le y \le -3.2\}$
51. $y = 3.3\{-3.3 \le x \le -3.2\}$
52. $x = -3.2\{3.2 \le y \le 3.3\}$
53. $y = 3.2\{-3.3 \le x \le -3.2\}$
54. $x = -3.3\{3.2 \le y \le 3.3\}$

Based on the visualization produced on Desmos, it can be seen that the geometric concept in Tengkuluk can be analyzed mathematically and visualized clearly. This finding supports the use of cultural artifacts as a learning medium that connects mathematics with real-world contexts. This is in line with research conducted by Dwi Novitasari and Masjudin. (Dwi Novitasari & Fitriani, 2021; Masjudin et al., 2024)

2. Panji

a. Description of Panji

Figure 2. Panji

Source: author's personal documentation

Based on the results of documentation by researchers at the National Museum of Indonesia, Panji is a textile artifact originating from the Sultanate of Banten in the 19th century. This artifact is in the form of a large piece of cloth with a surface covered with inscriptions and symbols in Arabic script. The writings are arranged in symmetrical and layered patterns, forming interconnected geometric shapes such as circles, squares, and ellipses. The surface of the panji displays a calligraphic arrangement that forms a pattern resembling a graph resulting from the combination of several functions. Among these patterns are several circles that form the main visual shape. At the bottom right, bottom left, and bottom center, there are squares and rhombuses arranged in layers and intersecting each other. The center of the banner displays a denser arrangement of calligraphy than the outer edges, with several circles containing Arabic writing that stands out prominently. Surrounding the main field is a row of writing that frames the entire side of the cloth. Based on the information listed on the artifact label at the Indonesian National Museum, this banner is decorated with writing and symbols from the Qur'an and was flown during activities to spread Islam or fight in the name of Allah by the Sultanate of Banten. Based on interviews with Arabic language lecturers who are also religious scholars, the Arabic writing on the Panji consists of the names of Allah, the Prophet Muhammad SWT, the Khulafaurrasyidin, martyrs and scholars, the shahada, excerpts from the Qur'an, and prayers. According to him, the writings on the Panji contain meaning when we pray to Allah. After mentioning the name of Allah, we mention the name of the Prophet Muhammad, the martyrs, the scholars, and the righteous predecessors. Not only in prayer, but idealism in religion must believe in Allah, the Messenger, the Qur'an, the Hadith, then the companions, the tabi'in, the fuqaha or al-ulama, and the salafu salihin. These things are guidelines for living a religious life in addition to the pillars of faith and the pillars of Islam.

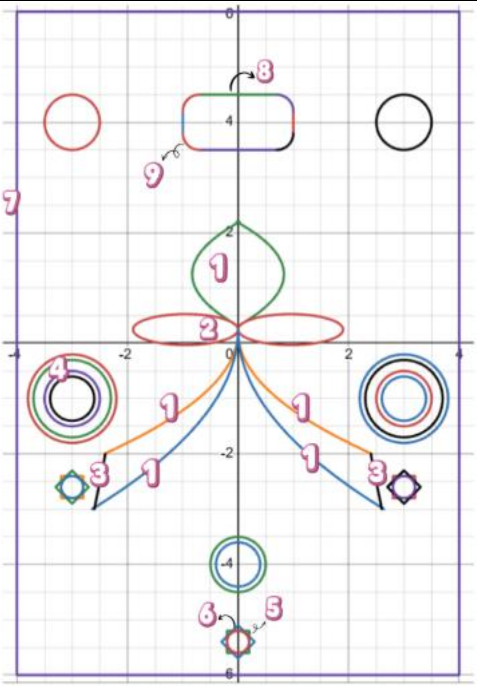
Based on interviews with curators at the National Museum of Indonesia, the Panji is an important artifact used by the Sultanate of Banten in religious activities and the spread of Islam. The source explained that the Panji serves as a political identity and religious symbol that conveys the message of Islam. The source stated that:

Informant: *"Banners like these were usually carried during missionary activities or religious propagation by the Sultanate of Banten. The Arabic script and verses on them were not merely decorative, but served to reinforce their religious identity and legitimize their struggle".*

This statement shows that the presence of Arabic inscriptions on the banner is not merely an aesthetic ornament, but has strong religious and social significance. In religion, there are guidelines for life that must be believed in, starting from worshipping Allah SWT, believing in the Prophet Muhammad, the Qur'an and Hadith, then studying religious teachings sourced from the Khulafaurrasyidin, the companions of the Prophet, the tabi'in, al fuqaha or al-ulama, and salafu salihin. When linked to its visual structure, the layered geometric patterns in the form of circles, ellipses, squares, and rhombuses serve to reinforce these symbolic affirmations. It is this relationship between religious meaning and geometric visuals that makes the banner relevant as a source of contextual learning.

b. Mathematical Concepts in Panji

Table 2. Mathematical Concepts in Panji Based on Desmos Visualization

Visualization on Desmos	
 	Based on the visualization analysis on Desmos, Panji consists of various mathematical elements, namely: 1. Graph of quadratic function $x = 0.95(y - 1.25)^2 - 0.83\{0.350 \le y \le 2.20\}$ $x = -0.95(y - 1.25)^2 + 0.83\ \{0.350 \le y \le 2.20\}$ $x = 0.5(y - 0.2)^2\{-2 \le y \le 0.25\}$ $x = -0.5(y - 0.2)^2\{-2 \le y \le 0.25\}$ $x = 0.25(y - 0.25)^2\{-3 \le y \le 0.25\}$ $x = -0.25(y - 0.25)^2\{-3 \le y \le 0.25\}$ 2. Two horizontal ellipses $\left(\frac{(x+0.95)}{0.95}\right)^2 + \left(\frac{(y-0.25)}{0.28}\right)^2 = 1$ $\left(\frac{(x-0.95)}{0.95}\right)^2 + \left(\frac{(y-0.25)}{0.28}\right)^2 = 1$ 3. Linear equation $x = -0.2y + 2\ \{-3 \le y \le -2\}$ $x = 0.2y - 2\ \{-3 \le y \le -2\}$
4. Circle • In quadrant III	$(x+3)^2 + (y+1)^2 = 0.8^2$ $(x+3)^2 + (y+1)^2 = 0.7^2$ $(x+3)^2 + (y+1)^2 = 0.5^2$ $(x+3)^2 + (y+1)^2 = 0.4^2$

- In quadrant IV

15 $(x-3)^2+(y+1)^2=0.8^2$

16 $(x-3)^2+(y+1)^2=0.7^2$

17 $(x-3)^2+(y+1)^2=0.5^2$

18 $(x-3)^2+(y+1)^2=0.4^2$

- In quadrant I

19 $(x-3)^2+(y-4)^2=0.5^2$

- In quadrant II

20 $(x+3)^2+(y-4)^2=0.5^2$

- In the middle of quadrants III dan IV

21 $x^2+(y+4)^2=0.5^2$

22 $x^2+(y+4)^2=0.4^2$

- Inside the diamond-shaped structure

35 $(x-3)^2+(y+2.6)^2=0.04$

40 $(x+3)^2+(y+2.6)^2=0.04$

49 $x^2+(y+5.4)^2=0.2^2$

5. Vertical and horizontal line segments that form three squares

23 $y=-2.4\ \{2.8\le x\le 3.2\}$

24 $x=3.2\ \{-2.8\le y\le -2.4\}$

25 $y=-2.8\ \{2.8\le x\le 3.2\}$

26 $x=2.8\ \{-2.8\le y\le -2.4\}$

27 $y=-2.4\{-3.2\le x\le -2.8\}$

28 $x=-2.8\ \{-2.8\le y\le -2.4\}$

29 $y=-2.8\ \{-3.2\le x\le -2.8\}$

30 $x=-3.2\ \{-2.8\le y\le -2.4\}$

41 $y=-5.2\ \{-0.2\le x\le 0.2\}$

42 $x=0.2\ \{-5.6\le y\le -5.2\}$

43 $y=-5.6\{-0.2\le x\le 0.2\}$

44 $x=-0.2\ \{-5.6\le y\le -5.2\}$

6. Linear equations that form three rhombuses

36 $x=-y-5.3\ \{-2.6\le y\le -2.3\}$

37 $x=y-0.1\ \{-2.9\le y\le -2.6\}$

38 $x=-y-5.9\ \{-2.9\le y\le -2.6\}$

39 $x=y-0.7\ \{-2.6\le y\le -2.3\}$

31 $x=-y+0.7\ \{-2.6\le y\le -2.3\}$

32 $x=y+5.9\ \{-2.9\le y\le -2.6\}$

33 $x=-y+0.1\ \{-2.9\le y\le -2.6\}$

34 $x=y+5.3\ \{-2.6\le y\le -2.3\}$

45 $x=-y-5.1\ \{-5.4\le y\le -5.1\}$

46 $x=y+5.7\ \{-5.7\le y\le -5.4\}$

47 $x=-y-5.7\ \{-5.7\le y\le -5.4\}$

48 $x=y+5.1\ \{-5.4\le y\le -5.1\}$

7. Vertical and horizontal line segments that form a rectangle	9. Circle equations with limited domains that form superellipses
50 $y=6\ \{-4\le x\le 4\}$	58 $(x-0.7)^2+(y-4.2)^2=0.09\{x\ge 0.7\}\{y\ge 4.2\}$
51 $x=4\ \{-6\le y\le 6\}$	59 $(x+0.7)^2+(y-4.2)^2=0.09\ \{x\le -0.7\}\{y\ge 4.2\}$
52 $y=-6\ \{-4\le x\le 4\}$	60 $(x-0.7)^2+(y-3.8)^2=0.09\{x\ge 0.7\}\{y\le 3.8\}$
53 $x=-4\ \{-6\le y\le 6\}$	61 $(x+0.7)^2+(y-3.8)^2=0.09\{x\le -0.7\}\{y\le 3.8\}$
8. Vertical and horizontal line segments that form a superellipse	
54 $y=4.5\ \{-0.7\le x\le 0.7\}$	
55 $y=3.5\ \{-0.7\le x\le 0.7\}$	
56 $x=1\ \{3.8\le y\le 4.2\}$	
57 $x=-1\ \{3.8\le y\le 4.2\}$	

The visualization on Desmos shows how the patterns of circles, ellipses, and combinations of several quadratic function graphs with specific intervals, as well as the quadrilateral field found on the Panji, can be represented mathematically through function equations and geometric curves that have been formulated. These visualization results can be used to explain to students how geometric concepts can be modeled from cultural artifacts through the process of mapping shapes to mathematical equations. The results obtained are in line with previous studies showing that cultural artifacts can be an effective link between visual observation and the formation of mathematical concepts through the modeling process (Prahmana & D'Ambrosio, 2020; Sari et al., 2025; Supiyati et al., 2019). The geometric structures visible in the center and frame of the flag provide opportunities to introduce mathematical concepts such as flat shapes, repeating patterns, and symmetry, while the historical significance and Islamic values contained within it can enrich the learning context, making it more meaningful for students.

3. Genta

a. Description of Genta

Figure 3. Genta

Source: author's personal documentation

Based on the researcher's documentation at the National Museum of Indonesia, Genta is one of the regalia instruments of the Sukarame Gamelan belonging to the Sultanate of Banten in the 19th century. During the sultanate era, Gamelan Sukarame was usually used for performances not only for entertainment but also for ceremonies at the palace. These musical instruments were only played at certain times, not on any given day. This information is supported by the results of the researcher's interview with the curator of the Indonesian National Museum, Rully Handiani S.S. she said,

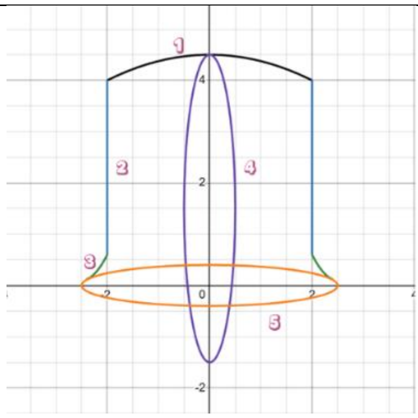
Informant: *"The Sukarame gamelan is an authentic relic from Daendels' invasion, the number one regalia of the Banten Sultanate. It was probably used for performances, but not solely for entertainment; it was also used for ceremonies, for example at the palace. It was not played on just any day."*

The Genta consists of 12 bells shaped like cups hanging from wooden beams. In general, the Genta is cylindrical in shape with a protruding base. The geometric shape of a cylinder or tube shows that there is a mathematical concept visible in the visualization of the Genta.

b. Mathematical Concepts in Genta

Table 3. Mathematical Concepts in Genta Based on Desmos Visualization

Visualization on Desmos	
	2. Vertical line 2 $x = 2\ \{0.6 \le y \le 4\}$ 3 $x = -2\ \{0.6 \le y \le 4\}$



Based on the visualization analysis on Desmos, Genta consists of various mathematical elements, namely:

1. Graph of a quadratic function

$$y = -\frac{1}{8}x^2 + 4.5\{-2 \le x \le 2\}$$

3. Graph of a quadratic function

$$y = 2x^2 + 10x + 12.6\ \{-2.4 \le x \le -2\}$$

$$y = 2x^2 - 10x + 12.6\{2 \le x \le 2.4\}$$

4. Vertical ellipse

$$\frac{x^2}{0.5^2} + \frac{(y-1.5)^2}{3^2} = 1$$

5. Horizontal ellipse

$$\frac{x^2}{2.5^2} + \frac{y^2}{0.4^2} = 1$$

The visualization on Desmos shows that the shape of Genta can be visualized using a mathematical formula formed from a combination of several quadratic function graphs, vertical lines, and vertical and horizontal ellipses. In addition, Genta also contains geometric elements of spatial figures. With these mathematical elements, Genta can be used by teachers as a medium to explain geometric concepts and quadratic functions to students and introduce cultural and Islamic values. This is in line with previous research showing that traditional musical instruments can be used as a concrete context for learning mathematics in relation to culture (Hafis et al., 2025; Masjudin et al., 2024; Sopamena et al., 2023)

CONCLUSION

Based on the research findings, it can be concluded that the cultural heritage of the Banten Sultanate in the form of Tengkuluk and Panji contains mathematical concepts such as plane geometry, including circles, ellipses, squares, rectangles, rhombuses, symmetry, patterns, line relationships, as well as the modeling of linear functions and quadratic functions as observed in the visual forms of the artifacts. In the Genta, mathematical concepts are found in the form of lines, graphs of quadratic functions, and a shape resembling a cylindrical three dimensional figure. In addition to mathematical concepts, the patterns or motifs found in the visual appearance of these heritage objects contain cultural and religious values that embody symbolic Islamic meanings, as well as aspects of calligraphic art and traditional aesthetics that reflect the religious and cultural perspectives of the Banten community. The integration of mathematics, art, and culture provides innovation in mathematics learning. Teachers can apply contextual approaches rooted in local wisdom so that mathematics learning becomes more meaningful. Thus, students' understanding of mathematical concepts, learning motivation, character, and cultural identity are improved.

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