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# Exploring Ethnomathematics in Parang Barong Naga Raja Batik at Sonobudoyo Museum

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**Abstract**

The current issue in education is the lack of learning related to culture, especially local culture. This results in students' limited understanding of the culture in their own region. Additionally, there is still little mathematics education that is linked to culture. Therefore, this study aims to explore ethnomathematics in batik, focusing on the geometric concepts involved, such as symmetry, patterns, and transformations in Batik Parang Borang, as well as the cultural values in batik. This research uses a qualitative approach with an ethnographic method; data were collected through observation, literature review, and interviews with cultural experts and batik artists. The findings show that Batik Parang Borang Naga Raja contains geometric concepts, such as symmetry, patterns, and transformations. This study reflects local wisdom values. These values are not only understood but also contemplated and applied in daily life, enriching the understanding of mathematics and introducing cultural dimensions into mathematics education in schools. This study also emphasizes the importance of preserving batik as part of cultural heritage and its contribution to enriching cultural understanding and the application of mathematics in daily life.

**Keywords:** Batik Parang Borang, Ethnography, Ethnomathematics, Geometry.

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## Introduction

Mathematics education plays a crucial role in introducing new dimensions to the relationship between individuals, society, and culture, potentially aiding in addressing social, economic, and cultural issues (D'Ambrosio, 1986; Bishop, 1979; Gutiérrez, 2013; Owens, 2023). Proficiency in mathematics is essential, as those who understand and can perform mathematical tasks are viewed as having more opportunities and choices for their future (Turrou & Fernandez, 2013). Walle (2007) stated that mathematical skills open the door to a productive future, while a lack of mathematical skills keeps that door closed. Mathematics has the potential to foster personal development. It requires thinking exploratively and creatively, not just mechanical and procedural counting (Cateni & Rocchini, 2011).

However, many students dislike mathematics due to its abstract nature and perceived dullness (Azmidar & Dahlan, 2017; Dohn, 2020). Therefore, there is a need for enjoyable mathematics learning that can elicit students' ideas in problem-solving by providing contextual learning related to local culture. In line with this, research by Yolanda and Putra (2022) found that ethnomathematics-based learning on batik patterns can positively impact students' learning processes and understanding of mathematics. Similarly, Wahyudi et al. (2021) noted that batik activities in Batik Tancep art can be considered contextual mathematics learning, involving mathematical aspects such as area, congruence, and volume.

Batik is an Indonesian cultural heritage rich in aesthetic and symbolic values (Apriliani, 2024). One batik motif with profound meaning is Batik Parang Barong Naga Raja. This motif not only reflects the beauty of visual art but also contains hidden mathematical elements within its geometric patterns (Pandanwangi et al., 2023).

Everyone in their daily lives has always used mathematics. It is a part of culture (Yavuz Mumcu, 2018; Rani et al., 2023). Therefore, contemporary mathematics education must be linked to real-life cultural contexts. This is consistent with Rosa and Orey's (2011) notion that effective mathematics learning occurs when teachers foster social and cultural interactions through dialogue, language, and symbolic representation in mathematics. Contextual learning aligns with this idea. It is a concept that helps teachers relate the material they teach to real-world situations, encouraging students to understand the connection between their knowledge and its application in their lives and culture.

One approach Adam (2004) suggested is using ethnomathematics as a foundation for formal mathematics teaching, appropriate for students at the concrete operational stage. Similarly, Shirley (2008) argued that culturally influenced mathematics can significantly contribute to the field. Culture impacts individual behavior and plays a significant role in developing understanding, including mathematics learning (Bishop, 1991).

Therefore, research on ethnomathematics in Batik Parang Barong Naga Raja provides insights into how mathematical concepts like symmetry, patterns, and transformations can be discovered and understood through this cultural heritage. This research is significant because it combines cultural and educational aspects, particularly in teaching geometry. Understanding geometric concepts in batik motifs can create more engaging and meaningful teaching methods for students. Additionally, this study can enrich the knowledge on how local culture can be an exciting learning source in mathematics education.

## Methods

This research is classified as exploratory, aiming to explore the forms of the Parang Barong Naga Raja batik motifs that can be utilized in teaching geometry. The approach used in this study is ethnographic, an empirical and theoretical approach designed to obtain a detailed description and analysis of culture based on intensive fieldwork (Spradley, 2006). In line with this research and the ethnographic approach, the researcher (human instrument) is the primary research instrument. The researcher is the leading data collector whose role must remain the same. Thus, the researcher is the principal instrument, supported by other instruments such as field notes, interview guides, observation guides, and documentation.

The study was conducted from June 2024 to July 31, 2024, at the *Sonobudoyo* Museum in

Yogyakarta. Data collection and reduction were performed to obtain valid data through source, method, and time triangulation. Data collection techniques included in-depth interviews with a batik expert, Gatot Trianto, a cultural expert and staff member at the Yogyakarta Batik Museum. Gatot Trianto is a 35-year-old male from Yogyakarta. The interview aimed to gain insights into the Parang Barong Naga Raja batik motif. The research instruments used included interview guides to ensure all relevant topics were covered during the interview, recording tools to capture important information, and a camera for visual documentation of the batik motifs studied. This visual documentation assists in analyzing the geometric patterns present in the batik motifs.

The collected data were analyzed using thematic analysis. This process involved coding the data to identify the main themes emerging from the interviews and visual documentation. Thematic analysis allows the researcher to identify patterns and relationships between the batik motifs and geometric concepts. The results of this analysis will be used to answer the research questions and achieve the set research objectives. This research method is expected to reveal how the Parang Barong Naga Raja batik motifs reflect geometric concepts and how the cultural and symbolic values of the motifs can be utilized in teaching geometry.

## Results and Discussions

Batik Parang Barong Naga Raja is one of Yogyakarta's distinctive batik designs that embodies historical values and mathematical concepts, which can be applied in teaching, particularly in geometry concepts such as symmetry, patterns, and transformations.

**Batik Parang Barong Naga Raja**

Batik Parang Barong Naga Raja is a batik motif rich in cultural significance and meaning, with a profound history (Guntur, 2019). This motif is part of the extensive Parang motif family, widely recognized in Indonesian batik. While Parang batik comes in various variants, Parang Barong Naga Raja stands out for its complexity and uniqueness.

**Symbolic meaning of the batik parang borang**

Batik Parang Barong Naga Raja is one of the batik motifs rich in symbolic and aesthetic meanings, with a deep and complex history. This motif is integral to the Javanese batik tradition and is often used in significant ceremonies, including royal events and traditional celebrations (Ansari, 2014). The Batik Parang Barong Naga Raja motif features a distinctive and complex design. Visually, this motif consists of slanted lines resembling slopes or 'parang,' often arranged in a regular repetitive pattern. These lines typically resemble the shape of the letter "S," akin to a pointing index finger. This motif uses rich and contrasting colors like dark blue, brown, and natural colors derived from traditional dyes. This pattern

serves an aesthetic function and reflects mathematical principles such as symmetry and repetitive patterns.

The origins of Batik Parang Barong Naga Raja can be traced back to the era of the Javanese kingdom, where this motif was exclusively used by the royal family and the nobility (Suyani, 2013). Historically, this motif symbolized a high social status and was only allowed for individuals of a particular social standing. The prohibition of using this motif outside the palace circles signifies its importance as a symbol of status and power.

Over time, this restriction was relaxed, and Batik Parang Barong Naga Raja began to be used more widely while maintaining its cultural and symbolic values. Today, this motif is used in formal or official contexts and in various traditional events and important ceremonies. The symbolic meaning of Batik Parang Barong Naga Raja is detailed in Table 1.

**Table 1**. Symbolic Meaning of the Parang Barong Naga Raja Batik Motif

| No | Batik Parang Barong Naga Raja Motif | *Cultural Values in Batik Parang Barong Naga Raja Motif* |
|---|---|---|
| 1 | Symbolic “Parang” | The ‘parang’ or slope pattern in this motif is considered a symbol of guidance and direction. |
| 2 | Finger-like Pattern | The pattern resembling a pointing index finger conveys that the wearer of this batik is expected to provide positive guidance or direction in life. |
| 3 | Symbolism of “Barong” and “Naga Raja” | In the Batik Parang Barong Naga Raja motif, “Barong” is often interpreted as a symbol of protection and safeguarding excellent and positive things. Meanwhile, “Naga Raja,” or the Dragon King, refers to the mythical dragon creature symbolizing great power and authority. |
| 4 | Meaning in Ceremonial Context | In this context, the motif symbolizes status and honour and expresses the wearer's wish for blessings and good fortune. Using this batik in traditional ceremonies also reflects the hope for a future filled with success and honor. |
| 5 | Repetitive Design | The continuous and consistent pattern depicts continuity and eternity. This reflects the idea that cultural values and traditions should be preserved and passed down from generation to generation. |
| 6 | Symbol of Status and Prestige | This motif, once used exclusively by the royal family and nobility, now symbolizes cultural values and identity diversity. The |

| | |
|---|---|
| | use of this motif in formal and traditional contexts reinforces the social values that are appreciated and perpetuated in Javanese society. |

From Table 1, it is explained that, philosophically, the 'parang' or slope pattern in this motif is considered a symbol of guidance and direction. The pattern resembling a pointing index finger conveys that the wearer of this batik is expected to provide positive guidance or direction in life. Therefore, Batik Parang Barong Naga Raja is often used in significant ceremonies such as circumcision, where this motif symbolizes hope and prayers for a prosperous and blessed future. The Batik Parang Barong Naga Raja motif is frequently used in traditional ceremonies, particularly those involving the royal family or significant events. For example, during circumcision ceremonies, this motif is worn by princes and consorts as a symbol of status and honor. The use of this motif in ceremonial contexts underscores the importance of batik as an integral part of Javanese culture and tradition and a medium for expressing cultural and social values. Overall, Batik Parang Barong Naga Raja is an essential example of Javanese cultural richness that combines art, symbolism, and mathematics in its design. This motif serves as a visual ornament and a symbol of power, status, and hope, reflecting the wealth of traditions and skills passed down through generations.

Batik Parang Barong Naga Raja is a batik motif with profound historical and cultural significance, particularly in the context of the Javanese kingdom. This motif is part of a batik tradition that reflects aesthetic beauty and symbolizes important symbolic and social values within Javanese culture. The Batik Parang Barong Naga Raja motif has origins closely linked to the history and traditions of the Javanese court. The word "Parang" in this motif refers to the slope or diagonal pattern, while "Barong" and "Naga Raja" refer to symbols associated with power and grandeur (Nursalim, 2016). The motif was initially designed and used exclusively by Java's royal family and nobility. As a symbol of status and power, it was only allowed to be worn by those with high social standing.

In the past, the use of Batik Parang Barong Naga Raja was highly restricted and regulated. The prohibition on using this motif outside the court circles signified the social importance associated with the motif. Only members of the royal family and high officials were permitted to wear batik with this motif, making it an exclusive symbol of power and prestige. Over time, this restriction was relaxed, especially during the colonial and post-independence era. Batik Parang Barong Naga Raja began to be recognized and worn by the broader public while retaining its values and symbolism. Social and political changes in Indonesia and the influence of modernization contributed to the spread of this motif to a broader audience, including beyond the royal context.

Today, Batik Parang Barong Naga Raja is used in formal or traditional events and on various occasions such as celebrations, weddings, and other cultural events. This motif has become essential to the broader Javanese cultural identity and is valued as a rich cultural heritage. Batik Parang Barong Naga Raja plays a significant role in various traditional ceremonies and customs in Java. For instance, in circumcision ceremonies, this motif symbolizes status and honor. Princes and royal family members wear it as a symbol of prestige and blessing. Using this batik in ceremonial contexts emphasizes its importance in Javanese culture and reinforces its symbolic meanings.

Creating Batik Parang Barong Naga Raja involves traditional batik techniques requiring high skill. Techniques such as kampong (smoothing the fabric), gemsbok (covering patterns with wax), *medel* (first dyeing), grok (removing wax), *mbironi* (covering colors with wax), and yoga (second dyeing) are part of the batik-making process that ensures the quality and beauty of the motif (Larasati et al., 2021). These techniques are an important cultural heritage and reflect the expertise of batik artisans in creating intricate and artistic motifs. Today, Batik Parang Barong Naga Raja is valued as one of the finest examples of Javanese batik art. Various institutions and communities are trying to preserve and promote this batik to ensure the motif remains known and appreciated. Batik museums, art galleries, and cultural organizations are crucial in preserving and disseminating knowledge about Batik Parang Barong Naga Raja to future generations.

Overall, the history of Batik Parang Barong Naga Raja reflects the long journey of this once-exclusive and symbolic batik motif becoming an integral part of a broader cultural heritage. Through its changes in usage and context, this motif has maintained its symbolic values and continues to be valued as part of the rich Javanese cultural identity.

**Interview Interpretation**

In the effort to understand the ethnomathematics dimension of Batik Parang Barong Naga Raja, an interview with Gatot Trianto, a cultural expert and staff member at the Yogyakarta Batik Museum, provided important insights. The findings from this interview support and deepen the ethnomathematical analysis related to this complex batik motif. Below is the interpretation of the interview findings:

**1. Origins and Social Restrictions**

Batik Parang Barong Naga Raja originates from the ‘parang’ motif, which means ‘slope,’ and *‘tuding,’* which can be interpreted as ‘index finger.’ According to the explanation, this motif was once an exclusive symbol that could only be used by the royal family, reflecting social status and power. These restrictions illustrate how batik motifs function not only as art but also as social indicators. Thus, using this motif among the nobility demonstrates the application of profound geometric principles within the context of culture and social hierarchy.

**2. Batik Production Process and Geometric Transformation**

Various processes involved in batik production, such as kampong, gemsbok, medel, grok, mbironi, and yoga, involve precise and systematic techniques directly related to geometric concepts like symmetry and transformation. For example, the processes of kampong and gemsbok, which involve applying wax to fabric to protect certain areas from dyeing, demonstrate the use of symmetry and pattern principles. These techniques support the orderly repetitive patterns in Batik Parang Barong Naga Raja, reflecting how transformations and symmetry are applied in batik creation.

**3. Symbolism and Patterns**

The 'S' motif in Batik Parang Barong Naga Raja often resembles a pointing index finger, symbolizing guidance and protection. This pattern is frequently applied repetitively across the fabric through translation techniques, creating a harmonious and orderly design. These findings confirm that batik patterns have aesthetic functions and convey cultural and symbolic meanings. Transformations such as translation and rotation demonstrate how geometric principles create consistent and meaningful patterns in batik.

**4. Social and Ritual Functions**

The use of Batik Parang Barong Naga Raja in significant ceremonies such as circumcision illustrates how this motif, previously a high-status symbol, is now more widely used while retaining its cultural and symbolic values. Using this motif in ritual and ceremonial contexts shows how geometric principles, such as symmetry and pattern, shape and affirm cultural identity. This supports the interpretation that batik is an art and an integral part of cultural and ritual practices.

**5. Aesthetics and Technical Expertise**

The techniques and skills required to create Batik Parang Barong Naga Raja reflect expertise in the art of batik. Techniques such as dyeing and wax application to create patterns show a deep understanding of mathematical and aesthetic principles. This expertise ensures that batik motifs are visually pleasing and mathematically well-structured, supporting the ethnomathematical analysis conducted.

Overall, the interview with Gatot Trianto, as a cultural expert, provides strong support for the ethnomathematical analysis of Batik Parang Barong Naga Raja. The findings confirm geometric principles in batik design and illustrate how techniques, patterns, and symbolism interact within Javanese cultural contexts. This interpretation deepens the understanding of how batik art functions as a medium for expressing cultural and mathematical values.

**Geometric Concepts in the Batik Parang Barong Naga Raja Motif**

The Batik Parang Barong Naga Raja motif, derived from the terms "Parang," meaning 'slope,' and "*Tuding,"* meaning 'index or pointing finger,' reveals an intriguing depth of philosophical and mathematical

structure. This motif can be analyzed from an ethnomathematical perspective to understand how geometric concepts such as symmetry, patterns, and transformations are applied in its design.

**1. Symmetry**

Symmetry is a critical geometric concept that is visible in the design of Batik Parang Barong Naga Raja. In this batik motif, symmetry appears in various forms, enhancing both the motif's visual beauty and symbolic meaning. Reflective symmetry, or mirror symmetry, can be observed in the Parang Barong Naga Raja motif through patterns arranged symmetrically across the fabric. For instance, the 'S' shape that resembles a pointing index finger appears repeatedly in a regular pattern, creating a balanced visual effect on both sides of an imaginary vertical axis. In this design, the pattern on one side of the mirror axis is balanced and aligned with the pattern on the other side, resulting in a harmonious and aesthetically pleasing motif. This reflective symmetry not only enhances the aesthetic quality but also reinforces the symbolic meaning of the motif, which aims to provide positive guidance and direction to the wearer.

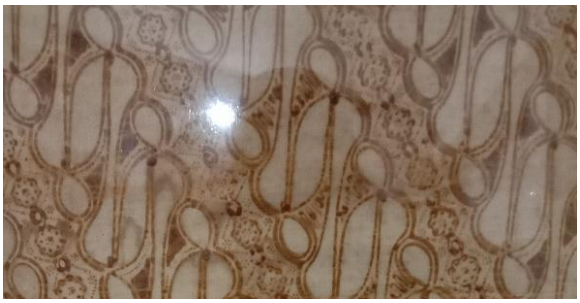


**Figure 1.** *Klowong* Process

Rotational symmetry is also evident in the Batik Parang Barong Naga Raja. In this motif, the "S"-shaped pattern, resembling an index finger, can be rotated at certain angles while maintaining consistency and harmony. This reflects mathematical principles where a pattern can be rotated at specific angles without altering its shape. This rotational symmetry gives the impression that the batik design can be viewed from various angles without losing balance, adding visual and dynamic dimensions to the motif.

Symmetry in Batik Parang Barong Naga Raja is also evident through the repetition of patterns. The "S" shaped pattern repeats systematically across the fabric, demonstrating the mathematical principles of repetition and periodicity. This pattern is arranged with consistent spacing and maintained balance, creating a harmonious visual effect. The repetition follows geometric principles where small design units are uniformly repeated to form a more extensive and integrated motif.

In a cultural context, symmetry in Batik Parang Barong Naga Raja is about aesthetics and symbolic meaning. Reflective and rotational symmetry can be interpreted as representations of balance and harmony in life. The orderly and symmetric motifs reflect principles of alignment and order valued in Javanese culture. Additionally, using these motifs in traditional attire, such as in circumcision ceremonies,

illustrates how batik designs can communicate social status and cultural values through mathematical principles.

**2. Patterns**

Patterns are a crucial element in the design of Batik Parang Barong Naga Raja, showcasing the application of mathematical principles such as repetition, periodicity, and order. The patterns in this batik reflect how the design is systematically arranged, creating a harmonious and consistent visual effect.

One of the main aspects of the pattern in Batik Parang Barong Naga Raja is consistent repetition. The primary motif, the "S" shaped pattern resembling an index finger, is regularly repeated across the fabric's surface. This pattern repetition follows the periodicity principle, where tiny design units are arranged in a recurring sequence to form a more extensive and integrated pattern. This repetition provides a sense of order and continuity and creates a visually pleasing structure.

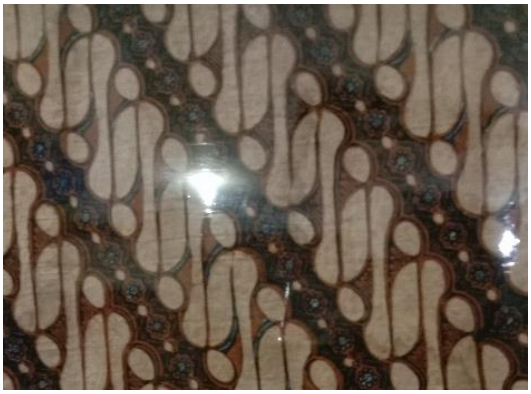


**Figure 2.** *Nglorod* Process

Periodicity in the Batik Parang Barong Naga Raja pattern refers to how the design is repeated at consistent intervals. Each "S" shaped pattern unit is placed at the same distance from the next, creating a stable and recurring rhythm. This periodicity reflects mathematical principles where the design is repeated and arranged in a systematic sequence to ensure visual alignment and balance. It helps create a harmonious and orderly appearance throughout the batik fabric.

The patterns in Batik Parang Barong Naga Raja also demonstrate meticulous order and harmony. Each pattern element is designed to integrate with other pattern units, creating a coherent and balanced look. This order is crucial for maintaining the aesthetic and integrity of the batik design, ensuring that each part of the motif functions as a component of the overall pattern. This harmony gives the impression that the batik design is thoughtfully and carefully planned.

Although the base pattern consists of repeating "S" motifs, variations can be found in how the pattern is applied to the fabric. For example, the pattern might be placed with subtle variations in size or orientation to add visual dynamism without compromising overall order. These variations allow the batik design to remain engaging and relevant within cultural and aesthetic contexts. The pattern in Batik Parang

Barong Naga Raja serves a visual function and holds symbolic meaning. The orderly and repetitive patterns reflect principles of harmony and balance in Javanese culture. The use of this pattern in traditional attire, such as in circumcision ceremonies, shows how batik designs function as decorative elements and symbols of status and cultural values.

**3. Transformations**

Transformations in the design of Batik Parang Barong Naga Raja involve mathematical principles related to changes in the shape and position of design elements. The concept of transformation in geometry involves changes in the position, size, or orientation of a pattern without altering its fundamental properties. In the context of this batik, transformations can be categorized into three main types: translation, rotation, and reflection. Translation is a transformation that shifts a pattern from one position to another without altering its orientation or shape. In Batik Parang Barong Naga Raja, the "S" shaped motif resembling an index finger is typically applied through translation. The pattern is shifted horizontally and vertically to create a uniform repetition across the fabric's surface. This process ensures the design remains orderly and consistent, creating a harmonious visual effect. Translation in this batik extends the motif across the fabric, maintaining the order and balance of the design.

Rotation is a transformation where a pattern is turned around a specific axis. In Batik Parang Barong Naga Raja, rotation is often seen in how the "S" pattern can be rotated at certain angles while functioning well within the design context. For example, a pattern rotated at a particular angle can create visual variation without changing the basic shape of the motif. Rotation provides flexibility in design, allowing the motif to adapt to various angles and directions, adding dynamism and visual complexity to the batik. Reflection, or mirror symmetry, is a transformation where a pattern is mirrored along a reflection axis to create a reversed copy of the original motif. In Batik Parang Barong Naga Raja, reflection can be applied to the "S" pattern to create a sense of symmetry in the design. The pattern may appear symmetric along a particular axis, creating a balanced and harmonious visual effect. Reflection helps maintain pattern consistency and enhances the design's beauty by creating a balanced appearance across the fabric.

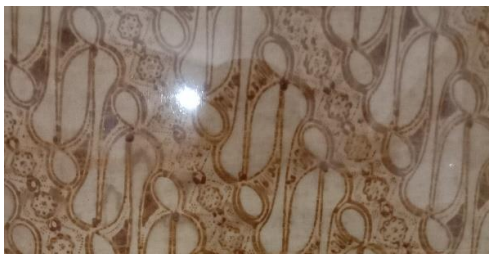
Transformations in Batik Parang Barong Naga Raja also involve balancing design elements. By applying translation, rotation, and reflection, batik designers create patterns that are not only aesthetically pleasing but also meaningful. These transformations allow the motif to be creatively adapted and applied across the fabric, creating a design that integrates well and functions visually in various contexts. The transformations in this batik design also carry deep cultural significance. Mathematical principles such as translation, rotation, and reflection create aesthetic patterns and reflect cultural and symbolic values. The orderly and symmetric patterns signify harmony and balance, while variations in transformations enrich the meaning and function of the design within the Javanese cultural context. Using transformation

principles in batik adds a mathematical dimension to the art of batik, illustrating the integration between art and science.

**4. Batik Production Process**

In batik, the creation of parang motifs generally involves the following procedures:

**a. Klowong**



**Fugure 3.** *Klowong* Process

*Klowong* is the process of applying batik wax for the first time to the fabric that will be batiked. This is done by tracing the wax onto the fabric according to the pattern design using a canting (for hand-drawn batik) or applying the wax with a copper stamp (for stamped batik).

**b. Nembok**

**Figure 4.** Nembok Process

'Nembok' is the process of covering specific areas of the pattern with wax to protect the previously dyed colours from subsequent dyeing.

**c. Medel**

**Figure 5.** Medel Process

'Medel' is the first dyeing process in classical batik, which involves dipping in dark blue dye using extracts from the stems and leaves of the indigo plant for natural colour and for synthetic colour, using naphthol AS-BO.

**d. Ngerok**

**Figure 6.** *Ngerok* Process

*Ngerok'* is the process of removing wax from certain parts of the batik fabric that are to be dyed, using a tool called *'cawuk' (*a thin metal plate bent into a U shape)

**e. Mbironi**

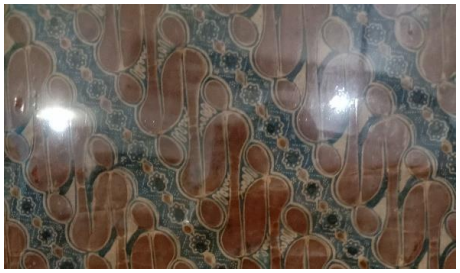


**Figure 7.** *Mbironi* Process

*'Mbironi'* is the process of covering certain areas of blue dye or sections that have been scraped off with batik wax.

**f. Nyoga**

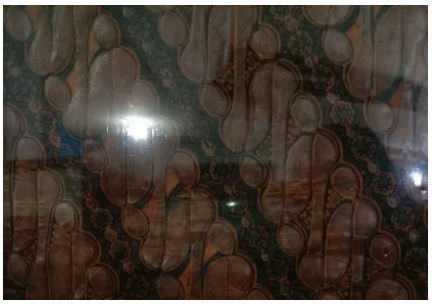


**Figure 8.** *Nyoga* Process

*'Nyoga'* is the second dyeing process in classical batik technique using brown dye obtained from the *soga* tree. For napthol, the recipe is AS – LB + orange GG salt for reddish-brown, and AS – LB + yellow GG salt for yellowish-brown.

**g. Nglorod/ ngebyok**

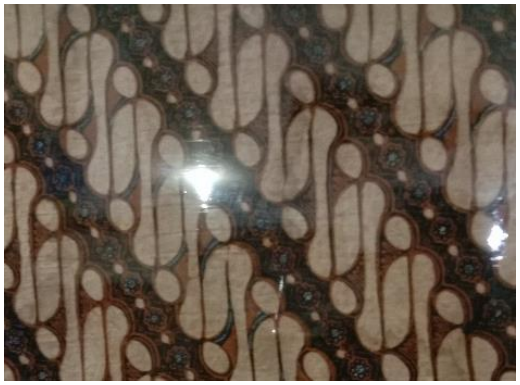


**Figure 9.** *Nglorod* Process

*'Nglorod / ngebyo'* is the final process in batik production, which involves boiling the batik fabric to remove the wax that remains on the fabric. In the Parang Barong Nagaraja batik motif, we have found several interesting mathematical topics. These will be explained below.

**1. Analytic Geometry**

**a. Equation of a Line**

The equation of a line is an equation that contains one or more variables, where the variables are of the first power. The equation of a line in the Parang Barong Naga Raja batik pattern is:

- The diagonal lines in the Parang pattern can be represented by the equation $y = mx + b$
- Suppose the slope of the Parang line is60°, then $m = \tan(60°) \approx 1.73$
- the starting point of the line is (0,0), the equation becomes $y = 1.73x$

**2. Gematric Transformations**

**a. Rotation:**

Rotation is the turning of an object around a pivot point.

- 180° rotation matrix: R = [-1 0; 0 -1]
- For a point (x, y), a 180° rotation results in (-x, -y)

**b. Reflection:**

Reflection is the flipping of an object over a line.

- Reflection over the y-axis : M = [-1 0; 0 1]
- Reflection of a point (x, y) over the y-axis: (-x, y)

**c. Translation:**

Translation or shifting is a type of geometric transformation where a point is moved in a straight-line direction within a flat plane.

- Translation vector $t$ = $(a, b)$ t=(a,b)
- Translation of a point (x, y): $(x', y')$ = $(x + a, y + b)$ (x ', y ') = (x+a,y+b)

**3. Symmetry and Groups**

**a. Symmetry and Group:**

- The Parang pattern has the symmetry group D2 (dihedral group of order 4)
- Group elements: {e, r, s, rs}, where e is the identity, r is a 180° rotation, and s is reflection

**b. Even Function:**

- For Bilateral Symmetry: f(-x) = f(x)
- Example: f(x) = x² on the symmetrical curves of the dragon motif

**4. Sequences and Series**

**a. Geometric Series:**

- If the size of the Parang motif forms a geometric series: $a_n = ar^{(n-1)}$
- Example: if the first motif is 5 cm and the ratio is 0.8, then $a_n = 5(0.8)^{(n-1)}$

**b. Arithmetic Series:**

- For a constant distance between motifs: $a_n$ = a1 + (n-1) d
- The initial distance is 10 cm and the difference is 2 cm: an = 10 + (n-1) 2

**5. Trigonometry**

a. Angles in Motifs:

- Angle between Parang lines: θ = arctan (m2 - m1) / (1 + m1m2)
- Where m1 dan m2 are the slopes of the intersecting lines

b. Trigonometric Circle:

The curvature in the dragon motif can be modelled with:

x = r cos(t), y = r sin(t), 0 ≤ t ≤ 2π

**6. Fractals and Dimension**

a. Fractals and Dimension

- Using the box-counting method:

  D = -lim[ε→0] log N(ε) / log(ε)

- Where N(ε) is the number of boxes with side length $\epsilon$ needed to cover the Moti fang

b. L-System for motif generation:

- Production rule: F → F+F--F+F

- Angle: 60°
- This iteration will produce a motif resembling Parang

From the discussion above, we can relate these mathematical concepts by applying them in academic learning in schools, such as:

1. Students can use dynamic geometry software like GeoGebra to draw and analyse batik motifs.
2. Utilizing Python or Processing programming to generate batik motifs based on mathematical algorithms.
3. Mini research projects where students measure and analyse proportions in original batik motifs.
4. Batik design workshops where students apply geometric transformations to create motif variations.
5. Statistical analysis of the frequency of certain shapes and patterns in museum batik collections.

By exploring the mathematical foundations of the Parang Barong Naga Raja batik, this research contributes to the field of mathematics education, highlighting the potential of culture as an engaging educational tool. The findings of this study align with existing literature that emphasizes the presence of mathematical elements in various cultural contexts, such as Euclidean geometric ideas developed from traditional Mozambican culture having educational power (Gerdes, P. (1988)). Unlike previous studies focusing on various cultural forms, such as Batik Making in Saung Baswet Village, Banjarsari Wetan, and Banyumas, involving various mathematical activities and concepts, including points, lines, angles, geometric transformations, and symmetry. Concepts of sets in traditional Wura Bongi Monca Bima dance (Khairullah et al., 2023), geometric patterns in Surakarta Kawung batik motifs (Abidin et al., 2023; Uula et al., 2024), and Yogyakarta batik Ceplokan motifs in enhancing students' understanding of mathematical concepts (Andriani & Septiani, 2020). This research expands the application of ethnomathematics, specifically into geometry. By exploring the Parang Barong Naga Raja batik, this study offers a new perspective on integrating culture into mathematics education, enriching pedagogical practice with culturally relevant content. Integrating cultural context into mathematics education is essential for creating an inclusive and engaging learning environment. The Parang Barong Naga motif exemplifies how culture can be an engaging pedagogical tool, facilitating a deeper connection between abstract mathematical concepts and real-world cultural practices.

## Conclusion

The Parang Barong Naga Raja batik is a tangible example of the Javanese people's rich cultural heritage and traditional philosophy, reflected in its design and symbolism. This research has revealed that this batik motif not only carries profound symbolic meanings—such as the "Parang," which represents

bravery and determination, and the "Barong" and "Naga Raja," which symbolize strength, power and protection—but also has a history that illustrates its evolution from a symbol of exclusive royal status to an integral part of a broader cultural heritage. Furthermore, the Parang Barong Naga Raja batik reflects geometric concepts such as symmetry, patterns, and transformations. The symmetry in the motif represents balance and harmony, while the repetitive patterns signify cultural continuity. The batik-making process, involving transformations of color and shape, applies mathematical principles underlying traditional batik creativity. The findings of this study have significant implications for mathematics education, particularly in teaching geometry. Using local cultural contexts, such as batik, in education can help students understand mathematical concepts in a more applied and contextual manner. This approach can motivate students by linking the curriculum to familiar and valued cultural aspects, enhancing their understanding of how mathematics plays a role in everyday life. The research also underscores the importance of preserving and promoting batik as part of cultural heritage. By understanding and appreciating the symbolic meanings and complex techniques of batik-making, we can better value and maintain local cultural diversity. The Parang Barong Naga Raja batik, with its embedded values and philosophy, plays a crucial role in preserving the traditions and cultural identity of the Javanese people. The Parang Barong Naga Raja batik is a stunning work of art and a window into understanding the relationship between culture and mathematics. This research highlights the importance of integrating cultural knowledge with mathematics education to provide a more comprehensive insight into the cultural heritage and the application of mathematics in a broader context.

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