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Analysis of Mathematical Thinking in the Geometry of Toronan Batik Motifs as a Source of Ethnomathematics for Elementary Schools

Kintan Nabila Mellisani[1*], Neni Mariana[1], Tassanee Juntiya[2]
[1]Elementary Teacher of Education, Surabaya State University, East Java,Indonesia
[2]Faculty of Education and Development Sciences, Kasetsart University, Kamphaeng Saen Campus, Nakhon Pathom, Thailand
*Correspondence: kintan.22288@mhs.unesa.ac.id

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ABSTRACT

Toronan Batik is one of the typical local cultures of Pamekasan that has the potential to contain mathematical concepts in the process of making it. This study aims to analyze the mathematical thinking process of batik in the concept of geometry in the Toronan Batik motif as an ethnomathematical source. This study employs a qualitative ethnographic approach. Data was obtained through observation, interviews, and documentation of batik makers at the MJ Batik House, Pamekasan Regency. The results of the study showed that the motifs of Lerres, Piring Pecah, Tong Centong, and Mata Keteran contain geometric concepts in the form of lines, triangles, circles, symmetry, repetition patterns, and translation. In addition, batik applies a mathematical thinking process in determining patterns, setting sizes, maintaining design balance, and arranging motif repetitions. Based on the results, it can be concluded that batik activities in Batik Toronan embodies mathematical processes that can be analyzed through an ethnomathematical approach and have the potential to be a source of contextual geometry learning in elementary schools.

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Batik is invaluable indonesian cultural heritage that embodies deep historical philosophy, and aesthetic values. Indonesia is a country that has a very rich cultural diversity, ranging from languages, customs, arts, to cultural heritage that is inherited from generation to generation (Sugianto, 2023). One of the cultures that has become the identity of the Indonesian nation is batik

(Rahayu, 2021). Batik is not only seen as a work of art, but also as a cultural symbol that contains high philosophical, historical, and aesthetic value (Tirtaamidjaja et al., 1966). In its development, batik has been recognized by UNESCO as an intangible cultural heritage that needs to be preserved because it reflects the cultural identity of the Indonesian people (Ulum, 2018).

Local culture has a close relationship with various mathematical concepts in people's lives. Mathematical concepts often appear in people's cultural activities, whether consciously or unconsciously (D'Ambrosio, 2007). One of the cultures that contains mathematical elements is batik (Islam & Mariana, 2021). During the production process, batik artisans, inherently, utilize geometric concepts, such as patterns, spiritual measurements, shape, replication, and structural balance. (Susilawati, 2015). Batik motifs that are arranged regularly show the application of mathematical patterns in people's daily lives. In addition, Batik can be used as a learning resource that enhances students' mathematical performance and engagement (Fitriyah et al., 2025). Shapes such as lines, circles, triangles, squares, and symmetry Many are found in the arrangement of traditional batik motifs (Islam & Mariana, 2021).

Geometry learning in elementary schools still faces various obstacles in the learning process. Learning mathematics is often considered difficult and boring because the material is presented abstractly and is less associated with real life (Surur & Oktavia, 2019). This condition causes a low student interest in understanding mathematical concepts, especially geometry (Naja et al., 2022). Therefore, a contextual learning approach is needed so that mathematical concepts can be understood more clearly and meaningfully (Clarke & Roche, 2018).

Ethnomathematics can be an alternative learning approach that connects mathematics with local culture. Ethnomathematics is a learning approach that connects the concept of mathematics with community culture (Ajmain, 2020). This approach helps students understand that mathematics is present in cultural activities and daily life (Serepinah & Nurhasanah, 2023). Through ethnomathematics, local culture can be used as a contextual learning medium so that mathematics learning becomes more interesting and easy to understand (Faradisa et al., 2020). Local culture-based learning is also able to improve students' understanding of mathematical concepts (Fitriyah et al., 2025).

Toronan Batik is one of the local cultures that has potential as a source of ethnomathematics. Pamekasan Regency is known as one of the largest batik-producing areas in Madura (Mubarak et al., 2023). Pamekasan batik is characterized by bold motifs and colors and is rich in geometric elements (Rahayu, 2021). One of Pamekasan's typical batik is Toronan batik which comes from Kowel Village (Solihin & Rahmawati, 2024). Toronan Batik has various distinctive motifs such as Lerres, Broken Plates, Tong Centong, and Mata Keteran (Rahayu, 2021). These motifs show the existence of geometric patterns that are arranged in a repetitive and orderly manner (Fajriyeh & Zayyadi, 2018).

The production process of Batik Toronan reveals mathematical thinking activities performed by the artisans. During this process, artisans implicitly apply mathematical thinking skills when determining patterns, arranging motifs, setting dimensions, balancing designs, and creating shape variations (Khairunnisa et al., 2022). These activities demonstrate that batik making is not merely an artistic and cultural endeavor but also involves complex mathematical thinking processes (Allawi et al., 2023). However, the mathematical thinking processes employed by artisans have rarely been

examined in depth; they are often viewed solely as artistic skills, meaning the inherent mathematical potential has not been widely utilized as a learning resource. Investigating this matter is crucial because mathematics instruction in primary schools particularly regarding geometry tends to be abstract, creating a need for real world contexts that resonate with students' lives and culture. Therefore, examining the mathematical thinking processes of Batik Toronan artisans not only enriches the study of ethnomathematics but also yields contextual learning resources that support mathematics education while simultaneously contributing to the preservation of local culture.

Research on ethnomathematics on batik has been conducted extensively and shows that batik motifs contain various geometric concepts that can be used in mathematics learning (Islam & Mariana, 2021). However, previous research has generally focused only on identifying The geometric shape of the batik motif, while the study of the mathematical thinking process of batik as a cultural batik is still limited. Therefore, the state of the art of this research lies in the analysis of batik activities from the mathematical thinking approach of batik. The novelty of this research is Reveal the mathematical thinking process of Toronan Batik batik makers in determining patterns, sizes, balances, and repetition of motifs that contain geometric concepts. This research is important to enrich the ethnomathematical study of Pamekasan Toronan Batik as well as to document mathematical knowledge that develops in the local culture.

METHODS

This research paper uses a qualitative approach with the type of ethnographic research (Moleong, 2019). The ethnographic approach is used because the research focuses on the cultural activities of the community, especially the process of making batik on Toronan batik in Pamekasan. Ethnographic research aims to understand the meaning, activities, and habits of people in a culture in depth (Spradley, 2007).

The study was conducted at Rumah Batik MJ in Pamekasan Regency, Madura. This location was selected because it is one of the centers for Toronan Batik that preserves the motifs, techniques, and traditional production processes passed down through generations. Unlike other batik production sites that have largely adapted their motifs to meet market demands, Rumah Batik MJ consistently maintains the authentic characteristics of Toronan Batik, allowing for a comprehensive observation of the artisans' thought processes during motif composition. These conditions make Rumah Batik MJ a relevant site for examining the cultural practice of batik making from an ethnomathematical perspective. The research subjects consisted of artisans directly involved in the creation of Toronan Batik motifs.

The research procedure began with a literature review on mathematical thinking in batik, followed by observations of the batik-making process. The researchers then identified geometric concepts embedded in Toronan batik motifs and analyzed the mathematical thinking processes employed by batik artisans in creating these motifs. Subsequently, interviews were conducted, and relevant batik documentation was collected. The validity of the findings was ensured through data triangulation, after which the data were interpreted and synthesized into the final research report. The complete sequence of the research procedure is presented in **Figure 1**.

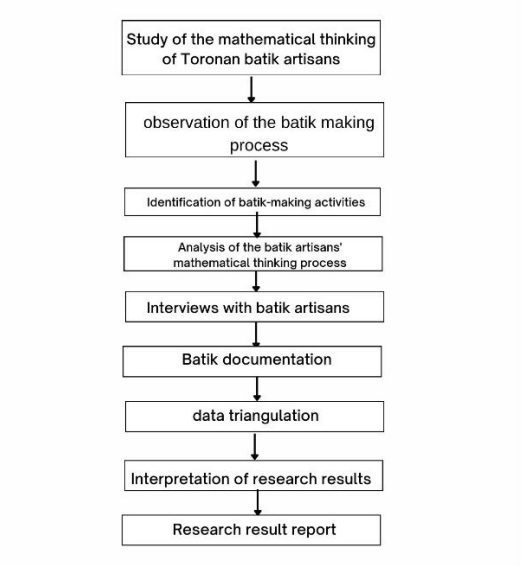

Figure 1. Research Producedure

The validity of the data was carried out using triangulation techniques and source triangulation (Sugiyono, 2021). Triangulation techniques are carried out by comparing the results of observations, interviews, and documentation, while source triangulation is carried out by comparing information from several different batik makers (Moleong, 2019).

RESULTS AND DISCUSSION

Toronan batik is one of the typical Pamekasan batik that has a repetitive motif pattern and is loaded with geometric elements (Rahayu, 2021). In the process of making it, batik indirectly applies the ability to think mathematically when determining patterns, arranging motifs, regulating the distance between ornaments, and maintaining design balance in batik fabric (Khairunnisa et al., 2022). These activities show that batik is not only related to art and culture, but also contains mathematical concepts, especially geometry (Allawi et al., 2023).

Motif Batik Lerres

Lerres motifs, as shown in **Figure 2**, have a pattern of parallel lines arranged repeatedly on batik fabric (Rahayu, 2021). This motif shows the existence of geometric concepts in the form of straight lines, parallel lines, and repeating patterns (Mailani et al., 2024).

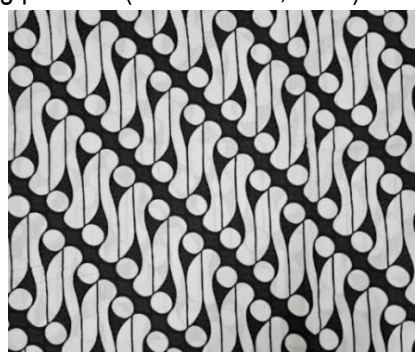

Figure 2. Motif Batik Lerres

Batik makers must pay attention to the distance between the lines so that the motif looks neat and balanced (Khairunnisa et al., 2022). Line repetition consistently shows the regularity of mathematical patterns and the concept of symmetry (Islam & Mariana, 2021).

Motif Batik Mata Keteran

The Broken Plate motif, as shown in **Figure 3**, is inspired by the shape of ceramic fragments that are arranged repeatedly (Rahayu, 2021). This motif shows the existence of geometric concepts in the form of triangles, broken lines, and pattern repetition (Fajriyeh & Zayyadi, 2018).

Figure 3. Motif Batik mata Keteran

In compiling these motifs, batik makers pay attention to the position and size of each ornament to keep it harmonious (Allawi et al., 2023). The repetition of shapes in motifs shows the existence of the concept of translation in geometric transformation (Rahmawati, 2024).

Motif Batik Tong Centong

The Tong Centong motif, as shown in **Figure 4**, has a curved line pattern and a repeating shape that arranged in an orderly manner (Solihin & Rahmawati, 2024). This motif shows the concept of curved lines, patterns, and symmetry in geometry (Mailani et al., 2024).

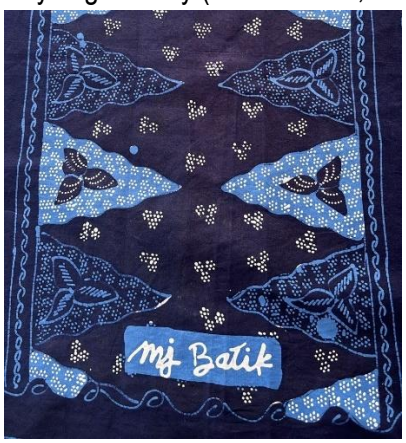

Figure 4. Motif Batik Tong Centong

Batik uses spatial visual skills to determine the location of the motif so that it looks proportional and balanced on batik fabric (Khairunnisa et al., 2022).

Motif Batik Mata Keteran

The Mata Keteran motif, as shown in **Figure 5**, has a shape that resembles a circle that is arranged repeatedly (Rahayu, 2021). This motif shows the concept of circle, central point, and rotary symmetry (Rahmawati, 2024).

Figure 5. Motif Batik Mata Keterangan

In the process of making it, batik keeps the size and position of the circle consistent and harmonious. This shows the existence of mathematical thinking skills in the form of measurement and repetition of patterns (Rosa & Orey, 2013).

Based on the results of observations, documentation, and interviews at the MJ Pamekasan Batik House, it was found that the Toronan Batik motif contains various geometric concepts in the motifs of Lerres, Broken Plates, Tong Centong, and Mata Keteran. The concepts found include points, lines, curves, triangles, rectangles, circles, symmetry, repetitive patterns, and translation. The existence of these concepts shows that batik activities not only produce works of art, but also contain mathematical elements that develop in people's culture.

The results of the interviews show that batik applies a mathematical thinking process when determining the shape, position, size, distance, and balance of the motif. Batik also repeats patterns regularly by relying on experience and visual observation. These activities show the ability to visualize, informal measurement, and pattern recognition that are carried out naturally in the batik making process.

Discussion

The results of the study show that the process of making Toronan Batik batik contains mathematical thinking activities related to the concept of geometry. Before drawing the motif, batik first imagines the shape and position of the motif on the fabric. This activity shows the ability to visualize, which is the ability to form a mental image of an object before it is manifested in real form. Visualization skills are one of the important aspects of mathematical thinking because they help a person understand the shape and spatial relationships of an object (Khairunnisa et al., 2022). Visualization skills also help individuals recognize the characteristics of geometric shapes and relationships between shapes more deeply (Mailani et al., 2024).

In addition to visualization, the mathematical thinking process is also seen when batik determines the distance between motifs and arranges patterns repeatedly. Batik artists use

experience and visual observation to estimate the appropriate distance so that the motif looks balanced and not too tight or too loose. The consistent repetition of motifs shows the ability to recognize patterns and regularity. According to Rosa and Orey (2013), the regularity of patterns that appear in cultural activities is a form of application of mathematical concepts that develop naturally in people's lives. In a geometric perspective, patterns The repetition is related to the concept of translation because the same form is moved to another position without changing its size and shape (Rahmawati, 2024).

Research results indicate that the Toronan Batik motif incorporates various geometric concepts, such as lines, repeating patterns, symmetry, and shape regularity. These findings suggest that the process of creating the motif is not based solely on aesthetic considerations but also involves the intuitive application of geometric concepts by the batik artisans. Consequently, Toronan Batik holds potential as a source of ethnomathematics that can be utilized in geometry instruction at the elementary school level (Islam & Mariana, 2021). The Broken Plate motif shows a triangular shape arranged in an orderly manner. Triangles are one of the basic flat shapes used to build complex geometric patterns (Mailani et al., 2024). The Tong Centong motif contains a repeating curve or curve pattern so that it shows visual regularity in the design of the motif (Solihin & Rahmawati, 2024). Meanwhile, the Mata Keteran motif features a circle shape arranged with a certain pattern. Circles are geometric shapes that are widely found in cultural artifacts and are often associated with the concept of symmetry (Rahmawati, 2024).

The findings of this study show that batik activities not only have cultural and aesthetic value, but also contain mathematical elements that develop through the cultural experiences and practices of the community. Mathematics is essentially part of human activities that grow and develop in the culture of society (D'Ambrosio, 2007). Ethnomathematics views that mathematical concepts can be found and learned through various local cultural activities so that learning becomes more contextual and meaningful (Ajmain, 2020). Cultural integration in mathematics learning can also help students understand concepts more clearly and close to daily life (Faradisa et al., 2020).

CONCLUSION

Based on the results of the research, it can be concluded that the Toronan Batik motif contains various geometric concepts found in the Lerres, Broken Plate, Tong Centong, and Mata Keteran motifs. The concepts of geometry found include lines, triangles, circles, symmetry, repetition patterns, and translation. In addition, The batik process shows the mathematical thinking activities carried out by batik in determining patterns, adjusting sizes, maintaining design balance, and arranging motif repetition. Thus, Toronan Batik not only has cultural and aesthetic value, but also contains mathematical concepts that can be studied through ethnomathematical approaches and has the potential to be a source of contextual geometry learning in elementary schools. This study is limited to a single research site; therefore, future research is expected to expand the scope of locations and further develop its implementation in mathematics instruction.

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