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Uncovering mathematical activities and concepts in *Batik Pendekar* of Madiun City through the lens of ethnomathematics

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Abstract

Despite the growing recognition of ethnomathematics as a bridge between culture and formal mathematics education, limited research has explored the mathematical knowledge embedded in regional cultural artifacts such as *Batik Pendekar* from Madiun City, Indonesia. This study aims to uncover the mathematical activities, concepts, and anthropological aspects inherent in the *Batik* Pendekar tradition to support culturally responsive mathematics education. This research employed a qualitative ethnographic approach. This research was conducted at the *Batik Murni* Madiun City Gallery by collecting data through observation, interviews, and documentation. The data were analysed qualitatively using triangulation methods. The findings reveal that artisans engage in meaningful mathematical practices, such as measuring fabric dimensions, counting dye usage and production costs, and designing motifs based on geometric principles. The mathematical concepts embedded in *Batik Pendekar* include geometry, triangular shapes, and transformation geometry (translation and reflection). Additionally, anthropological aspects, such as local wisdom, social values, and symbolic meanings, are integral to these activities. The study concludes that *Batik Pendekar* serves as a rich ethnomathematical resource, offering opportunities to bridge mathematics learning with local culture and enhance contextual understanding in mathematics education.

Keywords: *Batik Pendekar*; ethnomathematics; mathematical activities; mathematical concepts

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Introduction

In the 21st century, the rapid advancement of civilisation has affected various aspects of life, including education and culture. Education is inherently connected to culture (Syafril & Zen, 2019) and encompasses all human activities, such as beliefs, laws, morals, and knowledge. Culture encompasses all human activities, including beliefs, laws, morals, and knowledge (Rahmawati & Soebagyo, 2022). Culture is the totality of behaviour and outcomes obtained through structured learning in a social environment. These cultural experiences serve as valuable sources of learning that continue to influence future understandings. This is in line with the opinion of Meland and Brion-Meisels (2024), who stated that education and culture are inseparable from everyday life, culture forms an integral whole, while education fulfils a fundamental need of every learner in society. Education and culture are essential for shaping the national character and instilling societal values. (Pilkhwal & Manral, 2023).

As in mathematics education, this subject is embedded in everyday life and the development of cultured characters (Prahmana, 2022). Mathematics is not limited to numbers or abstract formulas, and many everyday practices naturally incorporate mathematical thinking, highlighting its relevance across disciplines and cognitive development (Harahap & Mujib, 2022; Nursyeli & Puspitasari, 2021). Learners' mathematical abilities are often shaped by their cultural background, as their understanding is influenced by their experiences and observations in their environment. Mathematics has been established as a core subject in schools to develop logical, analytical, critical, and systematic thinking (Mulyati & Evendi, 2020). However, the learning process often faces challenges, such as low student achievement, which is primarily attributed to limited comprehension of the material (Zhu & Wu, 2023). Contributing factors include insufficient learning motivation, an unsupportive environment, and a lack of effective teaching strategies (Surur et al., 2019). Additionally, an overreliance on textbooks makes it difficult for students to connect lessons to real-world applications (Prahmana & D'Ambrosio, 2020; Fajarsari et al., 2022).

To address this issue, educators are encouraged to adopt alternative and contextual learning resources by incorporating elements from the students' environment. One such culturally relevant learning medium is *batik*, a traditional Indonesian art form rich in mathematical patterns. Each region's *batik* design carries unique philosophical values, with Madiun's *Batik* Pendekar reflecting local heritage, plantation products, and historical iconography. Integrating *batik* into mathematics education introduces students to ethnomathematics, a field that explores mathematical ideas through the lens of culture, language, and history (D'Ambrosio, 2001; D'Ambrosio, 2006; Prahmana & D'Ambrosio, 2020; Astriandini & Kristanto, 2021). Ethnomathematics empowers educators to contextualise lessons, making mathematics more relatable and meaningful for students by linking it to the cultural practices they encounter in their daily lives (Prahmana & D'Ambrosio, 2020).

This study investigates the ethnomathematical elements found in *Batik* Pendekar, a traditional *batik* motif from Madiun, East Java. Ethnomathematics in *batik* has been explored in various studies, showing the relevance of cultural artefacts as mathematics learning resources for students. For example, Harahap and Mujib (2022) found that there are mathematical concepts in Medan Indonesian *batik* that can be used as learning resources. Agasi and Wahyuono (2019) highlighted geometric patterns in Jepara Indonesian Troso *batik* motifs that can be effectively integrated into geometry instruction. Prahmana and D'Ambrosio (2020) used Ethnomathematics on Yogyakarta Indonesian *batik* patterns as a source for learning geometry. Research conducted by Riyanti et al. (2022) also revealed the presence of geometric elements in the besurek cloth from Bengkulu, Indonesia. Research conducted by Irawan et al. (2022) investigated the use of traditional Java *batik* as a medium for learning mathematics, especially geometry transformation material. In addition, which was carried out by Ulum (2018) revealed that pasedahan suropati *batik* motifs can be used as relevant and contextual learning media. This is also supported by Wulandari and Suryadi (2021), who found that the use of local *batik* in Malang, Indonesia, can be used to teach various mathematical concepts, such as geometry, in an applicative manner in students' daily lives. Finally, Yolanda and Putra (2022) concluded that using *batik* as a learning resource enhances student engagement and provides a more enjoyable learning experience.

While previous studies have demonstrated the educational potential of various regional *batik* patterns, this study specifically focusing on *Batik Pendekar* has not been conducted by other researchers. Compared with other batik motifs, *Batik Pendekar* has unique characteristics, namely motifs related to silat movements, clothing, and philosophical and cultural values typical of Madiun. This study aims to fill this gap by exploring the mathematical concepts embedded in Madiun's *Batik Pendekar*. As a cultural artifact that reflects local values, history, and identity, *Batik Pendekar* offers rich opportunities for integrating cultural heritage into mathematics education. The results of this study are expected to have a positive impact on education and cultural preservation. By utilising *Batik Pendekar* as a contextual learning medium, this study contributes to the development of innovative and culturally grounded teaching materials. It also strengthens the role of Madiun *batik* as a creative and intellectual product that supports the preservation of East Java's cultural legacy. Through this approach, students can experience mathematics in a way that is meaningful and engaging and deeply rooted in their cultural environment.

Methods

This research employed a qualitative approach with an ethnographic focus. The ethnographic approach was used because it can describe culture and understand the view of life from the perspective of the Indigenous population (Ulum, 2018; Prahmana & D'Ambrosio, 2020). The ethnographic approach can also be defined as a way to study a cultural group as a result of research. This research was conducted at the *Batik Murni* Madiun City Gallery, which is located on Halmahera Street No. 21, Oro-oro Ombo, District Kartoharjo, Madiun City, East Java, Indonesia. This gallery was chosen as a research location because it produces batik works as a characteristic of the city of Madiun, which once won 1st place in a national craft event at the East Java provincial level. The research subjects were three craftsmen from Galeri *Batik Murni* Madiun. The research procedure is illustrated in Figure 1.

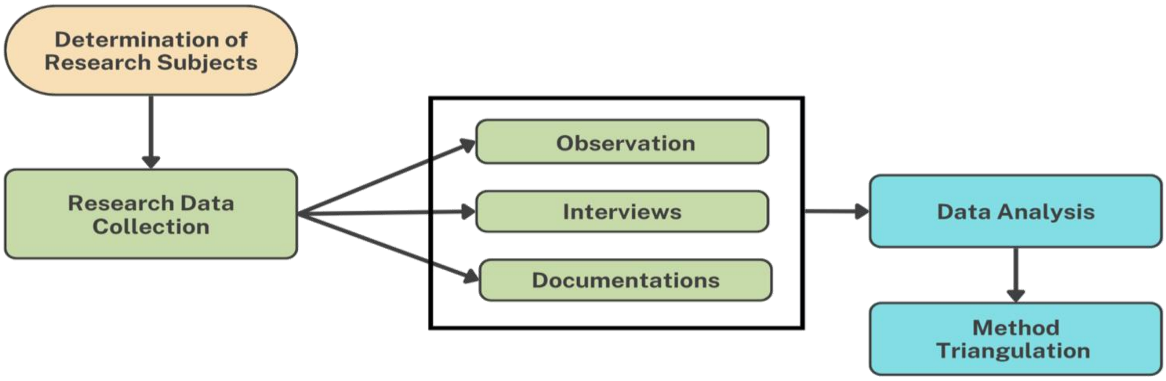

Figure 1. Research procedure

After the research subject was determined, data collection was carried out using research instruments. The main instrument in this research is the researcher himself, who plays a role in data collection. Data collection was done by observation, interview, and documentation. For that, researchers need auxiliary instruments, namely observation, interview, and documentation guidelines. Collecting data by observing and interviewing the Galeri *Batik* Madiun craftsmen. Observations made were observing the process of making *batik* and the results of *batik Pendekar*, which are supported by the results of documentation. Interviews conducted in this study are semi-structured interviews, meaning that researchers use guidelines but can develop according to the field situation, with interview guidelines in Table 1.

Table 1. Interview guidelines

No.	Ethnomathematics Indicators	Focus on the Problem	Problem Aspects
1	Mathematics Activities	The process of making *Batik Pendekar*	a. Tools and materials for making *batik Pendekar* b. The process of making *batik Pendekar*
2	Mathematics Concept	The results of the *Batik Pendekar* products	a. *Batik Pendekar* motif b. *Batik Pendekar* motif composition
		Mathematical operations found in the *Batik Pendekar*	The mathematical concept contained in the *batik Pendekar*
3	Anthropological aspects	Anthropological aspects in the context of ethnomathematics	Elements related to cultural values, social practices, beliefs, habits, traditions, language, local symbols, and the way a community understands and uses mathematics in their daily lives

Data analysis was carried out through several stages, namely data reduction, data presentation, and drawing conclusions or data verification (Miles et al., 2014). Data reduction was carried out to simplify and focus on information related to mathematical activities, mathematical concepts, and anthropological aspects. The reduced data was then presented in the form of descriptive narratives and visual documentation. Data presentation was carried out to identify the relationship between cultural elements and mathematical concepts that appear naturally in cultural practices, especially in the production process and the symbolic meaning of *batik Pendekar*. Conclusions were drawn based on the patterns that emerged in the data, then verified through method triangulation (combining interview results with direct observation and document studies).

Results

Mathematics activity on *Batik Pendekar*

Mathematical activity is an activity that involves abstracting from real-life experiences into mathematical concepts. Mathematical activities include counting, measuring, determining location and direction, making building plans, and playing. Mathematical activities in *batik Pendekar* are observed from the *batik*-making process.

The first step, the mori cloth is cut according to the desired size at Galeri *Batik* Murni Madiun, the size of the *batik* cloth is 240 cm long and 115 cm wide. The cloth is washed to remove the starch and then dried under the sun. Designing a pattern for *batik* on paper using a pencil. Then the pattern is re-made on the fabric with a pencil. After the pattern is made on the cloth, the cloth is *batik*ed using malam. The next step is coloring, as shown in Figure 2. Choosing the type of coloring under consumer demand, and measuring how many colors are needed for coloring *batik* cloth. After the coloring on the fabric is complete, drying is carried out. Perform the color drying process using the machine in Figure 3. The material used is water glass or alum, depending on the fabric dye used. If the dye used is a synthetic dye, then the color locking agent used is water glass. If natural dyes are used, then alum is the color-locking agent. Furthermore, it is allowed to stand for approximately 2 hours. The washing process is carried out to remove water glass from *batik* cloth in Figure 4.

Figure 2. *Batik* colouring

Figure 3. Color drying

Figure 4. *Batik* washing

The fabric is then immersed in a cauldron of hot water to remove the night that is still attached. This process is called *nglorot*. After that, the fabric is washed again in a tub of cold water to clean the fabric of dirt in Figure 5. The final stage is drying under the sun until dry in Figure 6. Once dry, the fabric can be ironed and folded.

Figure 5. *Nglorot* process

Figure 6. *Batik* drying

When examined, in the process of making *batik Pendekar,* several activities involve mathematics, including:

1. Measuring activity. This activity can be seen from the process of measuring *batik* cloth before cutting. An example of the application of measuring activities in math material is a *batik* cloth with a size of 240 cm × 115 cm used to cover a block-shaped tissue holder with a size of 18 × 10 × 8. How many tissue holders can be made that have been covered in warrior *batik*?

   The problem can be solved in the following way.

   $$Batik\ cloth\ area = p \times l = 240 \times 115 = 27{,}600\ cm^2$$

   $$\begin{aligned} Surface\ area\ of\ tissue\ holder &= 2(p \times l + p \times t + l \times t) \\ &= 2(18 \times 10 + 18 \times 8 + 10 \times 8) \\ &= 2(180 + 144 + 80) \\ &= 2(404) = 808\ cm^2 \end{aligned}$$

   $$\begin{aligned} A\ tissue\ holder\ that\ can\ be\ made &= \frac{Batik\ cloth\ area}{Surface\ area\ of\ tissue\ holder} \\ &= \frac{27{,}600}{808} = 34.15 \end{aligned}$$

   Then the tissue box covered with *batik* warrior cloth that can be formed is 34 pieces.

2. Counting activity. This activity can be seen from determining the amount of colour needed (see Figure 2), the amount of locking agent needed, the length of time needed during the drying process, and determining how much the selling price of the fabric is…

   An example of counting activities in math material is the application of social arithmetic problems as follows. A shirt designer buys 3 pieces of *batik Pendekar* writing technique cloth at a price of Rp 3,750,000. Then make 2 dresses for the *batik* fashion exhibition. The production cost of 2 dresses is Rp 1,075,000. During the exhibition, his works were ogled by fashion lovers with prices of Rp 2,950,000 and Rp 3,310,000. Does the clothes designer make a profit or loss? The application problem can be solved in the following way:

   $$\begin{aligned} H_b &= purchase\ cost\ +\ production\ cost \\ &= 3,750{,}000 + 1{,}075{,}000 = 4{,}825{,}000 \end{aligned}$$

   $$\begin{aligned} H_j &= dress\ 1 + dress\ 2 \\ &= 2{,}950{,}000 + 3{,}310{,}000 = 6{,}260{,}000 \end{aligned}$$

   $$\begin{aligned} U &= H_j - H_b \\ &= 6{,}260{,}000 - 4{,}825{,}000 = 1{,}435{,}000 \end{aligned}$$

Because the selling price is greater than the purchase price, the designer makes a profit. And the profit value obtained is $Rp\ 1{,}435{,}000$.

3. Activity of making building designs. This activity can be seen at the very beginning of making a *batik* pattern design. This is the same as the process of designing a building space (net) so that the building has the desired shape.

   An example of a building design activity in mathematics material is the application of making the nets of building spaces as follows. A student gets an assignment to make a letter box in the shape of a cube without a lid (see Figure 7) with a *batik Pendekar* decoration. The desired size is a box with a length of 20 cm. Then this problem can be solved by making a cube net-net pattern without a lid with a side length of 20 cm on paper, then making it also on *batik Pendekar* as a cube decoration. Here is the net-net of a lidless cube.

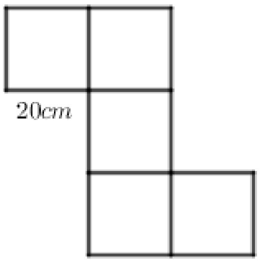

Figure 7. Cube nets without lids

Mathematical concepts in *Batik Pendekar*

1. Concept of Triangular Flat Buildings

   Batik Pendekar with canting technique has a motif that contains elements of mathematical concepts, namely triangular flat shapes. The triangular shape on the *batik* motif of the warrior is a depiction of the udeng cloth used by the warrior's head in Figure 8.

Figure 8. Triangle shaped motif

Apart from being used to find the types of triangles, there are other application models. Another application of the triangular flat shape of the warrior motif in math problems is to find the perimeter and area of a triangle. If the application is to find the perimeter, then the formula used is the sum of the three sides of the triangle or $k = s_1 + s_2 + s_3$. If looking for the area, the formula used is the base of the triangle multiplied by the height of the triangle or $L = a \times t$.

2. Transformation geometry

In addition to the mathematical concept of flat triangles, *batik Pendekar* also has another concept, namely transformation geometry. Transformation geometry is a branch of geometry that discusses changes in the location or shape of a point, angle, line, plane, and space (Maskar et.al, 2019). Transformation geometry is grouped into four, namely: translation (shift), reflection (mirroring), rotation (rotation), and dilation (change of scale). In *batik Pendekar*, the transformation geometry presented is translation and reflection.

Translation is the displacement or shift of a point of geometry with the same direction and distance. Translation has the formula "If the point $P(x, y)$ translated by $T = \binom{a}{b}$ then the shadow is obtained $P'(x + a, y + b)$".

In *batik Pendekar* wet night print technique, there are several motifs of a warrior doing martial arts movements that are depicted repeatedly (see Figure 9). When examined, the motif only experiences a shift in location. It can be said that the warrior motif undergoes translation in Figure 10.

Figure 9. *Batik Pendekar* motif translation

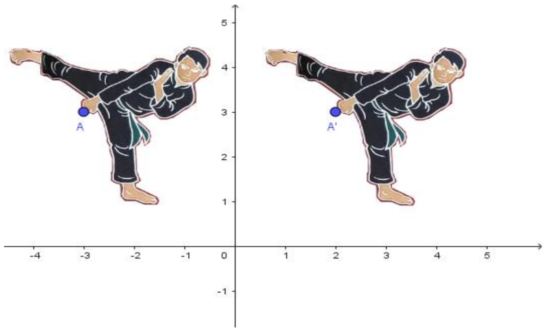

Figure 10. Example of application of translation

Point known $A(-3,3)$ translated by $T\binom{5}{0}$ then the shadow that point A has is....

$$\binom{x'}{y'} = \binom{x}{y} + \binom{a}{b} = \binom{-3}{3} + \binom{5}{0} = \binom{2}{3}$$

So, the shadow of A is $(2,3)$ or $A'(2,3)$.

Apart from translational properties, *batik Pendekar* also has reflection properties. Reflection or mirroring is the displacement of a geometric point using the properties of objects and flat mirror images (Setyo & Ba'diah, 2021). Reflection on *batik Pendekar* is divided into several types, namely against the $x - axis$, $y - axis$ and $x = h - axis$.

In *batik Pendekar* wet night print technique, pay attention to the right and left sides of the batik. There is a *pecel* motif with depictions of chili peppers and cassava leaves (see Figure 11). When examined, the motif applies the concept of reflection to the $x - axis$ in Figure 14. The formula for reflection on the $x - axis$: $\binom{x'}{y'} = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix} \binom{x}{y}$.

Figure 11. Reflection on the x-axis

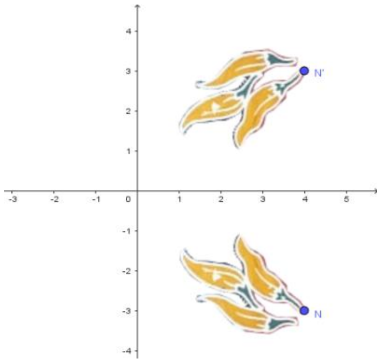

Figure 12. Example of application of reflection on the x-axis

Point known $N(4,-3)$, if the point is mirrored to the x-axis then the shadow is....

$$\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix} \begin{pmatrix} x \\ y \end{pmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix} \begin{pmatrix} 4 \\ -3 \end{pmatrix} = \begin{pmatrix} 4 \\ 3 \end{pmatrix}$$

So, the shadow of point N is (4,3) or $N'(4,3)$.

In *batik Pendekar* wet night print technique as well as reflection on the x-axis (see Figure 13), pay attention to the *pecel* motif at the bottom of the *batik* cloth. If you pay further attention, the *pecel* motif applies the nature of reflection to the y-axis in Figure 14. The reflection formula on the y-axis is as follows: $\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix} \begin{pmatrix} x \\ y \end{pmatrix}$.

Figure 13. Reflection on the y-axis

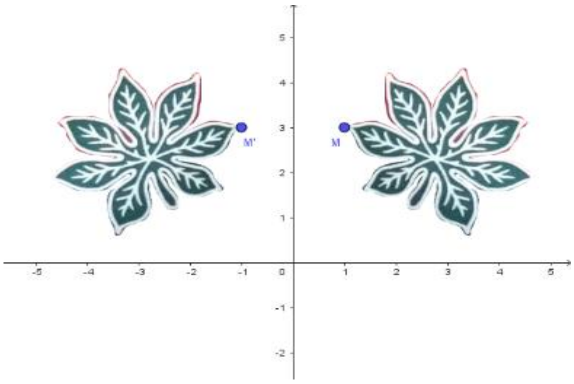

Figure 14. Example of application of reflection on the y-axis

It is known that the *batik* motif that symbolizes cassava leaves has one of its points, namely $M(1,3)$ Reflected on the y-axis, the shadow formed is...

$$\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix} \begin{pmatrix} x \\ y \end{pmatrix} = \begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix} \begin{pmatrix} 1 \\ 3 \end{pmatrix} = \begin{pmatrix} -1 \\ 3 \end{pmatrix}$$

So, the shadow of point M is $(-1,3)$ or $M'(-1,3)$.

In *batik Pendekar* wet night print technique, there is one motif of *Pendekar* that applies the nature of reflection by separating a considerable distance in Figure 15. This can be used as an application of the nature of reflection on the $x = h\ axis$ in Figure 16. Mirroring of the $x = h$ axis means that the mirror is located at $x = h$. The reflection formula on the $x = h\ axis$ is as follows: $P(x,y) \xrightarrow{x=h-axis} P'(2h-x,y)$

$$\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix} \begin{pmatrix} x \\ y \end{pmatrix} + \begin{pmatrix} 2h \\ 0 \end{pmatrix}.$$

Figure 15. Reflection about axis-(x=h)

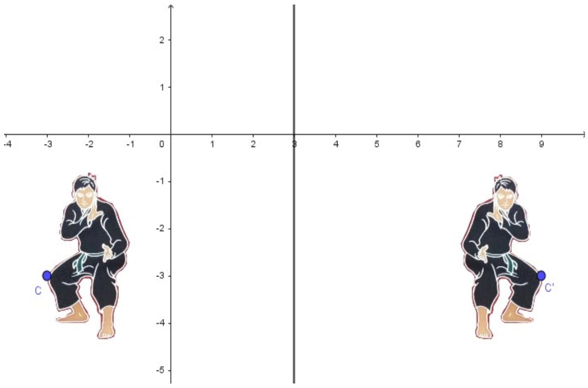

Figure 16. Example of application of reflection on the axis-(x=h)

Given a picture of a warrior whose one knee is at a point $C(-3,-3)$, when the image is reflected about the $x - axis = 3$, then the shadow formed is....

$$\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix} \begin{pmatrix} x \\ y \end{pmatrix} + \begin{pmatrix} 2h \\ 0 \end{pmatrix} = \begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix} \begin{pmatrix} -3 \\ -3 \end{pmatrix} + \begin{pmatrix} 2(3) \\ 0 \end{pmatrix} = \begin{pmatrix} 3 \\ -3 \end{pmatrix} + \begin{pmatrix} 6 \\ 0 \end{pmatrix} = \begin{pmatrix} 9 \\ -3 \end{pmatrix}$$

So, the shadow of point C is $(9,-3)$ or $C'(9,-3)$

Anthropological aspects

Anthropological aspects in the context of ethnomathematics are elements related to cultural values, social practices, beliefs, habits, traditions, language, local symbols, and the way a community understands and uses mathematics in their daily lives. In ethnomathematics, anthropological aspects are not just a cultural background, but an integral part of the construction of mathematical meaning in a particular cultural context.

That cultural elements such as *batik*, culinary, and traditional martial arts reflect the way local communities understand and construct mathematical meanings in everyday life. In Madiun City, *Pendekar* or warriors are not only known as martial arts experts, but also cultural figures who represent the noble values, spirituality, and philosophy of life of the people of East Java. Madiun *silat* movements, such as stances, evasions, and parries, contain deep symbolic meanings. This movement is not only born from physical aspects, but from the value of balance and order concepts that are also closely related to mathematical principles such as translation and reflection.

Batik Pendekar has a motif consisting of *Pendekar*, *pecel*, and *truntum* motifs. Each motif on this *Pendekar batik* has its meaning according to the noble values of the people of Madiun city. *Batik Pendekar* Madiun city depicts this narrative through a combination of three motifs: *Pendekar*, *pecel*, and *truntum*. The *Pendekar* motif symbolizes strength, wisdom, and moral integrity, while the *pecel* motif represents the community's agrarian cultural roots that uphold togetherness and simplicity. *Pecel* Madiun is not only a flavourful specialty, but also a symbol of social value.

The *truntum* motif, which means “to grow again,” reinforces the meaning of eternal love and sacrifice in Javanese families. *Truntum* symbolizes loyalty, sincerity, and unconditional love, especially in parent-child relationships. Visually, the motif is arranged in a repeating pattern of small stars, reflecting the principles of reflection and translation in mathematics, a clear example of how cultural values are embodied in geometry. Like the measured and repetitive patterns of *batik*, the noble values in Madiun culture are structured in daily life, passed down through practices such as *tirakat*, respect for teachers, and fasting, which strengthen the character of the community.

Discussion

The ethnomathematics study on *batik Pendekar* Madiun City can reveal mathematical activities, mathematical concepts, and anthropological aspects. Mathematical activity is an activity that involves abstracting from real-life experiences into mathematical concepts or vice versa (Rakhmawati, 2016). Mathematical activities in *batik Pendekar* are observed from the *batik*-making process. In the process of making batik, 3 mathematical activities are found, including measuring, counting, and making building designs.

Measuring activities in the *batik Pendekar* production process provides strong examples of how mathematical thinking is applied in cultural practices. The act of measuring cloth size (240 cm × 115 cm), adjusting pattern placement, and estimating area are real-life applications of length and surface area concepts. These align with Bishop (1997) identification of measuring as one of the six fundamental mathematical activities found in all cultures. Such practices, when brought into the classroom, support contextual learning that connects school mathematics with meaningful experiences (Meaney et al., 2017; Murtafiah et al., 2024). Ethnomathematics helps students see measurement not just as a school subject, but as a cultural tool used in daily life (Rosa & Orey, 2011; Muhtadi et al., 2017; Pratama & Yelken, 2024).

Counting activities are also deeply embedded in *batik* making. Artisans count how much dye is needed, how long to dry the cloth, and calculate the total cost and profit when selling the final product. These represent forms of everyday numeracy, which are essential for decision-making and problem-solving (Murtafiah et al., 2021). Including these counting practices in the classroom can help students engage in financial literacy and social arithmetic problems using familiar contexts (D’Ambrosio, 2006). Research also supports the idea that using real-world cultural contexts can improve students’ interest and understanding in mathematics (Civil, 2010; d’Entremont, 2015).

Designing building activities, especially in creating batik patterns, involve geometric thinking such as symmetry, spatial reasoning, and constructing nets for three-dimensional shapes. When artisans draw batik motifs or prepare cube nets for decoration, they perform actions very similar to those taught in school geometry. These activities show how culture can offer rich sources of mathematical structure (Sunzuma & Maharaj, 2019). Teaching geometry through cultural artifacts helps students understand abstract concepts through visual and hands-on learning (Prahmana & D’Ambrosio, 2020), making mathematics more inclusive and meaningful.

Batik Pendekar Madiun city motif can be integrated in mathematics concept, especially in the material of triangular flat shapes and transformation geometry. *Batik* is one part of Indonesian culture that not only has beauty value, but also provides an opportunity to learn the concept of flat shapes and geometry. The results of this study reinforce previous research conducted by Harahap and Mujib (2020) stated that the use of *batik* motifs in learning geometry is very relevant because *batik* motifs often contain complex geometric shapes, such as triangles and symmetrical patterns, that can be explained through the principles of geometry. This shows that through *batik* motifs, students are able to learn simple forms of geometry, such as triangles.

Batik Pendekar Madiun city is one of the *batiks* that has a triangular design as its element. This type of *batik* relies on the triangle shape in making symmetrical and structured patterns (Irawan et al., 2022). In addition to the triangular flat material, the concept of transformation geometry that includes translation and reflection is also found in the motif of *Batik Pendekar*. *Batik Pendekar* relies on transformation geometry to create symmetry that is clearly visible in the motif through translation and reflection (Riyanti & Syafri, 2020). This shows that transformation geometry is not only used in mathematical theory but also applied in art. In addition, it is also possible to teach mathematical concepts in interesting and varied ways, such as ethnomathematics. Ethnomathematics provides a new and broader perspective on how mathematics can be seen as a construction of diverse cultures (D'Ambrosio, 2004).

The use of such geometry is very important as it provides a great opportunity to introduce the concepts of transformation geometry (Pradana & Setyawan, 2019). Therefore, by observing the patterns in *Pendekar batik*, students can more easily understand how translation and reflection occur in everyday life and not just math theory. On the other hand, *batik* also helps link math learning with local culture. The use of *batik* in mathematics learning provides a cultural dimension that can enrich students' understanding of mathematical concepts, such as geometry and transformation (Suryana & Hidayah, 2020). Cultural integration in mathematics learning, such as *batik*, can help students see the direct relationship between the mathematical concepts taught and their application in everyday life. These mathematical concepts can be used as learning resources in learning (Masruroh et al., 2025). Thus, it is through ethnomathematics that serves as a bridge between culture and mathematics education that allowing students to see the connection between mathematical concepts and cultural contexts (Sriraman, 2007).

By utilizing *batik*, students can learn about the connection between mathematics and culture. *Batik* combines art and math, where the concept of transformation geometry is found in *batik* patterns to teach math. This shows that ethnomathematics has a positive impact beyond helping students understand the material of triangular flat shapes and transformations, but introduces local culture that enriches math learning. Thus, it can increase student engagement and make math learning more meaningful (Powell & Frankenstein, 1997).

The anthropological aspects in the context of ethnomathematics reflect how cultural values, social practices, beliefs, and local symbols not only serve as a background but actively shape the mathematical meanings within a community's daily life (Rosa & Orey, 2021). In Madiun City, cultural elements such as *batik*, culinary traditions, and traditional martial arts provide tangible expressions of this cultural-mathematical construction. Madiun *silat* movements, for instance, embody symbolic meanings that represent stability and firmness of life principles, while evasions reflect the wisdom of prioritizing harmony over confrontation concepts deeply aligned with mathematical principles like translation and reflection. The stance, for example, symbolizes stability and firmness of life principles, while the evasion reflects wisdom in dealing with conflict, prioritizing harmony over confrontation (Effendy, 2017; Abdullah & Ismail, 2010).

Batik Pendekar Madiun, through its combination of *Pendekar*, *pecel*, and *truntum* motifs, visually narrates values such as strength, community simplicity, and unconditional familial love. The truntum motif, arranged in repetitive star-like patterns, exemplifies geometric concepts such as translation and reflection. Created by *Kanjeng Ratu Kencana*, truntum symbolizes loyalty, sincerity, and unconditional love, especially in parent-child relationships (Soebandono, 2021).

Even the process of preparing *pecel* Madiun involves mathematical thinking, measuring portions, organizing spatial composition, and balancing side dishes. Dishes such as spinach, *kale*, *bunga turi,* and *sambal kacang,* typical of Madiun show how people utilize nature wisely (Setyaningrum & Fadli, 2022). The practice of serving them involves the skills of measuring proportions, organizing serving patterns, and arranging the composition of side dishes in a balanced manner, all of which reflect a mathematical structure based on life experience (Wibowo, 2021; Gembong et al., 2022).

These practices prove that mathematical ideas do not exist solely within formal education, but are deeply embedded in cultural expressions and everyday life, forming part of the community's identity and intellectual heritage. In an ethnomathematics perspective, all these elements prove that mathematics not only lives in the classroom, but also grows in *batik*, food, and silat movements, becoming the identity and intellectual heritage of local communities (D'Ambrosio, 2006; UNESCO, 2019; Rudolf & Sari, 2020).

This study presents a novel contribution to the field of mathematics education by uncovering the mathematical practices embedded in the *Batik Pendekar* Madiun City through the lens of ethnomathematics. While previous research has generally explored ethnomathematical elements in Indonesian *batik* (Agasi & Wahyuono, 2019; Prahmana & D'Ambrosio, 2020; Harahap & Mujib, 2020; Irawan et al., 2022; Ulum, 2018; Wulandari & Suryadi 2021; Yolanda & Putra 2022). This study distinguishes itself by offering a comprehensive analysis that integrates mathematical activities, measuring, counting, and spatial design with anthropological and cultural insights. Specifically, the study demonstrates how everyday practices in batik making, such as measuring cloth, calculating resources and profits, and designing symmetrical patterns, align with formal mathematical concepts like geometry, transformation, and numeracy. Furthermore, the integration of local cultural elements such as *silat* movements and culinary practices expands the scope of ethnomathematics to include cultural identity and values, thereby strengthening the pedagogical relevance of mathematics learning.

Conclusion

This study has revealed that *Batik Pendekar* Madiun city is rich with mathematical activities that emerge organically from its traditional production process. The activities of measuring cloth dimensions, counting the required amount of dye, and designing motifs demonstrate the real-life application of mathematical thinking. By identifying and analyzing these activities, the study emphasizes the value of connecting everyday cultural practices to school mathematics to enhance contextual learning and engagement.

The study also uncovers various mathematical concepts embedded in *batik*-making, particularly those related to geometry. The use of symmetrical patterns, triangular shapes, and transformation geometry (translation and reflection) in *Batik Pendekar* demonstrates how abstract mathematical ideas are concretely applied in art and design. These findings validate prior research suggesting that traditional art forms can serve as effective tools for teaching geometry and spatial reasoning. Thus, *batik* can be used not only as an aesthetic medium but also as a pedagogical resource to help students learn mathematical concepts in a more meaningful and culturally relevant way.

Beyond mathematics itself, this research highlights the anthropological aspects that shape and are shaped by mathematical meaning in the community of Madiun. Cultural values, such as strength, harmony, loyalty, and simplicity, are embodied in the *Pendekar*, *pecel*, and *truntum* motifs, reflecting the integration of mathematics with cultural identity. The inclusion of *silat* movements and local culinary traditions demonstrates how mathematical thinking extends into the physical and social dimensions of daily life. In this way, the study affirms that mathematics is not merely a school subject but a living knowledge rooted in the practices, beliefs, and values of a community, as envisioned by the ethnomathematics framework.

While this study provides valuable insights into the integration of mathematical activities, concepts, and anthropological aspects within the cultural artifact of *Batik Pendekar* Madiun City, several limitations should be acknowledged. First, the scope of the study was restricted to a qualitative exploration of selected *batik* motifs and cultural practices, which may not comprehensively represent the full diversity of mathematical ideas embedded in other regional *batik* traditions. Second, the data collection relied primarily on observation and document analysis, with limited direct involvement from artisans or local community members, which may have constrained the depth of cultural interpretation. Third, the focus was predominantly on geometry and arithmetic concepts, which might have overlooked other branches of mathematics, such as algebra or statistics, potentially present in batik-related activities. These limitations suggest the need for further studies with broader sampling, participatory methods, and interdisciplinary perspectives to strengthen the generalizability and cultural depth of ethnomathematical research in Indonesia.

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Conflicts of Interest

The authors declare no conflict of interest regarding the publication of this manuscript. In addition, the authors have completed the ethical issues, including plagiarism, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies.

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Author Contributions

Ika Krisdiana: Conceptualization, writing - original draft, editing, and visualization; **Titin Masfingatin:** Writing - review & editing, formal analysis, and methodology; **Wasilatul Murtafiah:** Validation and supervision; **Febriana Nor Fadhilla:** Writing - review & editing; **Gerald dG.Mabuti:** Writing - review & editing

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