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PRESERVING HERITAGE THROUGH MATHEMATICS: AN ETHNOGRAPHIC EXPLORATION OF GEOMETRY PRINCIPLES IN BATIK CEPLOK SOGAN SOLO MOTIF

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Abstract: Batik Ceplok Sogan Solo is one of the traditional batik motifs that has a distinctive golden brown color produced from natural dye of soga tree bark (*Peltophorum pterocarpum*), but it is less known by the younger generation. Therefore, the integration of batik in mathematics learning is one of the strategies to introduce the batik culture. This research aims at mathematical concepts such as geometry, algebra, arithmetic, and statistics in solo ceplok sogan batik motifs. This research uses qualitative ethnography. The subject of this research is the Solo Ceplok Sogan batik motif. Data validity was obtained through source triangulation, while data analysis included reduction, presentation, and conclusion drawing. The exploration process was carried out by answering four main questions, namely "where do I start looking?", "How do I find it?", "How do I recognize that it has found something significant?", and "How do I understand what it is?". The results show that of the four math concepts, only one, geometry, was found in this batik. Sub-concepts of flat geometry (quadrilateral and circle), and sub-concepts of plane geometry (congruence and straight line segment), as well as sub-concepts of transformation geometry (dilation, reflection, and translation). These findings can be integrated into mathematics learning through the development of ethnomathematics-based assessments oriented towards High Order Thinking Skills.

Keywords: batik ceplok sogan; math concepts; ethnomathematics

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Introduction

Indonesia has an abundant cultural heritage as it covers a vast area from Sabang to Merauke. According to the Indonesian Central Bureau of Statistics, in 2024, there will be more than 300 ethnicities and 1,340 tribes in Indonesia (Badan Pusat Statistik Indonesia, 2024). This diversity gave birth to Indonesian culture, which includes traditional houses, traditional ceremonies, traditional clothing, traditional dances, traditional musical instruments and songs, traditional weapons, and even a variety of special foods. This culture has a role and function as the identity of the nation's personality over time and the transition from era to era. One of Indonesia's cultures that became an intangible cultural heritage and was recognized by UNESCO in 2009 is batik (Candra *et al*., 2024). This recognition emphasizes the importance of the techniques, symbolism, and culture associated with batik cloth in the lives of Indonesians (Evita *et al*., 2022). Batik is a traditional textile art form originating from the island of Java,

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Indonesia, which is made with a color-painting technique using wax to form a pattern on the fabric before dyeing (Habibie *et al*., 2023). Since the recognition of batik by UNESCO, batik has become increasingly recognized by the world community. It is even present at international events, such as the 2015 Asia-Africa Conference and the 2022 G20 Summit, where batik is used as souvenirs and featured in art performances, and is recognized as a cultural symbol that strengthens diplomatic relations between participating countries (Kemensetneg, 2022; Yuniar, 2015).

In Indonesia itself, batik is used as part of the national identity (Febriani *et al*., 2023). Batik is used in various formal and non-formal occasions, such as traditional ceremonies, weddings, and work uniforms in government agencies and schools (Hakim, 2018; Musman & Arini, 2011). One of the batik motifs used in the event is the Ceplok Sogan Solo batik motif. Based on an interview with Mrs. Nita, a batik expert from Kauman Batik Village in Surakarta, the difference between the solo ceplok sogan batik motif (Figure 1) and other ceplok batik motifs, such as ceplok bunga batik (Figure 2) and ceplok sriwedari batik (Figure 3) lies in the flower motif and the colors used. This batik motif has a characteristic that is shaped like a rhombus and resembles flower petals. Batik ceplok flower motifs often look like hibiscus or lotus flowers and use soft colors. Meanwhile, the ceplok sriwedari batik motif is more delicate and complex, and sometimes there are elements of flora and fauna or puppet ornaments using colors other than soga. Furthermore, according to an interview with Ibu Nita, a batik expert as well as a batik craftsman and designer in Kauman Batik Village, Surakarta, among the various existing ceplok motifs, the Solo Sogan ceplok is the only motif that retains the traditional color of the soga tree. The uniqueness of this batik motif certainly needs to be preserved through the introduction of the younger generation as early as possible. One way of introduction is through the education sector, where this batik motif can be assimilated into student subjects, for example, through learning mathematics with an ethnomathematics approach.

Figure 1. Batik Ceplok Sogan Solo

Figure 2. Batik Ceplok Bunga

Figure 3. Batik Ceplok Sriwedari

Batik Ceplok Sogan Solo

Batik Ceplok Sogan Solo is one of the traditional batik motifs originating from Surakarta, Central Java, Indonesia. Historically, this motif began to develop during the Islamic Mataram Kingdom, especially in the Surakarta Sunanate (Elliott & Brake, 2004). During the Dutch colonial period, Surakarta's production of Sogan ceplok batik expanded and became popular among the general public. Nevertheless, Sogan's distinctive motifs and colors are still maintained as a symbol of the noble Javanese culture.

According to an interview with Mrs. Nita, a batik expert from Kauman Batik Village in Surakarta, the ceplok Sogan batik motif is known for its distinctive golden brown color produced from the natural dye of soga tree bark (*Peltophorum pterocarpum*). This is in line with the opinion of Soemantri (2020), who said that the soga tree bark produces the golden brown color that characterizes Batik Ceplok Sogan.

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Mrs. Nita added that this color symbolizes simplicity and closeness to nature, while reflecting the majestic value and local wisdom of the Javanese people. The combination of the symmetrical geometric motif and the natural sogan color makes this batik look elegant and meaningful. In form, Sogan ceplok batik motifs refer to geometric patterns inspired by flowers, stars, or other symmetrical shapes (Kerlogue & Sosrowardoyo, 2004). Figure 4 shows the motif of Batik ceplok sogan Solo.

Figure 4. Motif of Batik Ceplok Sogan

Furthermore, Sogan ceplok batik has a vital role in the surrounding community. According to Ms. Nita, this batik is used as traditional clothing by the royal family, nobles of the Surakarta Palace, as well as kyais or figures who are respected for their influence in society. In addition, Sogan ceplok batik is also often worn in traditional ceremonies, such as weddings, siraman, and other palace processions (Ramelan, 2021). Based on interviews with batik experts, this batik also has a role in various religious activities. For example, in the study of the spread of Islam, ceplok Sogan batik was chosen because it is believed to bring blessings and protection.

Given the importance of ceplok sogan batik as explained earlier, it is only right that the younger generation have a good understanding of this motif and help preserve it. However, the actual situation on the ground reveals a different picture. According to the batik expert's experience, a large number of students were unfamiliar with ceplok sogan batik. They cannot distinguish which ones include ceplok sogan batik and which ones do not. In fact, some students feel less confident when wearing batik because they think it is outdated. This state is certainly worrying, considering that batik is not merely a patterned cloth, but also part of the cultural identity that needs to be conserved. Therefore, batik conservation efforts, especially ceplok sogan batik, are significant in ensuring that this cultural heritage is preserved and recognized by the younger generation. One way that can be applied is by integrating it into the school curriculum. Through this integration, students can identify and understand cultural values in various disciplines. Several subjects, one of which is mathematics, can be used for this integration, for example by linking batik patterns in learning geometry, transformation, algebra, or other mathematical concepts. Thus, students not only learn mathematical concepts in the abstract, but also see their application in local culture. In this context, learning mathematics using an ethnomathematics approach to teach the relationship between ceplok sogan batik patterns and mathematical concepts, thus not only preserving cultural heritage, but also improving students' understanding of the subject matter.

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Ethnomathematics

The interdisciplinary topic of ethnomathematics examines the connection between mathematics and culture, particularly how various social groups comprehend, use, and evolve mathematical ideas within their cultural environment (Kusuma *et al*., 2024). The term was introduced by D'Ambrosio (1985) as an attempt to recognize the diversity of mathematical ways of thinking outside the Western mathematical tradition. Ethnomathematics includes not only traditional number systems, geometry, and measurement, but also everyday practices such as weaving patterns, architecture, games, and rituals that contain mathematical principles. According to Ascher (1991), ethnomathematics helps uncover "hidden mathematics" in non-Western cultures, while Ishartono & Ningtyas (2021), the study of ethnomathematics looks at how cultural customs and mathematical learning processes interact. Rosa & Orey (2011) emphasize its role as a pedagogical approach that makes mathematics learning more relevant to students from different cultural backgrounds. Barton (1996) argues that ethnomathematics broadens the definition of mathematics to include local knowledge. D'Ambrosio (2021) also sees ethnomathematics as a tool for social justice, promoting inclusivity in mathematics education. Furthermore, by identifying universal mathematical tasks like counting and measuring that are present in all cultures, Lipka *et al*. (2005) demonstrated that including ethnomathematics into the curriculum improved Indigenous students' participation.. Thus, ethnomathematics not only enriches mathematical understanding academically but also serves as a bridge between formal knowledge and local wisdom, supporting a more equitable and culturally-centered education. This study examines the mathematical ideas included in Solo ceplok sogan batik motifs using an ethnomathematics technique. The findings can be utilized to introduce ceplok sogan batik as a cultural treasure. Mathematics learning becomes more relevant to real contexts and meaningful, while fostering students' appreciation for the art of batik.

Previous Researches

Many previous studies have examined mathematical concepts in batik. Some of them are research conducted by Ervinawati (2019) examining the mathematical concepts in Tuban gedog batik. Prahmana & D'Ambrosio (2020) examined the mathematical concepts in typical Yogyakarta batik. Faiziyah *et al*. (2021) examined the mathematical concepts in typical Surakarta batik. Ishartono & Ningtyas (2021) studied the mathematical concepts in Surakarta Sidoluhur Batik. Permita *et al*. (2022) examined the exploration of mathematical concepts in batik gringsing motifs. Rahmasari & Mutijah (2023) studied the mathematical concepts in batik saung baswet Banyumas. However, none of these previous studies have specifically examined the mathematical concepts in Solo Ceplok Sogan Batik. This shows the need for in-depth research to reveal the mathematical concepts in the Batik Ceplok Sogan Solo motif. The findings of this study are expected to introduce Batik Ceplok Sogan as a cultural heritage through mathematics learning at various levels of education. They can help teachers present mathematics materials in a more contextualized manner based on local culture.

Based on this description, this research formulates the main problem of identifying mathematical concepts contained in Batik Ceplok Sogan. In more detail, the objectives of this study are to: (1) describe the methodology of exploring mathematical concepts in Batik Ceplok Sogan, and (2) explore various mathematical concepts contained in the Batik Ceplok Sogan motif.

Method

This research uses a qualitative approach with an ethnographic type; ethnography is a qualitative research design that involves an in-depth study of the cultural context to produce insights that can inform, reform, and change society (Qutoshi, 2024). Furthermore, ethnographic studies begin with a focus on answering four main questions: "Where do I start looking?", 'How do I find it?', 'How do I recognize that it has found something significant?', and 'How do I understand what it is?' (Prahmana &

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D'Ambrosio, 2020). Based on these four general questions, the ethnographic design in this study is presented in Table 1.

Table 1. Research Design

Questions	Preliminary Answer	Detailed Point	Specific Activity
Where do I start looking?	The observation starts with an analysis of the location of Solo Ceplok Sogan Batik.	Culture	Conduct interviews with batik experts.
How do I find it?	Directly examining the motif of Batik Ceplok Sogan Solo.	Alternative Thinking	Analyzing the motif of Batik Ceplok Sogan Solo.
			Finding out which mathematical ideas are present in the Batik Ceplok Sogan Solo motifs.
How do I recognize that it has found something significant?	Evidence (results) of alternative thinking is processed first.	Philosophy of Mathematics	Determining which mathematical ideas are included in the Batik Ceplok Sogan Solo motifs.
			The motifs found in Batik Ceplok Sogan Solo contain mathematical concepts.
How to understand what it is?	Important for culture and mathematics	Anthropology Methodology	Explain how two knowledge systems- mathematics and culture- are related.
			Explain the Batik Ceplok Sogan Solo motif's mathematical concept.

Data collection was conducted from February 28 to March 10, 2025, in a number of areas in Surakarta, such as Kauman and Laweyan batik villages. The object of this research is the mathematical concept in Batik Ceplok Sogan Solo, with reference to the four main areas of mathematics: geometry,

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algebra, arithmetic, and statistics (Rubenstein & Schwartz, 1999). The subject of this research is Batik Ceplok Sogan Solo.

This study uses qualitative data. Techniques for documentation, interviews, and observation were used to gather data. The study approach and batik motifs were documented, mathematical principles in Solo Sogan ceplok Batik were observed, and semi-structured interviews were used to validate observation data. The interview subjects involved four mathematics experts with doctoral degrees from a private university in Indonesia, each specializing in geometry, arithmetic, algebra, and statistics, who analyzed four different concepts in Solo ceplok Batik.

Especially in the interview technique, the researcher used the help of a semi-structured interview instrument. Two elements made up the instrument: 1) whether solo batik Ceplok Sogan contains mathematical principles, and 2) whether it can be utilized as a setting for teaching mathematics (geometry, algebra, arithmetic, and statistics). Then, the instrument has been validated by two experts in the field of mathematics and mathematics education and declared valid.

The data analysis process was carried out through three methodological stages according to Saldana (1994): data reduction, data presentation, and conclusion verification. Researchers conducted data analysis based on their understanding of mathematics and Batik Ceplok Sogan Solo to determine whether mathematical principles were included in Batik. In addition, the analysis's findings were validated by specialists as part of a data validity test (triangulation of data sources).

Results and Discussion

Where do I start looking?

The first step in this inquiry is to locate the Ceplok Sogan batik. In Kauman Batik Village Surakarta, specifically on Jalan Trisula III No.1, Kauman, Pasar Kliwon District, Surakarta City, Central Java, the researcher was able to locate the batik at last. There, the researcher interviewed the batik expert on the left (Figure 5) to explore more detailed information about the philosophy of Batik Ceplok Sogan, including its history, motif characteristics, symbolic meanings, and functions. The findings of this interview have been presented in the introduction of this article. Not only that, researchers also documented samples of Batik Ceplok Sogan motifs for further analysis in this study.

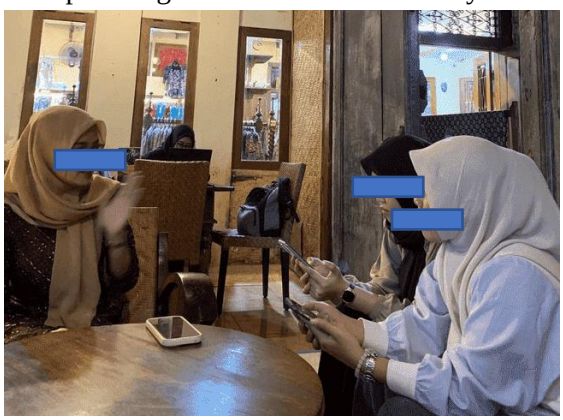

Figure 5. Interview with a batik expert of Kauman village

According to the findings of the interviews conducted with the Batik Ceplok Sogan sample for this study, it is a typical Surakarta Ceplok batik, which is distinguished by a dark or black background. The central motif of this Ceplok Sogan batik is the flower motif (bolded red), while the star and circle motifs are only complementary motifs to fill in the gaps in the batik.

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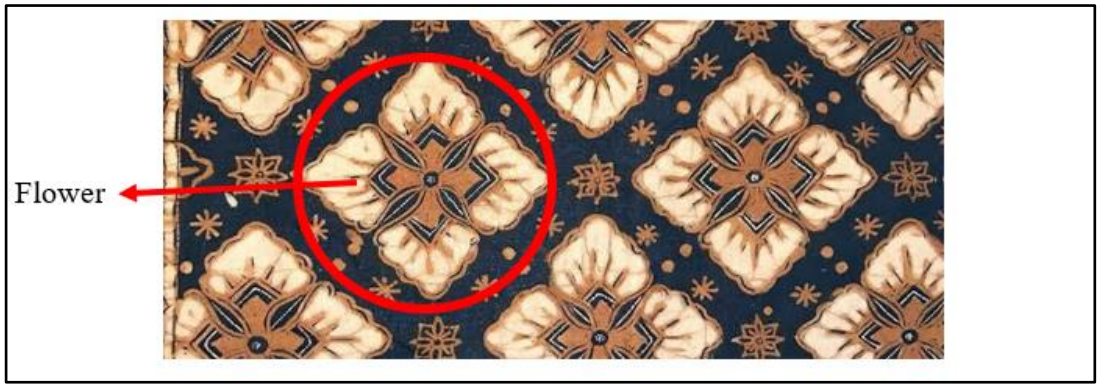

Figure 6. Primary Motif of Batik Ceplok Sogan Solo

How do I find it?

The researchers then noted the mathematical ideas present in the chosen Batik Ceplok Sogan motifs. Researchers, comprising four individuals, then examined the connection between the discovered mathematical concepts and the batik motif. A summary of the researcher's observations can be seen in Table 2.

Table 2. Identification of Mathematical Concepts by Researchers

Concepts	Existence of Concept	Sub Concepts	Topics
Geometry	Yes	Geometry of flat shapes	Quadrilateral Circle
		Geometry Transformation	Dilation Reflection Translation
		Plane Geometry	Congruence Line Segment
Algebra	No	-	-
Arithmetic	No	-	-
Statistics	No	-	-

How do I recognize that it has found something significant?

Based on the initial analysis related to mathematics concepts as presented in Table 2, only one mathematics concept was found in Batik Ceplok Sogan Solo, namely the idea of geometry. From this concept, there are six mathematical sub-concepts, namely the sub-concepts of flatness, congruence, straight line segment, dilation transformation, reflection, and translation.

a. Geometry of flat shapes

1) Quadrilateral

Based on the author's analysis, there is a sub-concept of flat geometry found in Solo Ceplok Sogan Batik, namely the quadrilateral, as shown in Figure 7. Figure 7 clearly displays a geometric structure consisting of quadrilateral flat shapes with perfect square characteristics. This is because this batik motif, which is in the shape of a flower, is designed with four sides that are symmetrical and have identical lengths, as indicated by the blue arrow lines in the figure. In addition, the four corners form right angles (90 degrees) of uniform size, as noted in the yellow arc symbol. This finding is in line with previous research that found the concept of quadrilateral (Nadjib, 2018).

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Figure 7. Quadrilateral

2) Circle

The topic of geometry is found in Batik Ceplok Sogan shown in Figure 8, especially the circular flat shape resembling a flower pistil in the middle marked with a yellow circle, because it fulfills the definition of a circle, which is a flat shape formed from a collection of points that are equidistant from one center point. This same distance is called the radius of the circle. In addition, the flat shape also fulfills the characteristics of a circle in general, namely having no corner points, having infinite folding symmetry and rotary symmetry, and having a diameter line that divides the circle into two equal parts. The concept of flat geometry was also found by Harahap & Mujib (2022) when exploring ethnomathematics in Medan batik motifs, and Permita *et al*. (2022) when examining the Gringsing batik motif.

Figure 8. Circle

b. Plane Geometry

1) Congruence

Another geometry sub-concept is also found in this batik, namely the sub-concept of congruence, as shown in Figure 9. The sub-concept of congruence in batik motifs fulfills the requirements of two or more flat shapes that have congruent properties, namely, the corresponding sides are the same length, and the corresponding angles are the same size. As seen in Figure 9, the flat motifs have sides that correspond to the same length (see blue line). Likewise, the corresponding angles are equal (see yellow arc) (Cummins *et al*., 2005). In addition, one way to show that in this batik motif is the concept of

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congruence, which is that the sketch/motif made is then given treatment or action, for example, mirrored, shifted, or rotated. With this process, another batik motif can be obtained in another position that has the same size and shape as the original batik motif.

Figure 9. Congruence

2) Line Segment

The motif in Ceplok Sogan Solo batik in Figure 10 shows the geometry of the straight line segment field. This batik has a motif that resembles a line segment marked in red. Rizki (2018) explains that a straight line segment is part of a straight line that has two clear and infinite endpoints. In everyday life, line segments are also called line segments. This is because straight line segments fulfill the elements or characteristics that have been determined as straight line segments, namely having a certain length, having a clear starting point and end point, can be measured in length, and consist of straight lines connecting two points. This is what distinguishes it from a straight line, which has the characteristics of extending indefinitely in both directions.

Figure 10. Line segment

c. Geometry Transformation

1) Dilation

In addition to the two sub-concepts above, the geometry of dilation transformation is also found in Solo Ceplok Sogan Batik. Lubis & Yanti (2018) revealed that dilation is a transformation that changes the size of geometric figures, such as enlarging or reducing, without changing their shape. Note that the batik motif is contained within the rectangular flat shape. If this motif is initialized as object “a”, then dilated based on a particular scale, it will get object “a', which is a motif that is congruent, but has a smaller size.

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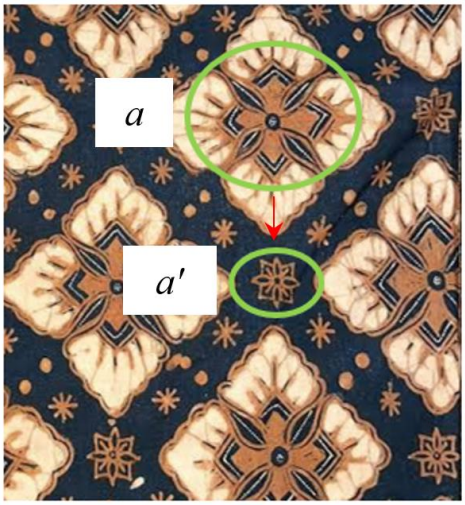

Figure 11. Dilation

2) Reflection

The geometry transformation sub-concept of the reflection of Ceplok Sogan Solo batik is shown in Figure 12. Sihombing *et al*. (2024) explain that reflection is a transformation that moves each point on the plane by using the mirror image properties of the points to be moved. As an explanation, connect the center point contained in the quadrilateral motif, and a "y" line will be formed. This line will act as a reflector (mirror). By taking motif "a" as the object reflected by line "y", the same object is obtained, namely -a'-. Similarly, by taking motif "b" as the object reflected by line "y", the same object is obtained, namely -b'-.

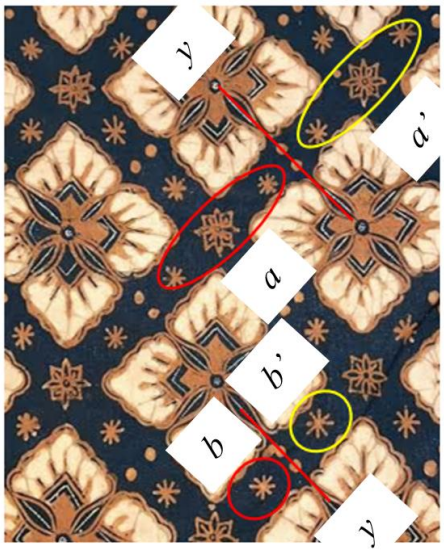

Figure 12. Reflection

3) Translation

The translational geometry transformation sub-concept is shown in Figure 13. The explanation of the translational geometry of the motif is explained by citing the reason for that translation (Berg et al., 2008).:

"The translation is a geometric transformation that moves every point of a figure or space by the same distance in a given direction."

With the above explanation, the batik motif in the green circle can be translated to a new position with a certain distance, namely the motif in the yellow circle. Similarly, the batik motif in the yellow

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circle can be translated into a motif in the red circle with a certain distance. Furthermore, the batik motif in the red circle can be translated into a motif inside the blue circle with a certain distance. With the same concept, the batik motif in the blue circle can be translated into a motif inside the green circle.

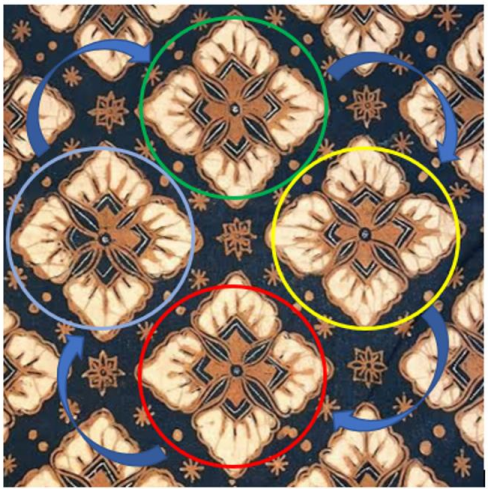

Figure 13. Translation

How to understand what it is?

By contrasting the researcher's presumptions about the mathematical ideas in Solo Sogan Batik ceplok, as shown in Table 2, with the viewpoints of specialists in geometry, algebra, arithmetic, and statistics, a data source triangulation procedure was conducted in an attempt to assess the reliability of the data. In order to compare the author's findings with the expert's opinion, the triangulation process is conducted through the walkthrough interview approach, in which the author speaks with the expert directly (Fitri & Prahmana, 2020). The experts are asked two basic questions: first, whether the context of Batik Ceplok Sogan Solo can be used to teach mathematics, and second, whether they have an opinion on the mathematical concepts in batik (this is to verify whether the mathematical concepts they discovered are the same as those found by the author).

When asked directly by the geometry expert, geometry was the first notion to be verified. of response to the first query, the expert shares the researcher's perspective on the mathematical ideas of Solo Sogan ceplok batik, particularly with reference to the subconcept of flat geometry. This agreement was found in the topics of a quadrilateral (Figure 7) and a circle (Figure 8). Then, congruence is found in the plane geometry subconcept, namely on the topics of congruence (Figure 9) and straight line segments (Figure 10). In addition, conformity is also found in the transformation geometry subconcept, namely on the topics of dilation (Figure 11), reflection (Figure 12), and translation (Figure 13).

Based on the analysis of mathematical concepts as well as the results of confirmation from experts, the ceplok sogan batik motif contains three subconcepts in geometry, namely flat geometry, transformation geometry, and plane geometry. In flat geometry, two topics were found, namely the quadrilateral and the circle. Then, in the geometry of transformations, three topics were found: reflection, translation, and dilation. Then, in plane geometry, the issues found were congruence and straight line segments. However, in the analysis conducted, no connection was found between the ceplok sogan batik motif and the concepts of algebra, arithmetic, or statistics.

Furthermore, to answer the second question, geometry experts argue that batik ceplok sogan can be used in real context-based mathematics learning because there are subconcepts of flat geometry, transformation geometry, and plane geometry that can support learning. Experts argue that in flat geometry and geometry of transformation, teachers can visualize one of the objects of batik ceplok sogan motifs using GeoGebra learning media in line with the research of Mollakuqe *et al*. (2021) which shows that GeoGebra has the advantage of displaying visual representations of mathematical concepts, which

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allows students to understand flat buildings and geometric transformation abstractions more realistically and easily. Then, in plane geometry, geometry experts argue that teachers can utilize the ceplok sogan batik motif to introduce the concept of congruence and straight line segments. For example, in learning activities, students can be invited to explore and find lines of symmetry in the batik motif.

Furthermore, the Batik Ceplok Sogan motif does not show any connection with the concepts of algebra, arithmetic, or statistics. Therefore, experts state that this motif is not suitable to be used as a learning context in these three areas of mathematics. This is in line with D'Ambrosio's opinion that the existence of mathematical concepts in cultural products is natural, not forced. This means that when a cultural product does not contain certain mathematical elements, then the product should not be compelled as a medium for learning mathematical concepts that do not exist in it.

The implementation of the research findings in Mathematics Instruction

The deepening of mathematical concepts in the Ceplok Sogan batik motif has opened up various aspects of geometry that can be optimally applied in the mathematics learning process. The results of this study have the potential to be used as a basis for developing assessment instruments that carry out the ethnomathematics approach, especially in developing questions with higher-order thinking skills (HOTS), which include cognitive levels C4 (analysis), C5 (evaluation), and C6 (creation). By involving batik motifs in the context of solving math problems, students can learn through real situations that support the strengthening of concept understanding. The following is an example of a HOTS problem that can be given to students.

The basic motif of ceplok sogan has a square-shaped pattern with the center point O(-4,1). One of the motif elements, the flower, is located at coordinates A(-7,-2), B(-1,-2), C(-7,4), and D(-1,4).

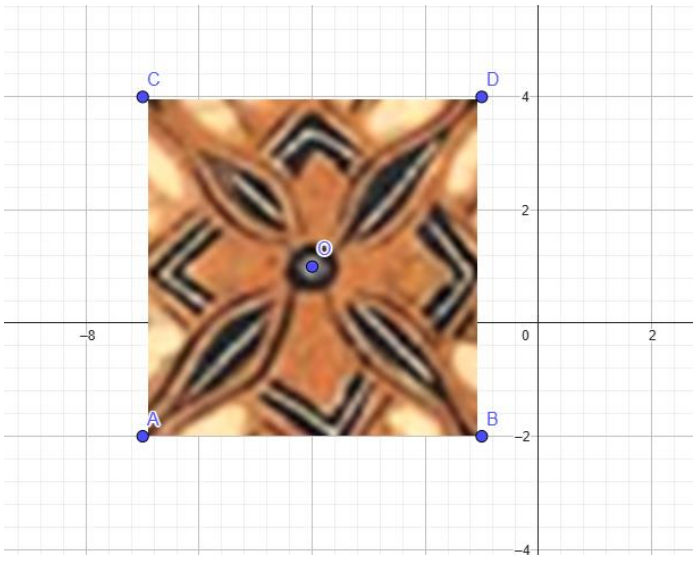

Figure 14. Coordinates of Flower Motif

Mr. Bambang wants to modify the motif by applying the following geometric transformations in sequence: Rotation by 90° counterclockwise about the center point O(-4,1). Dilation by a scale factor of 2 with respect to the center point O(-4,1). A translation of 3 units to the right and 1 unit down. Then answer the following questions:

a. *Find the final coordinates of the flower element after going through the three transformations!*
b. *Analyze how the area of the flower element changes after undergoing the dilation transformation.*

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c. *If Mr. Bambang wants to return the flower element to its original position after the transformation, what geometry transformations does he need to do and in what order?*

This question is designed to test students' higher-order thinking skills (HOTS) at the C4 (Analysis) cognitive level. In this problem, students are required to analyze each step of the given geometry transformation, namely rotation, dilation, and translation, and describe how each transformation affects the coordinates of the flower elements in the batik motif. In addition, in point b, students need to analyze the impact of dilation on the area of the flower elements, which involves understanding the concept of area comparison after transformation.

More than just memorizing formulas, this problem emphasizes the application of transformation geometry concepts in a real context, namely the typical Solo ceplok sogan batik motif. Students need to integrate several ideas at once to solve the given problem. Point C challenges students to think in reverse and devise a series of transformations required to return the flower element to its original position, exercising their problem-solving and logical reasoning skills. Furthermore, this problem relates the mathematical concept to local culture, namely batik, making it more interesting and relevant to students. This helps students realize that mathematics is not just an abstract science, but has practical applications in everyday life, including in art and culture.

Research Limitation

This research has some weaknesses that can be taken into consideration. For one, the study is limited to Solo Batik Ceplok Sogan motifs, so the results may not necessarily apply to other batik motifs that have different philosophical meanings and arrangements. On the other hand, the research data relies on interviews with local artisans and secondary literature, so it may not reflect the perspective of consumers or the younger generation towards the cultural value of Batik Sogan. Furthermore, the research has not been tested in a real teaching-learning activity, so a more in-depth study is needed to evaluate the benefits of integrating this motif in mathematics learning. Therefore, future research needs to include a variety of batik motifs as well as direct classroom trials to measure their effectiveness and applicability more thoroughly.

Conclusion

In an effort to preserve Batik Ceplok Sogan Solo through mathematics learning, it is essential to explore the mathematical concepts that can be extracted from the batik motif through an ethnomathematics approach. This exploration of mathematical concepts uses an ethnographic design, which is based on four main questions, namely “where do I start looking?”, “How do I find it?”, “How do I recognize that it has found something significant?”, and “How do I understand what it is?”. This process began with a visit to Surakarta's Kauman Batik Village to take samples of Solo Ceplok Sogan Batik and explore its philosophical meaning with a batik expert. Next, the researcher analyzed the mathematical aspects of the batik motif. The results of the analysis were then confirmed to the expert as a form of triangulation and an effort to deepen the understanding of the mathematical concepts contained therein. Based on the exploration results, of the four mathematical concepts studied (geometry, arithmetic, algebra, and statistics), only one mathematical concept was found in this batik, namely geometry. Sub-concepts of flat geometry (quadrilateral and circle), and sub-concepts of plane geometry (congruence and straight line segment), as well as sub-concepts of transformation geometry (dilation, reflection, and translation). These concepts can be integrated into mathematics learning, especially in the preparation of assessment instruments that carry out the ethnomathematics approach. This has the potential to develop questions with higher-order thinking skills (HOTS), which include cognitive levels of analysis (C4), evaluation (C5), and creation (C6).

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