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Students' Visual Challenges in Interpreting Geometric Elements in Batik Motifs

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Abstract

Purpose: This study aims to identify and analyze the visual challenges faced by elementary school students in identifying geometric elements in Sukowati batik motifs.
Methodology: Using a qualitative approach with an ethnographic design, data were collected from 12 fifth-grade students at Elementary School in Sragen, Central Java, through visual-based math tests, in-depth interviews, and observations.
Results: The results show that students experience visual challenges in describing geometric shapes, including an inability to distinguish between parallelograms and isosceles triangles, confusion in distinguishing rhombuses from squares, and difficulty in recognizing basic geometric shapes due to overlapping decorative elements and complex ornamental patterns.
Applications/Originality/Value: This study provides a basis for developing locally-based learning strategies by utilizing batik as a contextual medium to improve students' understanding of geometry and visual-spatial competence.

Introduction Section

Elementary school students are generally at the stage of concrete operational cognitive development according to Piaget's theory, where conceptual understanding is still highly dependent on real objects and direct experience (Phon et al., 2019). In this context, when analogized to geometry learning, there will be specific challenges, namely students' difficulty in analyzing the geometric elements in Sukowati batik motifs, which can be examined from three main aspects: visual, cognitive, and cultural. An alternative that can be used is to integrate a contextual and culture-based approach so that students can understand and apply geometric concepts in their daily lives (Murtafiah et al., 2021; Rashaad Shabab, 2024). The contextual approach not only makes learning more interesting, but also encourages students to think critically and creatively in solving problems related to geometry (Ahire et al., 2023), and culture-based learning can increase student engagement, contributing to a deeper understanding and mastery of geometry concepts (Cantillo-Rudas et al., 2024).

Geometric objects can be found in concrete objects inherited from ancestors, such as batik. Batik is a cultural heritage famous in Malaysia and Indonesia, with intricate and delicate decorative styles, created using brush strokes drawn with a slanted tool. The word batik is believed to originate from the Javanese word, a combination of Batik and tritik, with the suffix tik in each word translating to “dots” (Feng et al., 2024). Batik motifs as representations of local culture present complex and sometimes abstract visual forms (Fei, 2022; Nielsen, 2020), where the complexity of overlapping ornaments and patterns can make it difficult for students to recognize basic geometric elements. The basic shapes in batik motifs are often obscured by decorative elements such as curved lines, plant ornaments, and repetitive fillings, making it difficult for students to recognize the geometric structures contained within them. A context-based learning approach and visual case studies can train students to focus their attention on specific geometric elements (Bataller et al., 2022), and the application of visualization and direct observation activities can improve shape analysis skills in elementary school children (Qian et al., 2024).

In addition to visual challenges, elementary school students also face difficulties in connecting concrete shapes with abstract geometric symbols and terms. Students are often able to recognize shapes intuitively, but fail to associate them with mathematical concepts such as angles, symmetry, or perimeter. In this case, a learning approach is needed that provides opportunities for students to manipulate physical objects, helps develop visual images, and gradually reduces explicit visual support (Kholid et al., 2023). These characteristics are possessed by Concrete–Representational–Abstract (CRA) (Gibbs et al., 2018), where a contextual cultural approach supported by a step-by-step method such as CRA can improve students' conceptual understanding, spatial abilities, and retention of geometry material (AL-Salahat, 2022). Research conducted by (PennsylvaniaTraining and Technical Assisstance Network, 2017) shows that the Concrete–

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Representational–Abstract (CRA) approach significantly improves students' accuracy, conceptual understanding, and problem-solving skills, including for students with learning difficulties in mathematics. The application of visualization activities becomes more meaningful when explicitly linking mathematical concepts and local culture (Abay & Parola, 2024; Bassi & Brunetto, 2025), and create an interactive and engaging learning environment for students (Wang, C., Zhang, Y., Ding, H., 2023).

Previous studies have explored ethnomathematics approaches in elementary school mathematics learning by utilizing local cultural contexts, such as traditional Bengkulu houses for measuring length and area (Yumiati et al., 2024), traditional Sundanese games (endog-endogan and engklek) for basic arithmetic operations (Supriadi & Arisetyawan, 2020), as well as the Javanese Tedhak Siten ceremony, which involves time calculations and geometric shapes (Wiryanto et al., 2022). However, these studies focus more on physical activities, tangible measurements, or simple arithmetic operations in the context of local culture (Asmawati et al., 2023). To date, there has been no research specifically examining the challenges faced by elementary school students in identifying and describing the geometric elements in Sukowati batik motifs as a representation of Central Javanese visual art. In fact, batik motifs contain complex geometric patterns that have the potential to be a source of contextual learning for introducing the concepts of flat shapes, symmetry, transformation, and visual-spatial skills. Thus, this study aims to fill the gap in research by understanding the cognitive and visual challenges faced by students in analyzing Sukowati batik motifs, while also expanding the application of the ethnomathematics approach to geometry learning in elementary schools through the context of local cultural arts that are closer to students' daily lives (Kholid, Mahmudah, et al., 2024; Nugraha & Nugraha, 2025).

Geometry learning in elementary school students often faces visual challenges due to limited ability to recognize shapes when presented in complex visual contexts. Batik motifs, including Sukowati batik, have layered ornaments, repeating patterns, and decorative elements that cover basic geometric shapes, making it difficult for students to distinguish them. Previous studies have shown that students often mistake similar shapes, such as squares and rhombuses or parallelograms and triangles, because their focus is distracted by irrelevant visual details (Bataller et al., 2022; Cantillo-Rudas et al., 2024). These difficulties are consistent with the concrete operational stage, in which students still need tangible representations to understand concepts and are not yet able to perform visual abstraction optimally (Garip & Seymen, 2021; Haataja et al., 2024). Therefore, a learning strategy is needed that can direct students' attention to the characteristics of geometric shapes, especially when these shapes are presented in a complex cultural context (Kholid, Santosa, et al., 2024).

In line with these findings, several studies confirm the effectiveness of the ethnomathematics approach and the integration of local culture in mathematics learning. The use of batik motifs as a learning context not only increases student interest and engagement (Gonzales et al., 2025), but also helps them understand abstract concepts through visual experiences that are relevant to everyday life. Studies of culture in geometry show that traditional fabrics contain elements of symmetry, patterns, and transformations that are relevant as teaching materials (Halim et al., 2023; Yumiati et al., 2024). However, research that specifically examines students' visual difficulties in identifying geometric shapes in batik motifs, especially Sukowati batik, is still very limited. Therefore, this research is important to fill this gap, while emphasizing the need for an appropriate visual approach, such as the Concrete Representational Abstract (CRA) model, so that students can recognize geometric shapes more accurately in a context rich in cultural ornamentation.

Previous studies have shown that the ethnomathematics approach is effective in increasing learning interest and conceptual understanding through the use of cultural contexts such as traditional games, traditional rituals, and cultural artifacts based on measurement and arithmetic. However, most of these studies have not specifically examined students' visual difficulties in recognizing geometric shapes in complex patterned works of art such as batik motifs. The novelty of this study lies in the analysis of students' visual challenges in identifying geometric elements in Sukowati batik motifs as a culture-based learning medium. This differs from previous ethnomathematics studies, which generally utilize cultural contexts such as traditional games, traditional rituals, or artifacts based on measurement and arithmetic (Supriadi & Arisetyawan, 2020; Wiryanto et al., 2022; Yumiati et al., 2024), this study specifically examines visual perception errors and difficulties in recognizing flat shapes in complex batik patterns, which have rarely been studied. Thus, this study complements previous studies by strengthening the visual-spatial aspects of ethnomathematics-based geometry learning.

The research questions in this study focus on the challenges faced by elementary school students in identifying geometric elements in Sukowati batik motifs, the types of errors made by students in identifying geometric elements in Sukowati batik motifs, the level of students' mastery of visual and spatial concepts in the context of Sukowati batik motifs, and how local culture-based learning strategies can support students' understanding of geometric concepts. The purpose of this study is to identify and analyze the various challenges faced by elementary school students in identifying geometric elements in Sukowati batik motifs. This study also aims to reveal the types of errors made by students in the process of identifying geometric elements, as well as to examine the level of students' mastery of visual and spatial concepts in the context of batik motif-based learning. In addition, this study aims to examine how learning strategies that integrate local culture, particularly Sukowati batik, can support and strengthen students' understanding of geometric concepts.

Method

This study uses a qualitative approach with an ethnographic design. A qualitative approach with an ethnographic design was chosen because it was in line with the research objectives, namely to reveal in depth the visual experiences of students, forms of misperception, and cognitive strategies in identifying geometric elements in the cultural context of batik. Through ethnography, the researcher was able to trace the challenges students face, which were grouped into three categories, namely: (1) Challenges in visualizing shapes (Bataller et al., 2022), (2) Cognitive challenges in recognizing basic shapes (Cantillo-Rudas et al., 2024), (3) Cultural challenges in understanding the meaning of batik motifs (Rashaad Shabab, 2024). The research subjects were 12 fifth-grade students at Elementary School in Sragen, Central Java, who were selected because at Elementary School in Sragen, Central Javas, students and teachers wear Sukowati batik uniforms and geometry material is relevant to mathematics learning in fifth grade. The research instruments consisted of a test sheet containing visual-based math questions on Sukowati batik motifs, interview guidelines to explore information related to cultural integration and student difficulties, and an observation sheet to record student interactions and strategies when identifying geometric elements in batik motifs.

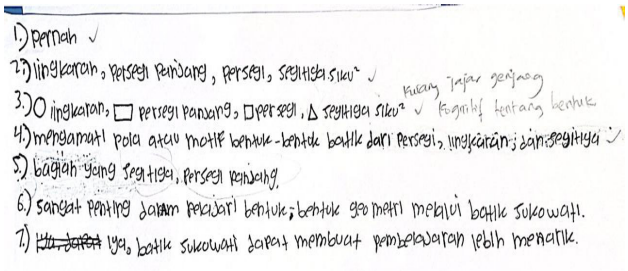
Data collection techniques were conducted through observation, interviews, documentation, and tests in accordance with the research conducted by (Kholid & Husodo, 2025) who researched the concepts of arithmetic and discrete mathematics in Sidomukti Solo batik. Data was collected through visual-based mathematics tests, in-depth interviews using structured guidelines, and direct observation to observe student interactions and strategies. Data analysis in this study was conducted in three stages according to Miles and Huberman, namely (1) data reduction by selecting and focusing on data from tests, interviews, observations, and documentation, (2) data presentation in the form of descriptive accounts of student understanding, challenges faced, and the relationship between geometric elements and batik motifs, and (3) drawing conclusions and verification through data interpretation and consistency of the data obtained (Shodiqin et al., 2020).

Result

Subject 1

The following section presents the results of students' answers in completing visual-based mathematics test questions on Sukowati batik motifs presented in Figure 1.

Original Version



Translated Version

1) yes, I have
2) circle, rectangle, square, right triangle
3) ○ circle, ▭ rectangle, □ square, △ right triangle.
4) observing the patterns or motifs of batik shapes from squares, circles, and triangles
5) the parts that are triangles and rectangles
6) very important in learning geometric shapes trough Sukowati batik
7) yes, Sukowati batik can make learning more interesting

Figure 1. Student 1's Answers

Based on Figure 1, students faced a visual challenge in the second question, "Observe the parts of the Sukowati batik motif. Do you see any geometric shapes in the picture on the side? Name the geometric elements you find (e.g., lines, angles, triangles, squares, etc.),"namely" circles, rectangles, squares, right triangles." Based on the students' answers to the second question, visual challenges were found in describing the geometric shapes of parallelograms and isosceles triangles. In addition, students faced a visual challenge in the third question, "Redraw a small part of the Sukowati batik pattern that you have observed. Write down the names of the flat shapes you find in the picture," namely "circle, rectangle, square, right triangle." The results of the students' answers to the third question show that the students were not yet able to distinguish between right-angled triangles and isosceles triangles, or between rhombuses and squares. The difficulties experienced by the students in completing these two questions show that they still face visual challenges in describing the geometric elements in Sukowati batik motifs.

The results of the mathematics test were reinforced by interviewing Subject 1 with the following questions (1) Which part of the Sukowati batik motif was the most difficult for you to understand in terms of its geometric shape?, (2) Did you experience confusion or difficulty in distinguishing between the batik pattern and the geometric shapes within it?, and (3)

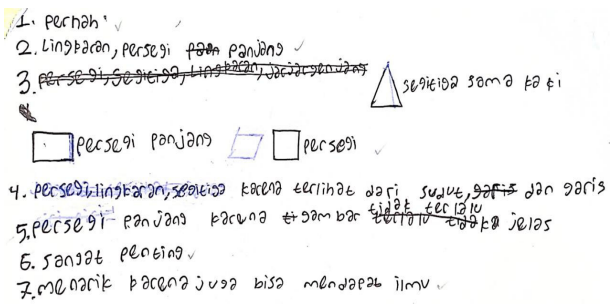
How did you recognize triangles, circles, or squares in the Sukowati batik motif?. The following are the results of the interview transcript with the students

Q1: "In the Sukowati batik motif, which part is the most difficult for you to understand in terms of its geometric shape?"
S1: "The square."
Q2: "Did you experience confusion or difficulty distinguishing between the batik pattern and the geometric shapes within it?"
S1: "Yes, it was difficult and confusing. Because it was difficult to recognize what shape it was."
Q3: "How did you recognize the triangle, circle, or square shapes in the Sukowati batik motif?"
S1: "By understanding the shape first."

Subject 2

The following section presents the results of students' answers in completing visual-based mathematics test questions on Sukowati batik motifs presented in Figure 2.

Original Version



Translated Version

1) yes, I have
2) circle, rectangle
3) △ insoceles triangle, ▭ rectangle, □ square
4) rectangle, circle, triangle because they can be seen from the corners, lines, and sides.
5) rectangle because the picture is not very clear.
6) very important.
7) interesting because we can also gain knowledge.

Figure 2. Student Answers 2

Based on Figure 2, students faced visual challenges in the second question, "Observe the parts of the Sukowati batik motif. Do you see geometric shapes in the picture on the side? Name the geometric elements you find (e.g., lines, angles, triangles, squares, etc.)," namely "circles and rectangles." Based on the students' answers to the second question, visual challenges were found in describing the geometric shapes of parallelograms and squares. In addition, visual challenges were found in the third question, "Redraw a small part of the Sukowati batik pattern that you have observed. Write down the names of the flat shapes that you find in the picture," namely "rectangles, squares, and isosceles triangles." The results of the students' answers to the third question showed that the students were not yet able to identify several flat shapes such as parallelograms and circles because they considered the image to be unclear, so they did not find several overlapping flat shapes. The difficulties experienced by the students in completing the two questions showed that they still experienced visual challenges in describing the geometric elements in the Sukowati batik motif.

The results of the mathematics test were reinforced by an interview with Subject 2 with the following questions (1) In the Sukowati batik motif, which part was the most difficult for you to understand in terms of its geometric shape? (2) Did you experience confusion or difficulty in distinguishing between the batik pattern and the geometric shapes within it? and (3) How did you recognize triangles, circles, or squares in the Sukowati batik motif? The following are the results of the interview transcript with the students

P1: "In the Sukowati batik motif, which part is the most difficult for you to understand in terms of its geometric shape?"
S1: "Parallelograms."
Q2: "Did you experience confusion or difficulty distinguishing between the batik pattern and the geometric shapes within it?"
A1: "Yes, I was confused because the motif and the shapes were mixed together and unclear."
Q3: "How did you recognize the triangles, circles, or squares in the Sukowati batik motif?"
A1: "From the shapes, which refer to flat shapes."

Discussion

Based on interviews with two students, it was found that they still had difficulty understanding the geometric shapes in Sukowati batik motifs, as seen from the differences in the shapes that each student considered most difficult, namely squares (S1) and parallelograms (S2). All three also admitted to being confused in distinguishing between batik patterns and geometric shapes because the shapes are difficult to recognize, mixed with motifs, or appear abstract. This is in line with research conducted by (Fei, 2022) which states that batik motifs as representations of local culture present complex and sometimes abstract visual forms, where the complexity of overlapping ornaments and patterns can make it difficult for students to recognize basic geometric elements. Nevertheless, they have strategies for recognizing geometric shapes, such as observing the basic shapes first (S1) and referring to the characteristics of flat shapes (S2). Overall, the interviews show that students understand basic geometric concepts but still need help when these shapes are applied in complex Sukowati batik motifs, which is consistent with research conducted by (Bataller et al., 2022) states that context-based learning approaches and visual case studies can train students to focus their attention on specific geometric elements.

The results of the observation show that students have difficulty identifying the geometric elements found in Sukowati batik motifs. When working on math test questions, some students appear hesitant in identifying basic shapes such as triangles, squares, parallelograms, and circles that are integrated into batik patterns. Students took a long time to determine the geometric shapes or batik ornaments because the overlapping patterns made the shapes unclear. This is consistent with research conducted by (Cantillo-Rudas et al., 2024) which states that students often mistake similar shapes, such as squares and rhombuses or parallelograms and triangles, because their focus is distracted by irrelevant visual details. Some students asked questions about the questions and the clarity of the shapes. Overall, these observations show that the complexity of Sukowati batik motifs is the main factor that makes it difficult for students to describe and recognize the geometric elements in them.

In addition, analysis of students' mathematics test answers shows that their visual-spatial abilities are not yet optimal when applying geometric concepts to complex batik motifs. Some students still make mistakes when redrawing or identifying shapes due to confusing ornament details. Simpler visual representations are proven to be easier for students to understand than complex motifs, so simplification strategies such as highlighting, shape tracing, and the use of contrasting motifs are needed to make geometric shapes easier to recognize (Kholid et al., 2019).

Conclusion

Elementary school students experience visual challenges when identifying geometric elements in Sukowati batik motifs because the complex patterns often make it difficult to recognize basic geometric shapes. Various errors arise, such as misidentifying flat shapes and inaccuracies in counting sides or angles. This condition shows that students' mastery of visual concepts still needs to be strengthened in the context of abstract and decorative culture. Culture-based learning, particularly Sukowati batik, can be an effective strategy to improve students' understanding of geometric concepts. However, the use of cultural contexts needs to be supported by systematic learning, such as the Concrete–Representational–Abstract (CRA) model, so that students can gradually transition from concrete forms to mathematical abstractions. This study provides a foundation for the development of more effective learning strategies in integrating ethnomathematics into geometry material in elementary schools.

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