Analysis of Geometric Forms in Kawung Batik Motifs Based on Geometric Transformation

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INFO ARTIKEL	ABSTRAK
	Kawung batik motif is one of Indonesia's cultural heritage that is full of philosophical and aesthetic meanings, and shows regular and symmetrical visual patterns. This research aims to analyze the geometric shapes in Kawung motif and identify the types of geometric transformations that form the pattern arrangement. The approach used in this research is descriptive qualitative method with geometric visual analysis technique. Data were obtained through documentation study of Kawung motif, visual observation of the pattern arrangement, and literature study related to geometric transformation theory. The results show that Kawung motifs contain four types of geometric transformations, namely translation (repetition of patterns horizontally and vertically), rotation (rotation of 90° and 180° towards the center point), reflection (reflection on the vertical and horizontal axes), and dilation (variation in the size of motif elements). Folding symmetry and rotating symmetry were also found to be part of the visual structure that reinforces the regularity of the motif. These findings show that the Kawung motif has a mathematical value that can be explained scientifically, in line with the principles of plane geometry. The conclusion of this study confirms that Kawung batik motifs can be utilized as contextual media in mathematics learning, especially for geometry transformation materials. Thus, the integration between local culture and science through this visual approach not only supports meaningful and applicable learning, but also becomes part of the strategy of cultural preservation through education.

INTRODUCTION

Batik is an Indonesian cultural heritage that is rich in philosophical, symbolic, and aesthetic values (Sugiarto et al., 2025). Its existence not only represents visual beauty in the form of ornaments on cloth, but also reflects the worldview, social structure, and cultural identity of the Indonesian people. The process of creating batik through complex techniques, as well as the choice of motifs and colors, shows how strongly art, culture and spirituality are intertwined in this tradition (Afwanni & Pamungkas, 2024). Therefore, batik is not just seen as a textile product, but as a cultural artifact full of meaning and noble values (Widagdo et al., 2021). One of the batik motifs that has a deep historical and philosophical value is the Kawung motif (Wahida & M. Hendra Himawan, 2024). This motif is known as one of the oldest motifs in Indonesia which originated

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from the Yogyakarta palace environment. Visually, the Kawung motif is characterized by a symmetrical arrangement of circles that resemble kolang-kaling fruit or palm seeds. However, the meaning behind this motif goes far beyond its simple form. In Javanese philosophy, the Kawung motif symbolizes purity, self-control, and equanimity, which are important principles in the life of Javanese society (Nimas Ayu et al., 2019; Widayanti & Handayani, 2024). The elegance and simplicity of this motif makes it a symbol of nobility and wisdom, which was once even only allowed to be worn by nobles or palace families (Kautsar et al., 2020).

In the midst of rapid modernization and globalization, preserving batik as a cultural heritage is a challenge (S. Nita Amalia et al., 2025). Changing market tastes and the development of the modern textile industry risk shifting the noble values contained in traditional batik. Therefore, batik preservation efforts need to be carried out not only through hereditary inheritance, but also through scientific and educational approaches that can reveal and strengthen the cultural values contained in it (Wang, 2019). This is important so that the younger generation not only recognizes batik as clothing, but also understands the meaning and cultural heritage attached to it. In its development, batik is not only interesting to study from a cultural and aesthetic aspect, but also holds great potential to be analyzed scientifically, one of which is through a mathematical approach (Siswanto, 2025; Wesnina et al., 2025). Many traditional Indonesian batik motifs, including the Kawung motif, have repeating patterns that are structured and symmetrical, allowing the application of basic concepts in mathematics, especially in the field of geometry (Abidin et al., 2023; Toha et al., 2024). The repetitive patterns, repetition of shapes, and regularity of arrangement in batik motifs reflect geometric principles such as translation (shifting), rotation (turning), reflection (mirroring), and dilation (scaling) (Abd Rahim & Mat Alim, 2021; Daniel et al., 2025; Lyu et al., 2025).

The Kawung motif, for example, consists of circular elements arranged symmetrically and regularly on a flat plane (Repiyan et al., 2023). The visual composition not only creates aesthetic harmony, but also forms a consistent geometric pattern that can be analyzed using the concept of geometric transformation. The arrangement of circles in the Kawung motif often forms a translational pattern that repeats horizontally and vertically, as well as showing rotation and reflection about a particular axis (Wahida & M. Hendra Himawan, 2024). Similarities in size and shape can also be studied through the principle of dilation. This shows that batik motifs are not only works of art, but also store logical and measurable mathematical structures (Ishartono & Ningtyas, 2021). With such patterned and organized visual richness, batik can be utilized as a contextual and locally-cultured mathematics learning medium. This approach allows learners to understand math concepts not abstractly, but through objects that are close to their lives. The utilization of batik as a teaching medium not only brings mathematics closer to cultural reality, but also fosters appreciation for the nation's cultural heritage through a creative and educational approach (Kabuye Batiibwe, 2024; Zuniari et al., 2025).

Although batik has long been recognized as a cultural heritage rich in symbolic and aesthetic values, formal studies linking batik to modern mathematical concepts are still relatively minimal. So far, batik has been studied more from the perspective of history, fine arts, or cultural anthropology, while its scientific potential, especially in the field of mathematics, has not been explored deeply and systematically. In fact, the regular and symmetrical structure of patterns in batik motifs, such as the Kawung motif, shows a close relationship with the basic principles in geometry (Abidin et al., 2023). This condition indicates a gap in scientific documentation that bridges between traditional

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cultural heritage and contemporary scientific approaches. Therefore, an effort is needed to scientifically document and analyze batik motifs, so that local cultural values are not only preserved aesthetically, but also academically. This kind of research will enrich the scientific treasure by presenting a new perspective in understanding Indonesia's cultural heritage, while strengthening the position of local culture in the realm of modern education and research. Thus, mathematical analysis of batik motifs is not only a form of cultural preservation, but also a real contribution to the development of integration between culture and science.

Based on this background and urgency, this research aims to analyze the geometric shapes that appear in Kawung batik motifs, as well as identify the types of geometric transformations that form these patterns, such as translation, rotation, reflection, and dilation. By mathematically analyzing the Kawung motif, this research is expected to show the regularity and logical structure contained in the visual design of batik, while at the same time demonstrating that traditional motifs cannot be separated from scientific principles that can be studied and explained rationally. In addition, this research wants to answer the void of studies that connect local cultural heritage, especially traditional batik, with modern mathematical concepts, which have not been widely developed in the realm of formal research. So far, mathematics learning in schools tends to be abstract and separated from the cultural context of students, whereas integration between local culture and subject matter can provide a more meaningful learning experience. Therefore, this research also aims to contribute to the integration between culture and science, especially in the context of contextualized and local wisdom-based mathematics learning. Hopefully, the results of this research can be one of the references in the development of learning media or pedagogical approaches that combine cultural values and mathematical concepts harmoniously.

METHODOLOGY

This research uses descriptive qualitative method with geometric visual analysis approach. This approach was chosen because the focus of the research lies on describing and understanding the patterns of geometric shapes found in Kawung batik motifs in depth, as well as identifying the types of geometric transformations that make up the arrangement of the motifs. The data in this research was collected through three main techniques, namely documentation study, visual observation, and literature study. The documentation study was conducted by collecting various examples of Kawung motifs from written sources, museums, or digital repositories. Visual observation was used to directly observe the structures and patterns found in the motifs, especially to recognize the basic shapes and geometric arrangements that appear. Meanwhile, the literature study focused on the theoretical study of geometric transformations such as translation, rotation, reflection, and dilation which became the basis for pattern analysis.

The data was analyzed descriptively by mapping the basic geometric shapes, such as circles, symmetry lines, and repeating patterns, found in the Kawung motif. Furthermore, these forms are studied to identify geometric transformations that occur, both in the form of horizontal and vertical translations, rotations to the center point, reflections to certain axes, and dilations to the size of visual elements. The results of this analysis are then interpreted to show how geometric patterns in Kawung batik motifs not only have aesthetic value, but also mathematical structures that can be explained scientifically. This approach is expected to contribute in connecting local cultural heritage with modern mathematical concepts in a contextual manner.

RESULTS AND DISCUSSION
Identification of Geometric Shapes in Kawung Motifs

Based on the observation of a number of examples of Kawung batik motifs obtained from visual documentation and literature sources, it was found that this motif is consistently composed of basic circular shapes, both in the form of complete circles and ellipses. These circles are arranged repeatedly in a symmetrical grid pattern, forming regular vertical and horizontal rows on the batik cloth. Each circular element in the Kawung motif is relatively uniform in size and evenly spaced, forming a visual grid that emphasizes order and symmetry in the motif's structure.

The circle shape as the main element in the Kawung motif not only has a simple and strong visual meaning, but also reflects symbolic meanings in Javanese cultural traditions. The circle symbolizes perfection, purity and equanimity, which are noble values in the Javanese philosophy of life, especially within the palace. The repetition of this shape also gives the impression of harmony and order, which strengthens the spiritual as well as aesthetic impression of the Kawung motif. From a geometric point of view, the repetition of circular shapes in a flat plane shows the characteristics of regular patterns that characterize geometric transformations such as translation and symmetry. These findings show that despite its cultural tradition, the Kawung motif contains a visual structure that can be explained scientifically through basic concepts in plane geometry.
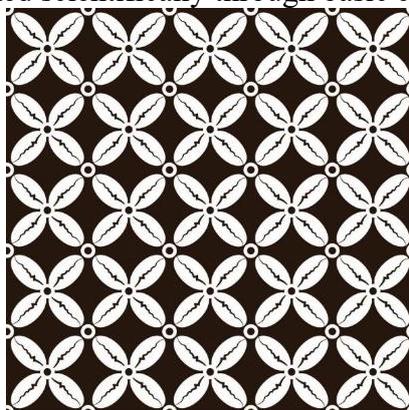
Figure 1: Kawung Batik Motif

Types of Geometric Transformations Found in Motifs

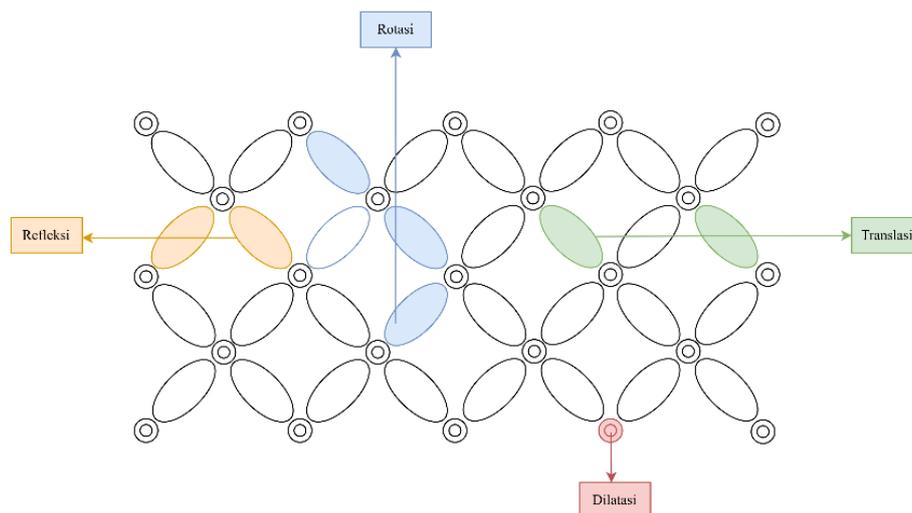(**Sonny Yalti Duma'[1]✉, Lidya Cahyani[2]**)

Figure 2: Geometric Transformation of Batik Kawung

The analysis of the visual structure of the Kawung batik motif in Figure 2 reveals the presence of four types of geometric transformations, namely translation, rotation, reflection and dilation, which are harmoniously integrated in the pattern arrangement. First, translation is identified through the horizontal and vertical repetition of the pattern, where one motif unit moves regularly with a constant distance, forming a regular two-dimensional grid. This translational pattern is a very distinctive form of geometric regularity in the Kawung motif, and forms the basis of the repetition of the overall design. Secondly, there is rotation of the motif units, specifically rotations of 90° and 180°, which occur about the center point of the motif circle. This rotation results in a symmetrical pattern that remains consistent and balanced even when the viewing angle changes.

The third transformation found is reflection, which is the mirroring of the pattern against the vertical and horizontal axes. This reflection is evident from the arrangement of motifs that have identical mirror pairs on the left-right and top-bottom sides of the central axis. This indicates the existence of fold symmetry in the motif pattern, which strengthens the impression of visual order. Finally, dilation is also found, which is a transformation in the form of differences in the size of the circular elements in some versions of the Kawung motif. Despite the change in size, the basic geometric shape is maintained, showing that the Kawung motif can adjust its scale without losing its visual identity.

The existence of these four transformations not only shows the complexity of the Kawung motif's geometric structure, but also emphasizes the relationship between symmetry and aesthetics in batik art. The visual regularity created by the combination of these transformations contributes to the beauty and harmony of the design, and shows that traditional art such as batik holds scientific principles that can be explained mathematically. These findings support the potential use of Kawung batik as a contextual medium in learning geometric transformations in educational settings.

Order and Symmetry as Aesthetic and Mathematical Value

Kawung batik motifs show a high degree of symmetry, both in terms of the basic form and the overall arrangement of the pattern. Visual observation shows that each motif unit composed of four symmetrical ellipses forms a flower-shaped pattern that is consistent and repeats regularly across the field. Symmetry in this motif includes folding

symmetry, where the pattern can be folded with respect to both the vertical and horizontal axes and still produce an identical image, as well as rotary symmetry, particularly in rotations of 180° about the center point. This high degree of symmetry not only provides visual stability, but also reflects the orderliness that characterizes traditional motifs designed with the principle of balance.

In the context of batik art, symmetry not only functions as a decorative element, but also contains philosophical meanings regarding harmony, order, and harmony of life, which are part of the cultural values of Javanese society. From a mathematical point of view, the order and symmetry in the Kawung motif show compatibility with the concept of repeating geometric patterns (tesselation) which is an important part of the study of plane transformation. Thus, there is a close relationship between visual order in art and structural order in mathematics, which strengthens the argument that batik motifs can be used as a bridge to integrate cultural values into science learning. This finding confirms that symmetry is not only a matter of beauty, but also a form of representation of logic and structure in mathematics that arises naturally in local cultural heritage.

Contextualizing Kawung Motif in Mathematics Learning

The results of the analysis show that geometric patterns in Kawung batik motifs have great potential as contextual media in learning mathematics, especially on geometric transformation material. This motif contains basic shapes such as circles and ellipses arranged in a repeating pattern. This arrangement shows the real application of the four types of geometric transformations, namely translation, rotation, reflection, and dilation. For example, translations in the pattern can be described mathematically with the formula:

$$T(x, y) = (x + a, y + b)$$

where (a, b) is the shift vector from one motif element to the next. The rotation of the Kawung motif, which often occurs by 90° or 180°, can be explained using the rotation transformation with respect to the center point (0,0) as follows:

- For 90° counterclockwise rotation:

$$R(x, y) = (-y, x)$$

- For 180° counterclockwise rotation:

$$R(x, y) = (-x, -y)$$

Reflections on the x or y axis are also common in this motif. Reflection about the y-axis can be expressed by:

$$Ry(x, y) = (-x, y)$$

While the reflection is towards the x-axis:
$$Rx(x, y) = (x, -y)$$

In some variations, the Kawung motif also shows a dilation or change in size without a change in shape, which can be explained through the formula:

$$Dk(x, y) = (k \cdot x, k \cdot y)$$

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Where kkk is the scale factor. If $k > 1$, the motif is enlarged; if $0 < k < 1$, the motif is reduced. From a pedagogical point of view, the application of these formulas in analyzing Kawung motifs allows teachers and students to connect theory with visual practice, so that learning becomes more concrete and relevant. Kawung motif can be used as a contextual source in the development of LKPD or teaching media, which invites students to analyze real forms of transformation in local culture. This approach is in line with the principles of local wisdom-based and contextual learning emphasized in the Merdeka Curriculum. Thus, the integration between cultural values and mathematical concepts not only strengthens students' understanding of transformation geometry, but also fosters a sense of appreciation for the nation's cultural wealth through meaningful and enjoyable learning.

CONCLUSION

Based on the analysis, it can be concluded that the Kawung batik motif has a complex yet organized geometric structure, which reflects the real application of the principles of geometric transformation. The motif contains basic elements in the form of circles or ellipses arranged in a repeating pattern, showing translations, rotations, reflections and dilations. These four types of transformations not only reinforce the aesthetic aspects and symmetry in batik art, but also show that traditional cultural heritage can be explained scientifically through a mathematical approach. These findings prove that Kawung batik motifs have great potential as contextual learning media in mathematics subjects, especially in geometric transformation materials. The integration between culture and mathematics through the analysis of Kawung batik motifs is expected to encourage more meaningful, applicable, and local wisdom-based learning, as well as a form of cultural preservation through a scientific approach.

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