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# Exploration of Mathematical Concepts in Slobog Solo Batik Motifs

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**ABSTRACT**

Previous ethnomathematics studies on Indonesian batik have largely focused on widely recognized motifs, leaving several classical motifs with unique visual and philosophical characteristics understudied. Batik Slobog Solo is one such motif that has received limited mathematical exploration. This study aims to investigate and describe the mathematical concepts embedded in the Batik Slobog Solo motif as a foundation for developing culturally contextualized mathematics learning. This research employs a qualitative design with an ethnographic approach, using observation, semi-structured interviews, and documentation at the Danar Hadi Batik Museum in Surakarta. The findings reveal that Batik Slobog Solo contains various mathematical concepts, including plane geometry, transformational geometry, arithmetic patterns such as square numbers and arithmetic sequences, as well as discrete mathematics concepts related to tiling and graph theory. These concepts are expressed through repetition, regularity, spatial relationships, and systematic arrangement of motif elements. The study demonstrates that Batik Slobog Solo offers substantial potential as a culturally grounded educational resource to support meaningful mathematics learning. Moreover, the research enriches ethnomathematics literature by expanding mathematical analysis to less-explored batik motifs and underscores the importance of integrating local cultural heritage into mathematics education to enhance conceptual understanding while promoting cultural preservation.

**Keywords:** Batik Slobog Solo, Ethnomathematics, Geometry, Arithmetic Patterns, Discrete Mathematics

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## INTRODUCTION

Batik is a fabric dyeing technique that employs a resist method using hot wax applied with tools such as the *canting* or stamped *cap* (Hafiza et al., 2021). Beyond its function as a textile product, batik embodies cultural symbols that reflect the identity and noble values of Indonesian society (Febriani et al., 2023). Visually, batik is classified into three main categories: geometric patterns, non-geometric patterns, and special patterns. In terms of stylistic characteristics, batik is generally divided into inland "*pedalaman*" and coastal "*pesisir*" styles, each representing the geographical and social contexts of its artisans (Uula et al., 2024). Since the designation of October 2 as National Batik Day and UNESCO's recognition of batik as an intangible cultural heritage, public awareness regarding the importance of batik preservation has continued to rise. This development reinforces the urgency of safeguarding the continuity of batik's cultural values so that they remain embedded in the collective memory of global society (Atabay et al., 2024; Covarrubia, 2022).

***Batik preservation efforts***

Integrating batik into mathematics learning through an ethnomathematical approach represents a strategic effort to preserve cultural heritage while enhancing the relevance of instruction for students (Sugiarto et al., 2025). By utilizing batik motifs as a context for mathematical analysis, students not only engage with abstract concepts such as geometry, symmetry, transformation, and patterns, but also develop an understanding of the cultural values embedded in each batik design (Siswanto, 2025). This approach bridges local knowledge and academic knowledge, thereby fostering students' appreciation of national culture within the learning process. Moreover, the use of batik as a learning resource supports sustainable cultural preservation by involving younger generations in recognizing, appreciating, and reflecting on the philosophical meanings and visual structures of batik (Sugiarto et al., 2025). Thus, ethnomathematics not only enriches pedagogical practices but also serves as an educational medium that contributes to the continuity of batik traditions in contemporary society.

Efforts to preserve batik require an understanding of its characteristics according to the regions in which it developed. Coastal batik, which emerged in northern coastal areas of Java "*Pantura*", is characterized by vibrant colors and more expressive motifs influenced by cultural interactions through maritime trade (Wesnina et al., 2025). In contrast, inland batik that developed in non-coastal regions such as Yogyakarta and Surakarta features refined motifs, soft color palettes, and profound philosophical meanings. This style is often referred to as Mataraman or Keraton batik, as it is rooted in the aesthetic traditions of the royal courts (Uula et al., 2024; Widiastuti et al., 2022). The emergence of batik in these two regions is closely linked to the 1755 Giyanti Agreement, which divided the Mataram Kingdom into the Yogyakarta Sultanate and the Surakarta Sunanate (Latifah et al., 2024). Following this division, the Surakarta Sunanate adopted several Mataram batik motifs and later developed new variations while retaining the essential characteristics of the original designs (Santosa & Noorwatha, 2025). To this day, the influence of Mataram batik remains strongly evident in the motifs of Surakarta batik, including Batik Slobog Solo, which evolved within both cultural centers.

***Batik Slobog Solo***

Batik Slobog is one of the classical batik motifs known in Javanese tradition, both in Yogyakarta and Surakarta (Puryanti et al., 2022). Although originating from the same cultural roots, Batik Slobog from these two regions exhibits notable differences in both visual characteristics and philosophical meanings (Wesnina et al., 2025). In general, the term *"Slobog"* derives from the Javanese word *"lobok"*, meaning "loose," which conveys the hope that the spirit of a deceased person may return to God without obstacles (Kusrianto, 2021). In Yogyakarta, Batik Slobog is used in funeral ceremonies and typically features simple geometric patterns, consisting of square fields divided diagonally into four small triangles with dots inside them (Pullen, 2021). The colors used in Yogyakarta's Slobog tend to be lighter, such as white or yellowish brown, with minimal ornamental variation (Ari Wulandari, 2022). In contrast, the Surakarta version of Batik Slobog presents more complex and detailed visual characteristics (Aurora & Chrysoberyl, 2024). While retaining the diagonal square structure, Slobog Solo incorporates more intricate *isen-isen* fillings and accompanying motifs typical of the Surakarta court style, along with deep *indigo* tones that evoke a classical and sacred atmosphere (Wiranata, 2021). Its philosophical meaning is also more profound, emphasizing values such as humility, sincerity, and acceptance in confronting the cycles of life (Sharma et al., 2023). These distinctions indicate that Batik Slobog Solo possesses unique aesthetic and cultural qualities that make it highly relevant for further investigation within the framework of ethnomathematics, particularly in uncovering the mathematical concepts embedded within its structure (Prayitno, 2020).

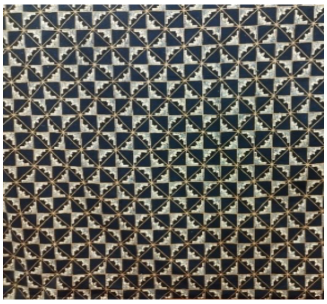

**Figure 1. Slobog Batik Solo**

**Figure 2. Slobog Batik Jogja**

**Figure 3. Slobog Batik Mangkunegaran**

Based on the interview with Gigih, the Functional Staff of the Danar Hadi Surakarta Batik Museum, conducted on November 6, 2025, it was explained that…

> *"....Batik from Solo (Figure 1), Batik from Yogyakarta (Figure 2), and Batik from the Mangkunegaran environment (Figure 3) each present distinct characteristics, yet Batik Slobog Solo is fundamentally defined by its loose, simple composition with minimal isen-isen, reflecting the philosophies of openness, patience, and nrimo embedded in Solo's cultural values. Slobog from Yogyakarta maintains the characteristic uncompact pattern but features sharper lines and the h igh-contrast black-and-white palette typical of Yogyakarta batik, as clearly visible in the figure, creating a direct and assertive impression aligned with the cultural character of the Mataraman tradition. Meanwhile, the Mangkunegaran version of Slobog exhibits a more refined aesthetic, marked by the addition of delicate isen-isen and the use of more golden-toned sogan hues, producing an elegant, orderly, and aristocratic visual identity consistent with Mangkunegaran courtly style. Although all three variations share the underlying concept of slobog, meaning "spacious" or "loosely arranged,"*

*each region expresses it through unique visual forms and philosophical nuances shaped by their respective cultural environments....”*

***Ethnomathematics***

The concept of ethnomathematics was first introduced by Ubiratan D’Ambrosio in 1977. He described ethnomathematics as an approach to mathematics education that takes into account the cultural context in which mathematical concepts develop, focusing on the forms of reasoning and mathematical systems used by specific cultural groups (D’Ambrosio, 1985). In its subsequent development, D’Ambrosio (1994) this definition into an anthropological study of mathematical culture, encompassing both everyday practices and educational settings. Machaba & Dhlamini (2021) reinforce this perspective by asserting that ethnomathematics includes diverse mathematical ideas and practices emerging across cultural communities, ranging from traditional ethnic groups to professional groups. This highlights that in a multicultural society such as Indonesia, each community possesses its own distinctive ways of understanding and applying mathematical ideas (Murtafiah et al., 2022).

The selection of Batik Slobog Solo as the object of study in this research is grounded in both its rich philosophical values and its distinctive visual characteristics, which remain relatively underexplored within ethnomathematics research. Unlike more popular batik motifs such as Kawung, Parang, and Sidomukti which have been extensively examined in previous studies (Eldiana et al., 2023; Murtafiah et al., 2022), as well as studies on the development of instructional media based on Batik Slobog Yogyakarta (Sari et al., 2023). Batik Slobog Solo has yet to receive substantial mathematical analysis. Its characteristic structure, consisting of diagonally intersecting square grids filled with repetitive dots, offers rich potential for in-depth examination through concepts of reflection, rotation, translation, and tiling.Culturally, Batik Slobog is traditionally worn in sacred contexts such as funeral rites and *ruwatan* ceremonies, and it embodies profound Javanese values including sincerity, simplicity, and humility. These cultural meanings make Batik Slobog highly relevant as contextual learning material in mathematics education that foregrounds local wisdom. Therefore, the use of Batik Slobog Solo in this study not only addresses the gap in research on less-explored motifs but also strengthens the integration of cultural heritage into mathematics education, aligning with the principles of ethnomathematics proposed by D’Ambrosio (1985) & Powell (2009).

Numerous ethnomathematics studies have been conducted on Indonesian batik. These include analyses of mathematical concepts applied in Batik Solo (Faiziyah et al., 2021), studies on mathematical concepts in the Madurese salt production process (Hanik et al., 2024), investigations of mathematical ideas embedded in Yogyakarta batik motifs (Prahmana & D’Ambrosio, 2020), examinations of mathematical concepts in the *Pranatamangsa* system and birth death rituals in Yogyakarta (Prahmana et al., 2021), studies on mathematical concepts found in Yogyakarta hand-drawn batik (Repiyan et al., 2023), analyses of mathematical concepts in Batik Truntum Surakarta (Nurcahyo et al., 2024), studies on geometric concepts in Batik Kopi Pecah Salem (Fauziah et al., 2025), investigations of mathematical ideas embedded in Sundanese culture (Lidinillah et al., 2022), analyses of mathematical concepts in Batik Gajah Mada with the Sekar Jagad Tulungagung motif (Afifah et al., 2020), studies on geometric transformations such as translation and reflection in traditional Lagosi motifs from Wajo Regency (Pathuddin & Busrah, 2024) and ethnomathematics research on arithmetic and discrete mathematics in Batik Sidomukti Solo (Kholid & Husodo, 2025).

The purpose of this study is to describe the process of exploring the mathematical concepts embedded within the Batik Slobog Solo motif. Through this approach, the research is expected to contribute to the advancement of knowledge by (1) providing a conceptual contribution through identifying and characterizing mathematical concepts embedded in the Batik Slobog Solo motif; (2) offering a methodological contribution by demonstrating the use of an ethnographic lens to analyze cultural artifacts as mathematical objects; and (3) presenting a pedagogical contribution by informing the development of contextual mathematics learning strategies that integrate local cultural elements particularly batik as part of national cultural heritage into educational practices that are more meaningful and relevant for students.

## METHOD

This study employs a qualitative research design using an ethnographic approach, which is considered appropriate for exploring and describing the relationship between culture and mathematics within the Batik Slobog Solo motif. The ethnographic approach was selected because it enables the researcher to gain an in-depth understanding of the cultural meanings and social contexts in which mathematical practices are embedded and developed. According to (Prahmana & D'Ambrosio, 2020), ethnographic exploration begins by addressing four overarching questions: "Where do I start looking?", "How do I find it?", "How do I know that I have found something significant?", and "How to understand it?". Accordingly, this study is also guided by these four questions, as outlined in Table 1.

**Table 1.** Research Methods

| Frequently Asked Questions | Initial Answer | Specific Points | Specific Activities |
|---|---|---|---|
| Where do I start looking? | The observation began by examining where Batik places are located in Slobog Solo Batik | Culture | Conducting interviews with people who know a lot about Batik Slobog Solo |
| How do I find it? | Investigate the motives of Slobog Solo Batik | Alternative Thinking | Analyzing Slobog Solo Batik motifs Determining what mathematical concepts are contained in Slobog Solo Batik motifs |

| Frequently Asked Questions | Initial Answer | Specific Points | Specific Activities |
|---|---|---|---|
| How do I know that I have found something significant? | The results of alternative thinking are reviewed first | Philosophy of Mathematics | Identify what mathematical concepts are contained in the Slobog Solo Batik motif<br>The existence of a mathematical concept was found in the Slobog Solo Batik motif |
| How to understand it? | It is essential for the preservation of Batik culture, and is essential for the development of mathematics | Anthropological Methodology | Linking two knowledge systems (culture and mathematics) as a collaboration of preservation and knowledge<br>Describe the mathematical concepts found in the Slobog Solo Batik motif |

This study is planned to be conducted at the Danar Hadi Batik Museum in Solo (Jl. Slamet Riyadi No. 261, Sriwedari, Laweyan District, Surakarta, Central Java, 57141, Indonesia). The site was selected based on its relevance to the traditional production processes and cultural representation of Batik Slobog Solo. The focus of this study centers on the mathematical concepts embedded in the Batik Slobog Solo motif, with the motif itself positioned as the research subject that represents an expression of local cultural identity.

Qualitative data were collected through observation, interviews, and documentation. Observations were conducted to identify visual patterns and structural elements within the Batik Slobog motif that potentially represent mathematical concepts. The identified elements were then systematically analyzed through a coding process, beginning with open coding to document all mathematical indicators observed, followed by axial coding to group similar indicators into conceptual categories, and finally selective coding to confirm the dominant mathematical concepts emerging from the motif.

Semi-structured interviews were conducted with a mathematician from a private university in Indonesia to support and validate the observational findings. The interview protocol was first validated by an ethnomathematics expert from another private university in Indonesia to ensure content accuracy and conceptual relevance. The interview questions focused on: (1) whether the identified patterns align with established mathematical concepts, and (2) the pedagogical feasibility of using the Batik Slobog context in mathematics learning.

Documentation procedures were used to record all observation notes, motif photographs, and interview transcripts. To ensure validity and reliability, methodological triangulation was conducted by comparing findings from observations, interviews, and documentation, while expert validation was employed to assess the accuracy of identified mathematical concepts and the credibility of the categorization process.

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Data analysis was conducted in three main stages: data reduction, data presentation, and conclusion drawing (Johnson & Christensen, 2024). In the data reduction stage, the collected data were filtered and focused on information relevant to the research objectives. The data were then presented descriptively to illustrate the relationship between the Batik Slobog Solo motif and various general mathematical concepts, including geometry, patterns and relations, arithmetic, algebra, measurement, basic statistics, mathematical logic, as well as discrete mathematics and combinatorics in a broader sense. Nevertheless, the integration of these mathematical concepts into instructional practice remains underexplored. Conclusions were drawn based on the researcher's interpretation, supported by expertise in both mathematics and batik culture, to ensure that the analysis reflects an authentic connection between mathematics and the cultural context of Batik Slobog Solo. The validity of the findings was strengthened through data triangulation, involving additional experts to enhance the accuracy of interpretation and analysis.

## RESULTS & DISCUSSION

***Where do I start looking?***

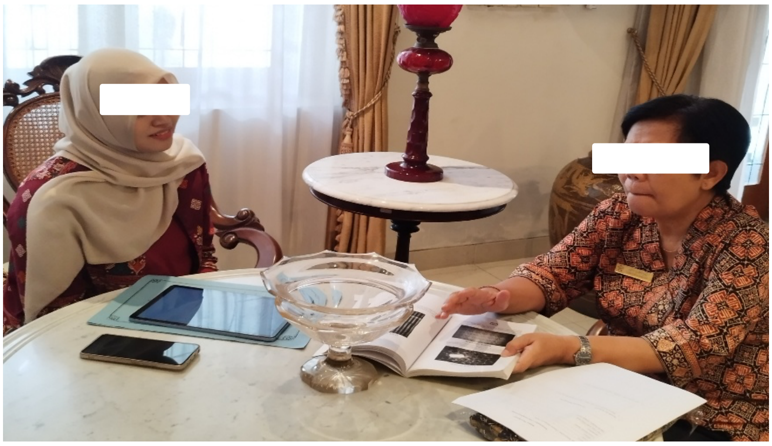

**Figure 4. Interview Process with Asti Suryo Astuti, S.H, K.N**

The researcher examined Batik Slobog Solo at the Danar Hadi Batik Museum in Surakarta (Jl. Slamet Riyadi No. 261, Sriwedari, Laweyan District, Surakarta City, Central Java, 57141, Indonesia). During this visit, the researcher conducted an interview on 6 November 2025 with the museum manager and curator, Asti Suryo Astuti, S.H., K.N. (55 years old), who has been actively involved in the world of Javanese *batik pedalaman* for more than 25 years, regarding the values and philosophies underlying Batik Slobog Solo (Figure 4).

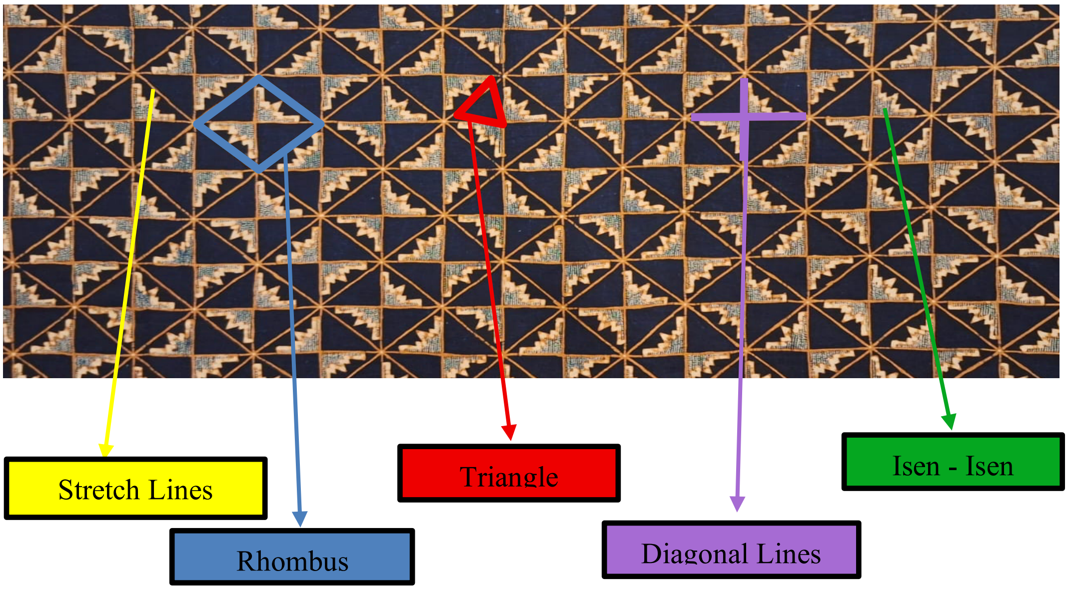


**Figure 5. Variety of Ornaments in Slobog Solo Batik**

Based on the visual characteristics and traditional standards of Surakarta batik, the ornamental elements found in Batik Slobog Solo generally consist of loosely arranged lines (Yellow Arrow) as the primary components that create a spacious impression, as well as a variant of *parang slobog* designed with wider spacing, a gentler slope, and substantial distance between motifs. In addition, Batik Slobog Solo incorporates simple geometric forms such as rhombus (Blue Arrow), small triangles (Red Arrow), diagonal lines (Purple Arrow), and dots as minimalist *isen* that fill space without making the motif appear dense (Green Arrow). Simple *isen-isen* ornaments such as *cecek* (dots) and *sawut* (parallel lines) are still used but in limited amounts, allowing empty areas or negative space to become an essential component of the *slobog* aesthetic,see figure 5.

***How do I find it?***

Batik Slobog Solo holds significant historical relevance in the development of Surakarta batik. As one of the variants of the *Sundananan* style, this motif emerged within the cultural context of the Mataraman tradition, which underwent substantial transformation following a major political event, the Giyanti Agreement on 13 February 1755. According to Gigih, a functional staff member at the Danar Hadi Batik Museum (interview, 6 November 2025),

*"...The Giyanti Agreement divided the Mataram Sultanate into two political territories, placing the entire Mataram batik tradition under the authority of the Yogyakarta Sultanate. From that point onward, the Mataram style of batik was maintained as the standard reference for Yogyakarta batik, while the Surakarta Sunanate later adapted certain elements of its motifs. These adaptations generated new visual innovations without abandoning the fundamental Mataraman patterns, allowing various contemporary batik motifs including Batik Slobog Solo to be understood as developments derived from this tradition...."*

This study is grounded in an in-depth observation of the Batik Slobog Solo motif from an ethnomathematical perspective, with the aim of examining the relationship between cultural expression and mathematical concepts. The research focuses on identifying visual elements that exhibit general mathematical structures, such as geometry, arithmetic, and discrete mathematics, as manifested in the composition of the motif. The ultimate goal is to understand how these elements reflect the integration of traditional aesthetics and the mathematical ideas inherent in the design of Batik Slobog Solo.

***How do I know that I have found something significant?***

The validation results indicate that mathematical concepts encompassing arithmetic, geometry, and discrete mathematics are indeed identifiable in the motifs of Batik Slobog Solo, thereby reinforcing the answer to the first research question. The expert confirmed that all four concepts are clearly evident within the visual structure of the batik. These concepts are reflected through the repetition of motifs that illustrates arithmetic regularities, the arrangement and tessellation of shapes that demonstrate geometric structuring, the variation in motif placement that reveals combinatorial principles, and the interconnected visual elements that can be interpreted through graph-based relationships. Furthermore, field observations reveal that hand-drawn batik (*batik tulis*) exhibits a lower degree of symmetry compared to stamped batik (*batik cap*), which is produced using stamping techniques that allow for greater consistency in size and shape. Nevertheless, both *batik tulis* and *batik cap* demonstrate the application of mathematical principles through simple arithmetic regularities, geometric shapes and transformations, as well as discrete mathematical characteristics such as repetition, connectivity, and motif variation. A more detailed elaboration of each validated mathematical concept is presented in the following section, organized according to the relevant branches of mathematical study.

***Geometry***

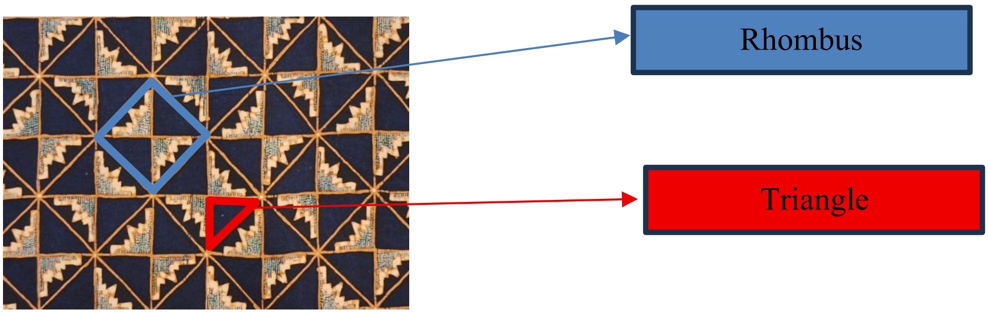


**Figure 6. Plane Geometri Batik Slobog Solo**

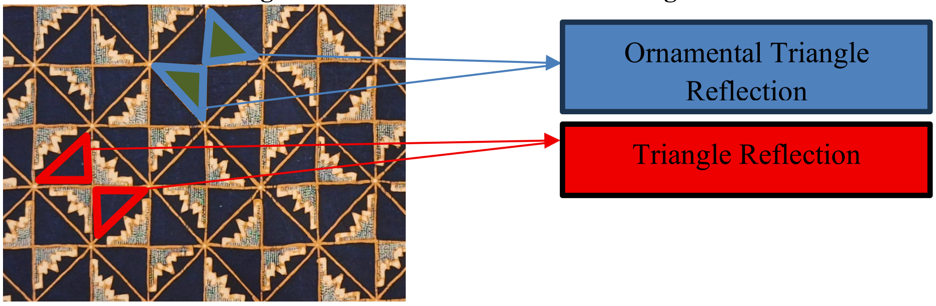


**Figure 7. Reflection of Slobog Solo Batik**

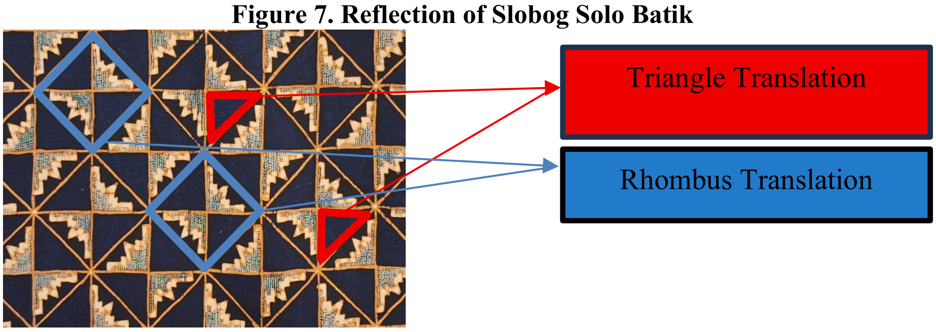


**Figure 8. Translation of Slobog Solo Batik**

The geometric concepts in Batik Slobog Solo are primarily reflected through the application of plane geometry and transformational geometry that consistently shape the visual structure of its motifs. In terms of plane geometry (Figure 6), the slobog pattern features fundamental shapes such as rhombuses and small triangles that appear as filler ornaments within the rhombus field. From the perspective of transformational geometry, Batik Slobog Solo employs the principle of translation to create repeated rhombus and triangle motifs at uniform intervals, resulting in a stable and continuous repeating pattern (Figure 8). Several motif variations also indicate the presence of reflection, visible through shapes that appear as mirror-like counterparts of elements positioned elsewhere (Figure 7). Altogether, the application of geometric shapes and transformations contributes to the orderly and structured visual character of Batik Slobog Solo, while still maintaining the "open" impression aligned with the philosophy of *slobog*, which symbolizes a pattern that is intentionally not tightly enclosed.

***Arithmetic***

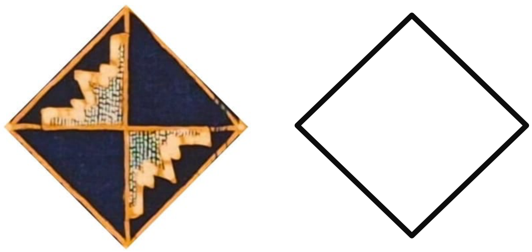

**Figure 9. Batik Slobog Solo as a rhombus**

The researcher studied the formation of motifs arranged in stages, namely a series of rhombus motifs that form units larger than the basic motif. The first level formation (1×1) is the simplest form (Figure 9), consisting of a single rhombus as the basic motif. At this level, there has been no pattern repetition other than the main shape. Although it may seem simple, unit 1×1 serves as the basis for the formation of the formation of the order at the next level, since all the more complex formations are the development of this unit. Therefore, the 1×1 formation contains only one rhombus motif.

Then there are the next level formations such as 2x2, 3x3, even the formation repeats infinitely until it meets the batik fabric used.

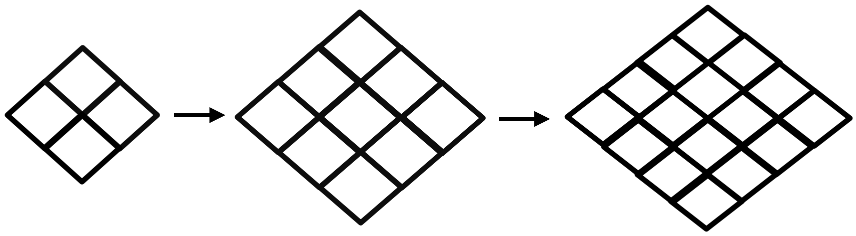

**Figure 10. Quadratic Arithmetic Series in Slobog Solo Batik**

Based on the results of observations of the four levels of formation, it can be seen that the square number pattern appears consistently at each stage (Figure 10). Overall, the recapitulation of the number of units at each level can be seen in the following table (Table 2).

**Table 2.** Representation of Arithmetic Series and Corresponding Squared Values

| Formation | Number of Rhombus Formations 1 x 1 | Number of Rhombus Formations 2 x 2 | Number of Rhombus Formations 3 x 3 | Number of Rhombus Formations 4 x 4 | Total Number of Rhombus |
|---|---|---|---|---|---|
| 1 x 1 | 1 | - | - | - | 1 |
| 2 x 2 | 4 | 1 | - | - | 5 |
| 3 x 3 | 9 | 4 | 1 | - | 14 |
| 4 x 4 | 16 | 9 | 4 | 1 | 30 |
| .... | .... | .... | .... | .... | .... |
| $n \times n$ | $n^2$ | $(n-1)^2$ | $(n-2)^2$ | $(n-3)^2$ | $\frac{n(n+1)(2n+1)}{6}$ |

To ensure the correctness of the formula, a verification process is carried out through the substitution of several values $n$. At $n = 3$, results were obtained $S_3 = \frac{3(4)(7)}{6} = 14$, and on $n = 4$ obtained $S_4 = \frac{4(5)(9)}{6} = 30$. These two results are in line with data obtained through observation. Thus, it can be ascertained that the arrangement of rhombus motifs visually forms a series of arithmetic squares.

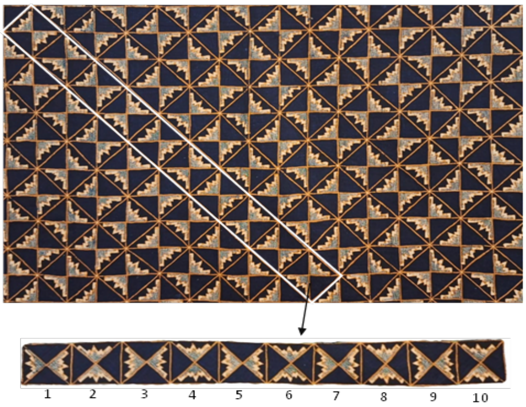

**Figure 11. Arithmetic Sequence**

In addition to the motifs arranged in stages, the researcher also found the presence of arithmetic row patterns in the visual structure of rhombus motifs. This pattern can be seen from the arrangement of the number of units at each level of formation that increases regularly. In this context, arithmetic rows appear in increments of larger rhombuses, such as sequences 1, 3, 5, 7, and so on that form a pattern of regular increments based on the difference in odd numbers. Can be seen in the picture (Figure 11).

From this pattern, it can be determined that the first tribe in the row $(a)$ is 1 or 2. Different $(b)$ shows consistency with a value of 2. Then the arithmetic row equation of the tribe $n$ can occur with formula

$$U_n = a + (n - 1)b,$$

and the number of tribes $n$ with formula

$$S_n = \frac{n}{2} \times (a + U_n).$$

For example, to validate $n = 5$, so $U_5 = 1 + (5 - 1)2 = 9$. From the picture (Figure 11) it can be seen that the 9th quarter of the arithmetic row is 9. Thus, it can be ascertained that the arrangement of rhombus motifs visually forms arithmetic rows. This increase also shows that each level of formation not only follows a series of squares, but also contains arithmetic rows that affect the structure of the growth pattern. These findings indicate that Slobog Solo's motifs not only reflect geometric principles, but also contain a distinctive numerical regularity through the combination of quadratic patterns and arithmetic lines on each of their constituent layers.

***Mathematics Discrete***

Rather than asserting a direct application of formal graph theory, the visual organization of motifs is more appropriately described as exhibiting structured connectivity patterns. The relationships among motif elements are based on spatial proximity, alignment, and recurring positional arrangements, creating an impression of interconnectedness without forming a rigorously defined mathematical graph. Similarly, instead of framing motif variation strictly within combinatorics, the patterns are better understood as demonstrating systematic variation in arrangement, orientation, and repetition, reflecting underlying ordering principles without involving explicit combinatorial calculations.

By adopting this more measured interpretation, the study maintains conceptual connections to mathematical thinking while avoiding overextended theoretical claims. The focus remains on how cultural design practices embody intuitive mathematical ideas through pattern organization, repetition, variation, and spatial relationships. This perspective aligns with the goals of ethnomathematics, which emphasizes the identification of mathematical meaning in cultural artifacts while recognizing the distinction between contextual interpretation and formal mathematical proof.

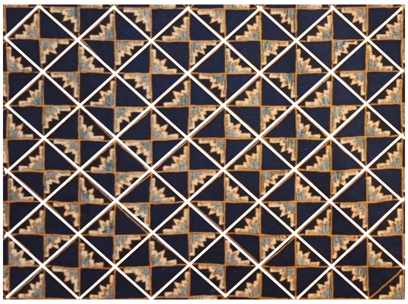

**Figure 12. Batik slobog Solo**

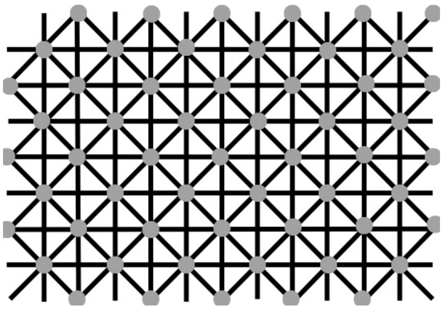

**Figure 13. Vertices (Nodes) and Connecting Lines**

The discrete mathematics concepts in Batik Slobog Solo are primarily reflected through the application of graph theory, tiling, and combinatorics, which together shape the structural regularity of its motifs. Graph theory is a branch of discrete mathematics that focuses on the study of graphs, a mathematical construct used to model relationships between pairs of objects (Erciyes, 2021). A graph consists of a set of vertices connected by edges, and it is widely applied in fields such as computer science, transportation, and social networks (Aggarwal & Murty, 2020). In the context of Batik Slobog Solo, graph theory (Figure 12 and 13) can be observed through the arrangement and interconnections of motifs across the cloth. Each motif may be interpreted as a vertex, while the spatial alignment and symmetry between motifs represent the edges. These relationships form network like patterns that reflect the underlying structure of a graph. The presence of graph theory in Batik Slobog Solo highlights the mathematical logic embedded within traditional art, offering new ways to interpret cultural patterns through the lens of formal mathematics. Previous studies have also identified the application of graph theory in other batik motifs, such as those found in *Batik Grompol, Batik Parang*, and *Batik Kawung* (Akmal et al., 2021).

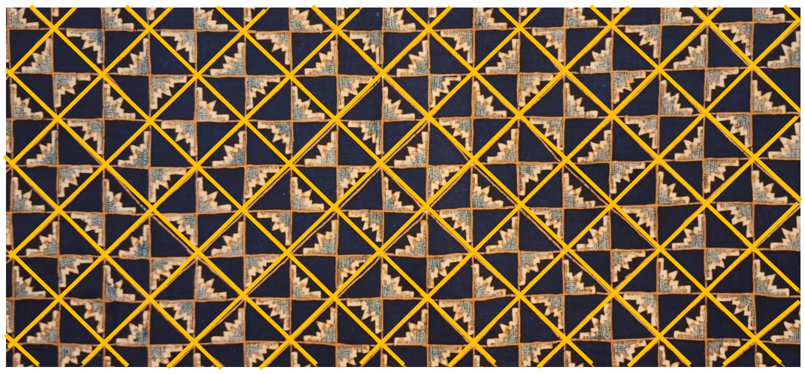

**Figure 14. Tiling Batik Slobog Solo**

The concept of tiling is clearly reflected in the way motif units in Batik Slobog Solo (Figure 14) fill the surface of the cloth repeatedly without gaps or overlaps. The basic units may consist of diagonal lines, small triangular shapes, or other geometric forms arranged in a repetitive pattern, resulting in periodic tiling (Adams, 2023). Each motif functions as a “tile” that is consistently positioned both horizontally and vertically, creating a stable and rhythmic visual structure. This tiling pattern can be categorized as either regular or semi-regular, depending on the uniformity of the basic shapes and the variation within their repetitions (Wu et al., 2021). Thus, Batik Slobog Solo demonstrates the application of tiling concepts in discrete mathematics through the repetitive arrangement of motifs that form a harmonious and structured composition.

The concept of combinatorics in Batik Slobog Solo (Figure 15 and 16) emerges through the variations in motif arrangement that allow for numerous possible configurations derived from the same basic elements. The combinations of small triangle orientations, variations in the thickness of slobog lines, or the spacing between motif components illustrate the principles of permutation and combination in discrete mathematics. Each choice of orientation, repetition order, and shape variation produces a distinct pattern, enabling the total number of possible designs to be analyzed combinatorially. Although the slobog motif has a stable underlying structure, the balance achieved in arranging its visual elements demonstrates that the batik contains a wide scope for compositional exploration, which can be understood through combinatorial principles. Thus, Batik Slobog Solo provides a concrete example of

**Figure 15. Batik Slobog**

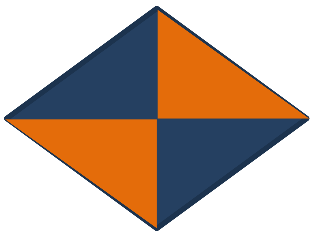

**Figure 16. Combinatorics**

how the diversity of patterns in traditional culture can be explained through foundational concepts of discrete mathematics.

To validate the research data, the researcher conducted source triangulation by comparing the initial assumptions regarding the mathematical concepts arithmetic, geometry, and discrete mathematics identified in Batik Slobog Solo with the perspectives of a mathematics expert competent in all four domains. The triangulation was carried out using a walkthrough interview method, which involved direct communication between the researcher and the expert to assess the alignment between the findings and the expert's interpretation. (Fitri & Prahmana, 2020; Tracy, 2024).

***How to understand it?***

The validation findings demonstrate that mathematical elements related to arithmetic, geometry, and discrete structural patterns are identifiable within the motifs of Batik Slobog Solo, thereby supporting the response to the first research question. The expert affirmed that these conceptual elements are visibly embedded in the batik's visual composition. In addition, field observations indicate that hand-drawn batik (*batik tulis*) tends to display a lower degree of symmetry than stamped batik (*batik cap*), as the stamping technique enables greater uniformity in size and form. Despite these differences, both forms consistently reflect mathematical reasoning through observable arithmetic regularities, geometric forms and transformations, as well as discrete structural features such as repetition, patterned variation, and relational organization among motifs.

With respect to the second research question, the expert acknowledged the potential of Batik Slobog Solo to serve as a meaningful contextual resource in mathematics education. The batik motifs may be utilized to illustrate arithmetic operations and numerical regularities, geometric shapes and transformations, and structured pattern relationships derived from systematic arrangement and visual organization. By examining recurring patterns, spatial relationships, and variations in motif placement, learners are able to engage with abstract mathematical ideas through culturally situated visual representations that are closely aligned with their learning environment.

Nonetheless, further inquiry remains necessary, particularly concerning the practical implementation of Batik Slobog Solo within classroom settings and the evaluation of its instructional effectiveness. Subsequent research could extend the present findings by investigating pedagogical applications and learning outcomes, thereby contributing not only to students' understanding of arithmetic, geometry, and structured pattern reasoning, but also to fostering a deeper appreciation of the cultural heritage embodied in Batik Slobog Solo.

As support for instructional implementation, the researcher has compiled several studies that discuss the use of batik in mathematics learning, particularly in the form of mathematical problems and student worksheets (LKPD). Fakhriyah et al. (2025) examine geometric problems embedded in the Sidomukti Solo batik motif, Aliantari & Sumardi (2024) provide examples of constructive mathematical problem applications using the Laweyan batik motif, Kholid & Husodo (2025) develop arithmetic problems based on the Sidomukti batik, and Masyudin et al. (2020) discuss the use of student worksheets (LKPD) in the context of Jambi batik..

Based on the findings of this study, it is recommended that teachers utilize Batik Slobog Solo as a learning resource for teaching mathematical concepts that include arithmetic, geometry, and discrete mathematics. These findings contribute to both cultural and educational domains, particularly mathematics education: they not only support the preservation of Batik Slobog Solo as part of Indonesia's cultural heritage but also offer an innovative and contextual approach to mathematics instruction. Future research may expand this work by integrating cultural elements into mathematics learning to enhance 21st-century competencies such as reflective thinking (Sa'dijah et al., 2020), as well as by combining ethnographic approaches with STEAM-based learning and flip-flop instructional models (Ishartono et al., 2024).

## CONCLUSION

The findings of this study indicate that the motifs of Batik Slobog Solo not only reflect Javanese cultural values rich in philosophy but also contain mathematical structures that can be systematically analyzed. Through an ethnographic approach, it was identified that the visual patterns of this batik represent concepts of arithmetic, geometry, and discrete mathematics through the regularity of motif repetition, numerical sequences, geometric shapes, transformations, tiling, and spatial relationships between elements. Expert validation confirmed that the identified mathematical structures are inherently embedded in the design of Batik Slobog Solo and demonstrate strong potential as meaningful contextual resources for mathematics education. This study contributes to the advancement of ethnomathematics by providing culturally grounded examples that can support the development of context-based learning materials and instructional practices. By linking mathematical concepts with local cultural heritage, the findings offer practical implications for making mathematics learning more relevant and engaging for students. However, this study is limited to four mathematical concepts and has not yet examined classroom implementation. Therefore, further research is recommended to explore additional mathematical ideas present in Batik Slobog motifs and to investigate the effectiveness of integrating these cultural contexts into diverse learning environments.

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