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Ethnomathematics: Arithmetic and Discrete Mathematics Concepts in Batik *Sidomukti* Solo

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Abstract

Ethnomathematics is the study of the relationship between mathematics and culture and its application in everyday life. Batik, as one of Indonesia's most iconic cultural heritages, contains patterns and structures rich in mathematical ideas, making it a relevant and engaging case study for mathematics education. Batik has the potential to contextualize abstract mathematical concepts through visual and cultural elements. This study specifically focuses on Batik *Sidomukti*, a classical batik from Surakarta, which is characterized by its distinctive curved patterns known as *Isen Ukel*. *Isen Ukel* refers to ornamental curved or spiral lines used as filler patterns, which traditionally symbolize life, continuity, and aesthetic harmony in Javanese batik art. To explore the mathematics concepts embedded in Batik *Sidomukti*, this study employed a qualitative approach using ethnography and Ethnomathematics Guiding Questions. Ethnography is suitable for this context as it allows for an in-depth understanding of the cultural and artistic context of batik making, including the symbolic meanings and design structures. Data were collected through field observation, motif documentation, and literature review. This approach enabled the researcher to identify and analyze arithmetic and discrete mathematics elements present in the batik designs. For instance, modular and tiling arithmetic are reflected in the repetitive and structured arrangement of motifs, while discrete mathematics is represented through graph theory and combinatorics. The application of combinatorics, in particular, contributes to the aesthetic appeal and design variation of Batik *Sidomukti*. These findings highlight the significance of ethnomathematics in bridging cultural heritage and mathematics education. Batik motifs, especially Batik *Sidomukti*, are not only traditional artworks passed down through generations, but also a rich source of inspiration for developing culturally relevant mathematics instruction.

Keywords: Arithmetic, Batik *Sidomukti*, Discrete Mathematics, Etnomathematics

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INTRODUCTION

Mathematics is a basic discipline taught at all levels of education, from elementary school to college. It is closely related to philosophy, logic, and science, plays an important role in daily life, and supports the development of various fields of science. As stated by Sutriyani et al. (2023), mathematics is not just a collection of abstract numbers, symbols, and formulas, but grows and develops along with real human experience. Nevertheless, mathematics is often perceived only as a formal subject separate from the reality of life. Weyl & Wilczek (2021) describe mathematics as a perfect and objective science, but still, many students feel that mathematics is irrelevant in their lives. This shows that there is a gap between the concepts of mathematics taught in schools and the real experience of students. Therefore, an approach to connect mathematics with the real-life context is needed, for instance a culture-based approach. This approach allows students to understand abstract concepts in mathematics in a more concrete and meaningful way through the integration of local cultural values and practices.

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The application of mathematical thinking in real life will be limited if learning focuses only on abstract mathematical concepts. Therefore, an innovative approach is needed, especially delivering mathematics materials to students. One effective strategy is to use objects that are relevant to students' daily lives, for instance cultural objects. As explained by Acharya et al. (2020), culture is an important factor that influences the way individuals understand and interpret processes such as assessment, development, implementation, and other related functions, as it is a tangible and pervasive aspect of life. Known for its cultural wealth, including priceless relics of the past, Indonesia holds immense potential for the incorporation of culture into mathematics learning (Sari et al., 2022). In mathematics education, a bridge is needed to connect mathematical concepts with culture and daily life.

Mathematics and culture are indispensable in life. Mathematics is a source of knowledge, whereas culture fosters noble values in society. Utami et al. (2022) argued that mathematics learning can benefit from integrating culture into the learning process. Culture-based mathematics learning allows students not only to learn about mathematical concepts, but also to think mathematically about the circumstances and cultural contexts in which they live (Murtafiah et al., 2022). Cultural values such as harmony, symmetry, balance, and repetition that are often reflected in traditional arts such as batik are closely related to mathematical principles (Soliana et al., 2021). For example, Javanese culture's emphasis on aesthetic balance and regularity is reflected in batik patterns that exhibit geometric transformations, modular arithmetic, and combinatorial arrangements (Nurcahyo et al., 2024). This relationship shows that cultural practices are not only expressions of identity, but also tangible forms of mathematical thinking embedded in everyday life.

Ethnomathematics explores the relationship between mathematics and culture, particularly in the context of education. By D'Ambrosio (1985), it is the study of linking mathematics to cultural practices. Meanwhile, Baker (2022) defined ethnomathematics as rooted in multicultural and critical perspectives on mathematics and its teaching. In essence, ethnomathematics provides a framework for understanding how mathematical ideas arise from and are shaped by cultural contexts. This way of interpreting ethnomathematics is consistent with Machaba & Dhlamini (2021) that the purpose of ethnomathematics is to recognize that there are different ways of doing mathematics, taking into account the mathematical knowledge developed in different sectors of society as well as different ways in which society conducts activities. Thus, ethnomathematics serves as an effective framework for embedding mathematics learning within cultural heritage, especially in regions rich in traditional art such as Indonesia.

Indonesia's cultural diversity, particularly in visual and textile arts, provides abundant opportunities to contextualize mathematics learning through cultural artifacts. One of Indonesia's cultural objects is batik. A batik piece contains cultural symbols reflecting the identity of the Indonesian people (Febriani et al., 2023). Batik is a dye-resist technique in which hot wax is applied to fabric using either a canting or a stamp, as illustrated in Figure 1. This technique originates from the island of Java in Indonesia (Hafiza et al., 2021). Based on the pattern, batik is classified into three types: (1) batik with a geometric pattern; (2) batik with a non-geometric pattern; and (3) batik with a special pattern.

Meanwhile, based on the style, batik is divided into two types: inland batik and coastal batik (Uula et al., 2024). Following the establishment of the National Batik Day on October 2, 2009, and the designation of batik as an intangible cultural heritage by UNESCO, there has been growing awareness that batik is an ancestral heritage whose sustainability and cultural value must be preserved to ensure that it remains part of the world community's collective memory (Nuriyanto, 2022).

Figure 1. Dye-resist technique with hot wax batik production

Batik *Sidomukti*, which originates from Surakarta (Solo), Central Java, is made using natural soga dyes (Fakhriyah et al., 2025). The characteristic patterns is symmetrical curves called *Isen Ukel*. It is one of the types of batik that develops within the confines of the Surakarta Court, tracing its existence since the time of the Mataram Sultanate (Wasino et al., 2021). The word *Sidomukti* stands for the Javanese words *sido* and *mukti*. *Sido* means "to be" or "to become", while *mukti* means "happiness," "power," and "not lacking anything" (Kerlogue & Pospíšilová, 2021). Batik *Sidomukti* is widely recognized for its profound historical and cultural significance. However, prior study by Fakhriyah et al. (2025) has only provided limited insight into geometrical concepts in Batik *Sidomukti*. Although certain investigations have addressed aspects of its geometrical concepts, there remains a notable absence of ethnography research focusing on the integration of arithmetic and discrete mathematics concepts within the traditional motifs of Batik *Sidomukti*. This study seeks to address this research gap by exploring the existence of arithmetic and discrete mathematics concepts in Batik *Sidomukti* patterns, thereby contributing a novel perspective at the intersection of cultural tradition and mathematical theory.

Many ethnomathematical studies have focused on Indonesian batik. These include a study on the mathematical concepts applied in Batik *Solo* (Faiziyah et al., 2021), a study on the mathematical concepts Process of Madurese Salt Production (Hanik et al., 2024), studies on the mathematical concepts applied in Batik *Yogyakarta* motifs (Prahmana & D'Ambrosio, 2020), a study on the mathematical concepts in Pranatamangsa System and the Birth-Death Ceremonial in Yogyakarta (Prahmana et al., 2021), a study on the mathematical concepts in Yogyakarta's Typical Hand-Drawn

Batik (Repiyan et al., 2023), a study on mathematical concepts in Batik *Truntum Surakarta* (Nurcahyo et al., 2024), a study on the geometry concepts in Batik *Kopi Pecah Salem* (Fauziah et al., 2025), a study on the mathematical concepts applied in Sundanese culture (Lidinillah et al., 2022), and a study on the mathematical concepts in Batik *Gajah Mada* with the *Sekar Jagad Tulungagung* motif (Afifah et al., 2020). Previous studies suggest that ethnomathematics is commonly applied in the learning of mathematical concepts. Nonetheless, the integration of culturally rooted contexts into mathematics problems remains infrequent in actual classroom practices. Batik *Sidomukti* holds significant potential to exemplify foundational concepts in arithmetic and discrete mathematics, such as modular arithmetic, tiling arithmetic, graph theory, and combinatorics. However, its application in instructional settings within these mathematical domains has not been sufficiently investigated.

This study sought to explore and explain the arithmetic and discrete mathematics concepts in Batik *Sidomukti*. Furthermore, the researcher intends to provide examples of mathematical problems, such as arithmetic and discrete mathematics concepts, developed through ethnography approach, drawing upon the patterns and structures found in Batik *Sidomukti*. The results of this research are expected to serve as a guide for developing innovative media for culture-based mathematics learning. In addition, the incorporation of Batik *Sidomukti* in mathematics learning will increase the meaningfulness of the learning process as it provides a familiar everyday context to students, especially those living in the Surakarta area. Therefore, this research contributes not only to the field of ethnomathematics but also to the advancement of culturally relevant mathematics instruction aligned with Indonesia's educational objectives.

The ethnomathematical approach to examining the patterns of Batik *Sidomukti* not only enriches the understanding of local cultural heritage, but also contributes to the achievement of the Sustainable Development Goals (SDGs), particularly Goal 4: Quality Education and Goal 11: Sustainable Cities and Communities. By exploring the interconnections between mathematics and local cultural values, such as the philosophical meanings embedded in batik, this study supports the development of inclusive and contextualized education that values indigenous knowledge as an authentic learning resource (D'Ambrosio, 2006; Rosa & Orey, 2016). This aligns with Target 4.7 of SDG 4, which emphasizes the importance of education that fosters appreciation for cultural diversity and its role in sustainable development (UNESCO, 2017). Moreover, the preservation and documentation of mathematical patterns in traditional batik represent a tangible contribution to sustaining cultural heritage, in line with Target 11.4 of SDG 11, which promotes efforts to protect and safeguard the world's cultural and natural heritage.

METHODS

This ethnomathematics study employs ethnography approach to explore and describe the relationship between culture and mathematics in Batik *Sidomukti* motifs. The ethnography approach was selected as it allows the researcher to gain an in-depth understanding of cultural meanings and the social context in which this mathematical practice is embedded and developed. According to Prahmana & D'Ambrosio (2020), an ethnography exploration starts with the design contains four common questions that need to be answered: "Where do I start looking?", "How do I do it?", "How do I know that I have found something significant?", and "How do I understand it?". Therefore, this research is also based on those four questions, as detailed in Table 1.

Table 1. Design of ethnography research

Ethnographic Guiding Questions	Initial Answer	Theoretical Lens	Specific Activities
Where do I start looking?	The observation began by examining places from which Batik *Sidomukti* pieces could be obtained.	Culture	• Conducting interviews with experts on Batik *Sidomukti*
How do I do it?	By investigating the motifs of Batik *Sidomukti* directly.	Alternative Thinking	• Analyzing the motifs of Batik *Sidomukti* • Identifying the arithmetic and discrete mathematics concepts present in the motifs of Batik *Sidomukti*
How do I know that I have found something significant?	The outcomes of alternative thinking are reviewed first.	The Philosophy of Mathematics	• Identifying the arithmetic and discrete mathematics present in the motifs of Batik *Sidomukti* • Discovering the presence of arithmetic and discrete mathematics concepts in the motifs of Batik *Sidomukti*
How to understand it?	It is important for the preservation of Batik culture and for the development of mathematics.	Anthropological Methodology	• Integrating two systems of knowledge (cultural and mathematical) to support both preservation and knowledge • Describing the arithmetic and discrete mathematics concepts in the motifs of Batik *Sidomukti*

The research was conducted at several locations in Surakarta, including a batik shop, a batik production center, and a batik museum. These sites were selected for their relevance to the traditional production processes and cultural representation of Batik *Sidomukti*. The object of study was the arithmetic and discrete mathematics identified in the Batik *Sidomukti* motifs, while the subject was the batik motifs themselves as cultural representations.

Qualitative data was collected through observation, interview, and documentation. Observation was conducted on the arithmetic and discrete mathematics concepts applied in Batik *Sidomukti*. An interview was conducted in a semi-structured manner with a mathematician from a private Indonesian university specializing in arithmetic and discrete mathematics to support the observation data. The instrument used to guide the interview was validated in advance by an expert in ethnomathematics from a private university in Indonesia. The questions primarily asked about the following things: (1) whether or not certain arithmetic and discrete mathematics concepts are applied, and (2) whether or not the context of Batik *Sidomukti* can be used in mathematics learning. Documentation was performed to document the observation and interview results.

Data analysis was conducted in three main stages: data reduction, data presentation, and conclusion drawing (Johnson & Christensen, 2024). During the data reduction phase, 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 Batik *Sidomukti* motifs and arithmetic and discrete mathematics concepts, such as modular arithmetic, tiling arithmetic, graph theory, and combinatorics. However, their integration into instructional practices within these domains has yet to be adequately explored. Conclusions were drawn based on the researcher's interpretation, supported by expertise in both mathematics and batik culture, to ensure the analysis reflects an authentic relationship between mathematics and Batik *Sidomukti* culture. The validity of the findings was ensured through data source triangulation, involving other experts to enhance the accuracy of interpretation and analysis. Three experts were consulted during this process: a mathematics educator, a batik practitioner, and a cultural studies scholar. Their input helped refine the categorization of mathematical concepts identified in the batik motifs, ensured cultural authenticity, and strengthened the relevance of the interpretation to mathematics education.

RESULTS AND DISCUSSION

Where do I Start Looking?

The researcher explored two Batik *Sidomukti* pieces in two different places. The researcher observed the first Batik *Sidomukti* piece 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 August 16, 2024, with the manager and curator of the museum, Asti Suryo Astuti, S.H., K.N. (54 years old), who has been active in the field of Javanese interior batik for over 24 years, regarding the values and philosophy behind Batik *Sidomukti*. Figure 2 depicts the motif of Batik *Sidomukti*.

Figure 2. Batik *Sidomukti* piece made by the Danar Hadi Batik Museum

Based on the interview, it was figured out that

> *"...there are several types of Batik Sido motifs. Among them are Batik Sidomulyo, Batik Sidomukti, and Batik Sidoluhur. These types of batik motifs are characterized by diamond- or rhombus-like patterns all over the fabric, sized approximately 5 cm x 5 cm with stripes 1 cm wide in between. What is striking lies in the background of each type of sido motif* (Figures 3, Figure 4, and Figure 5)*."*

Figure 3. Batik *Sidomukti*

Figure 4. Batik *Sidoluhur*

Figure 5. Batik *Sidomulyo*

The second Batik *Sidomukti* piece was observed at the Gunawan Batik Production Center, located in Kauman Batik Village (Jl. K.H. Hasyim Ashari No. 6, Kauman, Pasar Kliwon District, Surakarta City, Central Java, 57112, Indonesia). The researcher conducted an interview with a batik stamping craftsman, known as a *Batik Cap* craftsman, named Sutanto (64 years old), who has been engaged in the *Batik Cap* sector for more than 48 years, regarding the making of Batik *Sidomukti* using the stamping method. The Batik *Sidomukti* sample obtained during this visit was of a *Batik Cap* type. Figure 6 depicts the stamping tool (*Cap*) of Batik *Sidomukti*.

Figure 6. Batik *Sidomukti* stamping tool

The Batik *Sidomukti* sample selected was merchant batik, featuring a naturally soga-dyed *Isen Ukul* background. This batik piece includes four ornamental varieties: houses or *Joli*, *Garuda* wings, bouquets or *Buketan*, and animals. Figure 7, Figure 8, Figure 9, and Figure 10 depict the varieties of *Joli*, *Buketan*, *Garuda* wings, and animals.

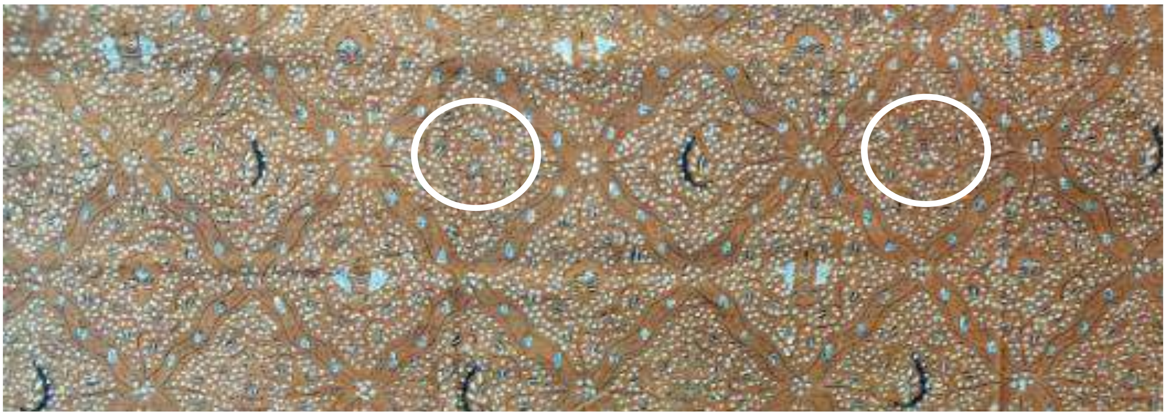

Figure 7. Variety of *Joli*

Figure 8. Variety of *Garuda* wings

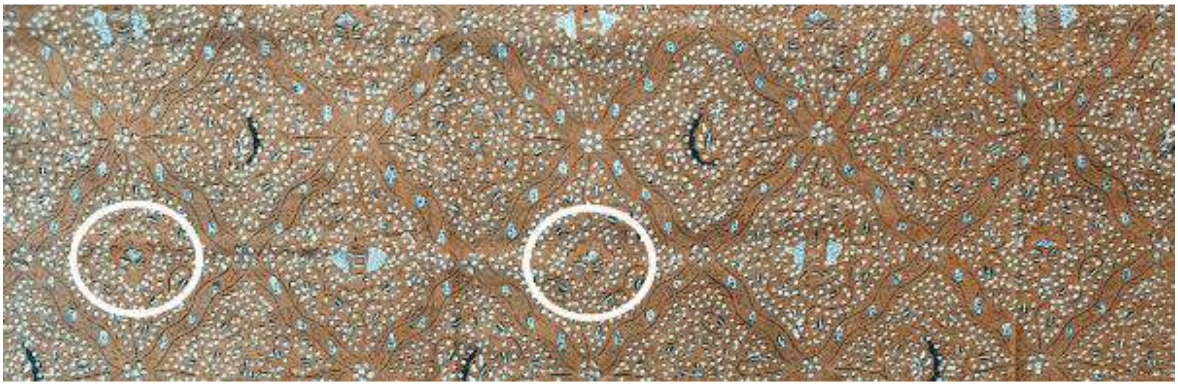

Figure 9. Variety of *Buketan*

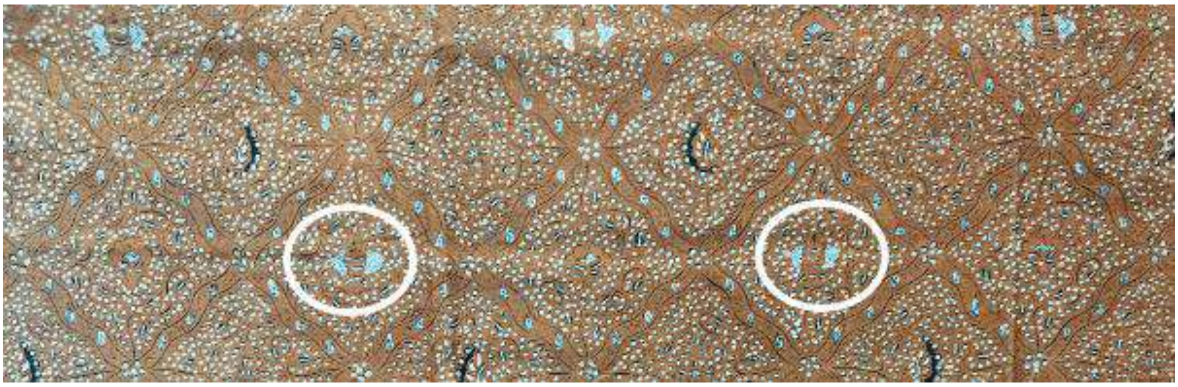

Figure 10. Variety of animals

How do I do It?

Batik *Sidomukti* carries an interesting historical story. Batik *Sidomukti* is one of Batik *Surakarta Sundananan* adapted from the Yogyakarta Sultanate. From an interview with Zubair, a functional staff member of the Danar Hadi Batik Museum, on August 16, 2024, it was revealed that,

> *"…the birth of Batik Surakarta was marked by the political event of the ratification of the Giyanti Agreement on February 13, 1755, which divided the Sultanate of Mataram into two. Following the territorial partition, all batik of the Sultanate of Mataram fell into the possession of the Sultanate of Yogyakarta. Since then, the Mataram-style batik heritage has been preserved, serving as a reference and standard for Yogyakarta-style batik. The Sunanate of Surakarta later adapted several motifs of Mataram-style batik. Innovations of batik motifs emerged while sticking to references of the basic (Mataram-style batik) motifs. To date, numerous batik motifs have come up as adaptations of Mataram batik works, including Batik Sidomukti."*

This research is initiated through a detailed observation of Batik *Sidomukti* motifs within the framework of ethnomathematics, aiming to investigate the interconnection between cultural elements and mathematical concepts. The observation concentrates on identifying visual components that potentially reflect mathematical structures, particularly those associated with arithmetic and branches of discrete mathematics such as modular arithmetic, tiling arithmetic, graph theory, and combinatorics, all embedded within the batik's design compositions.

Based on these observations, a further analysis was conducted to explore the presence of mathematical concepts such as modular arithmetic, tiling arithmetic, graph theory, and combinatorics. This research seeks to uncover repetition patterns, structural regularities, and inter-element relationships that reflect underlying mathematical principles within the Batik *Sidomukti* design. These findings are expected to contribute to the development of culturally contextualized mathematics learning.

How do I Know that I have Found Something Significant?

The researcher initially determined four mathematical concepts, modular arithmetic, tiling arithmetic, graph theory, and combinatorics, as the focus of investigation. Through a detailed analysis of the visual patterns and structural elements of Batik *Sidomukti*, these concepts were identified to be inherently present within the batik's design. The repetition of motifs reflects modular arithmetic, the arrangement of shapes demonstrates tiling arithmetic, the variation in motif placement reveals combinatorics, and the interconnected elements can be interpreted through graph theory. These findings confirm that Batik *Sidomukti* not only embodies cultural values but also encodes mathematical principles that are highly relevant for contextual learning.

Modular arithmetic is a system of arithmetic for integers, where numbers "wrap around" after reaching a certain value known as the modulus. It is widely used in various fields, including computer science, cryptography, and number theory (Banoth & Regar, 2023). In the context of this study, modular arithmetic was identified within the visual patterns of Batik *Sidomukti*. The repetition and regular interval of motifs in the batik design reflect congruence relationships characteristic of modular systems, where specific elements repeat after a fixed number of positions. This indicates that traditional batik designs, though developed artistically, inherently demonstrate mathematical structures that align with modular arithmetic principles (Putri et al., 2024). Previous research has also identified the application of modular arithmetic in various other batik motifs, such as those in Batik Tuntrum (Nurcahyo et al., 2024).

Figure 11 illustrates four main ornamental elements appear periodically across several units. These ornaments are repeated every two rows and two columns. In this representation, rows are indicated by blue lines, while columns by yellow lines. Positions can be labeled using coordinate pairs (i, j), where i denotes the row index and j the column index. Consequently, the position of a specific ornament can be determined using modular arithmetic.

Figure 11. Batik *Sidomukti* as a row and column

For instance, the *Garuda* Wings motif appears at positions where:

$i \bmod 2 = 0$

$j \bmod 2 = 0$

That is, for all *(i, j)* such that:

$i \in \{2,4,6,8,12\}$

$j \in \{2,4,6,8,12\}$

Therefore, the *Garuda* Wings ornament is placed at the following coordinates:

(2,2), (2,4), (2,6), (2,8), (2,12);

(4,2), (4,4), (4,6), (4,8), (4,12);

(6,2), (6,4), (6,6), (6,8), (6,12);

(8,2), (8,4), (8,6), (8,8), (8,12);

(12,2), (12,4), (12,6), (12,8), (12,12).

This periodic arrangement exemplifies the application of modular arithmetic in the spatial organization of traditional batik patterns.

Tiling arithmetic refers to the study of mathematical patterns that emerge from the systematic arrangement of repeating units or shapes to completely cover a surface without gaps or overlaps (Adams, 2023). It is commonly used in geometry and design to analyze how space can be efficiently partitioned through regular repetition (Wu et al., 2021). In the context of this study, tiling arithmetic was identified in the layout of Batik *Sidomukti*, where the ornamental motifs are arranged in a highly structured and periodic manner. The repetition of geometrical patterns such as parallelograms and floral elements demonstrates a tiling structure that aligns with mathematical principles of tessellation. This reveals how traditional batik designs inherently apply spatial reasoning and regularity, reflecting the essence of tiling arithmetic. Previous research has also identified the application of tiling arithmetic in various other batik motifs, such as those in Batik *Solo* (Faiziyah et al., 2021).

Figure 12 illustrates a Batik *Sidomukti* pattern that clearly exhibits the principles of tiling arithmetic. The motif is organized in a systematic and repeating rhombus-based grid, where each tile delimited by white diagonal lines contains a distinct ornamental unit. These units are replicated across both horizontal and vertical directions without gaps or overlaps, forming a tessellated plane. The consistency of this repetition, especially in terms of spacing and orientation, is a hallmark of tiling arithmetic, which studies the mathematical structuring of space through repeated units. In conclusion, the design exemplifies how traditional batik patterns inherently apply the mathematical logic of tiling, demonstrating spatial regularity and symmetry. This serves as evidence that cultural artifacts like batik can be rich sources for contextualizing abstract mathematical concepts, particularly in educational settings focused on geometry and pattern recognition.

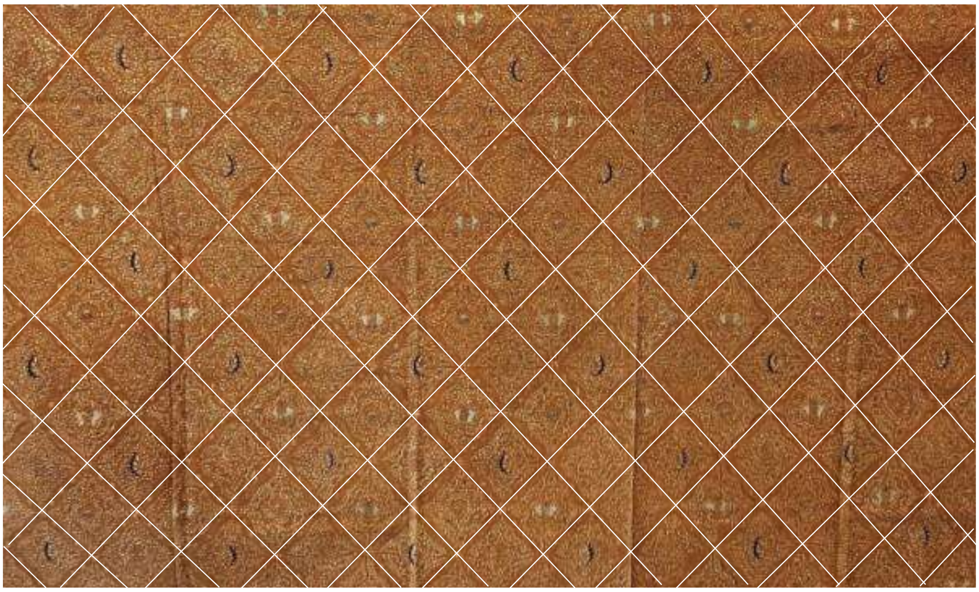

Figure 12. Tiling in Batik *Sidomukti*

Graph theory is a branch of mathematics that focuses on the study of graphs, mathematical concepts used to model relationships between pairs of objects (Erciyes, 2021). A graph consists of a set of vertices (or nodes) connected by edges, and is widely applied in fields such as computer science, transportation, and social networks (Aggarwal & Murty, 2020). In the context of Batik *Sidomukti*, graph theory can be observed through the arrangement and connection of motifs across the fabric. Each motif can be viewed as a vertex, while the spatial alignment and symmetry between motifs represent edges. These relationships form a network-like pattern that reflects the underlying structure of a graph. The application of graph theory in Batik *Sidomukti* highlights the presence of mathematical logic embedded in traditional art, offering new ways to interpret cultural patterns through a formal mathematical lens. Previous research has also identified the application of graph theory in various other batik motifs, such as those in Batik *Grompol*, Batik *Parang*, and Batik *Kawung* (Akmal et al., 2021).

The application of graph theory can be clearly observed in the Batik *Sidomukti* pattern, as illustrated in Figure 13. The motifs are arranged in a systematic and repetitive grid, where each intersection of the rhombus tiles creates a potential point of connectivity. This structural arrangement is further abstracted in Figure 14, where the dots represent the vertices (nodes) of a graph and the connecting lines serve as the edges.

Figure 13. Batik *Sidomukti*

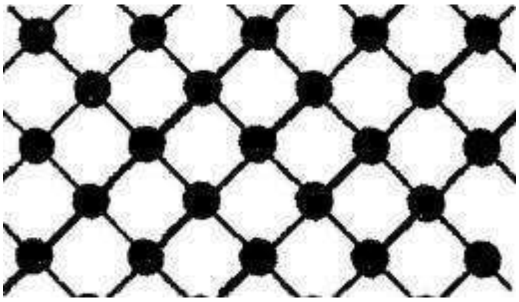

Figure 14. Vertices (nodes) and connecting lines

Each black dot in Figure 14 functions as a vertex, representing a fixed motif position within the batik layout. The lines connecting the dots illustrate the relationships or connections between adjacent motifs, forming a network structure that aligns with the principles of graph theory. The consistency in spacing and direction of connections across the design exemplifies a planar and regular graph structure. In conclusion, the spatial organization in Batik *Sidomukti* not only reflects aesthetic harmony but also demonstrates fundamental graph-theoretical properties. This confirms that traditional textile patterns inherently contain mathematical elements that can be modeled, analyzed, and even utilized for educational purposes within the framework of discrete mathematics.

Combinatorics is a branch of mathematics that focuses on the study of counting, arrangement, and selection of objects based on specific rules or constraints (Ravichandran & Razdan, 2025). It is essential in analyzing patterns, permutations, and combinations within discrete structures (Aigner, 2023). In the context of Batik *Sidomukti*, combinatorics principles can be observed in the strategic placement of various ornamental elements such as *Joli*, *Garuda* wings, *Buketan*, and animals motif. These elements are not randomly distributed but are arranged in specific sequences and combinations to create aesthetic balance and thematic coherence. The repetition, variation, and alternation of motifs reflect combinatorial reasoning, where different motifs are selected and positioned systematically to generate a visually harmonious design. This demonstrates that traditional batik patterns are rich with mathematical thought, particularly in how they organize complex visual elements through combinatorial structures. Previous research has also identified the application of combinatorics in coloring determination line motif batik design (Izza et al., 2023).

Figure 15 depicts each batik tile features a symmetrical ornamental motif, then Figure 16 illustrates structure using four colored rhombus shapes, orange, blue, yellow, and gray, each representing a distinct variation or component within a motif. The arrangement of these colored shapes reflects the application of combinatorics principles, where different combinations of elements result in visually distinct units while maintaining overall symmetry. In conclusion, the variation and repetition of motif components in Batik *Sidomukti*, as modeled through colored segmentation, demonstrate the use of combinatorial logic in traditional textile design. This shows that batik not only serves as a cultural artifact but also embodies structured mathematical ideas that can be explored in educational contexts.

Figure 15. Batik *Sidomukti*

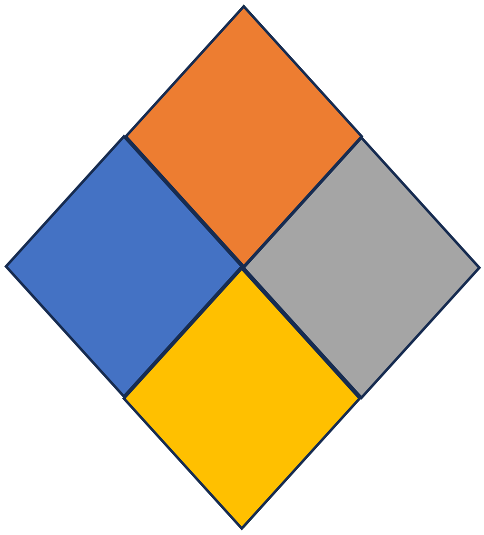

Figure 16. Combinatorics illustrate

How to Understand It?

To validate the data, source triangulation was conducted by comparing the researcher's assumptions about the arithmetic and discrete mathematics concepts applied in Batik *Sidomukti* with the perspectives of a mathematics expert specializing in the four targeted concepts: modular arithmetic, tiling arithmetic, graph theory, and combinatorics. The source triangulation process was carried out using a walkthrough interview, where the researcher communicated directly with the expert to compare the findings with the expert's opinions (Fitri & Prahmana, 2020; Tracy, 2024). Two fundamental questions were posed to the expert: (1) whether the arithmetic and discrete mathematics concepts are applied in Batik *Sidomukti*, and (2) whether the context of Batik *Sidomukti* could be used in mathematics education.

The proposed arithmetic and discrete mathematics concepts were validated by an expert in the field. The expert confirmed the researcher's findings by identifying the same key concepts of modular arithmetic, tiling arithmetic, graph theory, and combinatorics, thus supporting the answer to the first research question. Observations revealed that motifs in *Batik Tulis*, which are drawn manually, tend to exhibit less symmetry compared to the highly symmetrical motifs in *Batik Cap*, where consistent shapes and sizes are achieved through the stamping technique. Despite this difference in symmetry, both techniques, manually drawing and stamping, fundamentally applied the principles of arithmetic and discrete mathematics, particularly about modular arithmetic, tiling arithmetic, graph theory, and combinatorics.

In response to the second question, the expert confirmed that Batik *Sidomukti* can be effectively utilized as a learning context in mathematics instruction. The expert stated that teachers can integrate Batik *Sidomukti* into the teaching of arithmetic and discrete mathematics, particularly in modular arithmetic and tiling arithmetic. Furthermore, Batik *Sidomukti* is also relevant for introducing graph theory and combinatorics, where students are encouraged to analyze the repetition patterns, connectivity between motifs, and variations in motif arrangements across the fabric. This approach offers students the opportunity to engage with abstract mathematical concepts through culturally grounded and visually contextualized representations.

Several aspects of this research still need further investigation, particularly concerning the implementation of Batik *Sidomukti* in mathematics instruction and its effectiveness. Further investigation into these aspects will expand the benefits of the research, not only in enhancing students' mathematics understanding, but also in increasing their familiarity with the cultural heritage of Batik *Sidomukti*.

To support practical implementation, the researcher has developed an example problem related to arithmetic and discrete mathematics concepts, along with the solution, which can be directly implemented in mathematics instruction. An example is intended to enhance teachers' familiarity with a broader range of problem types in areas such as modular arithmetic, tiling arithmetic, graph theory, and combinatorics. Figure 17 presents an example of a contextualized mathematical problem within Batik *Sidomukti*. However, this study remains limited in scope, focusing exclusively on the application of those specific discrete mathematics concepts within Batik *Sidomukti*. Therefore, further research is needed to explore other mathematical ideas that may be embedded in various batik designs beyond Batik *Sidomukti*.

Based on the findings, it is recommended for teachers to utilize Batik *Sidomukti* as an instructional resource for teaching arithmetic and discrete mathematics concepts. The impact of this research extends across both cultural and educational domains, particularly in mathematics education: it supports the preservation of Batik *Sidomukti* as part of Indonesia's cultural heritage, while also offering a novel and comprehensive approach to mathematics instruction. Future research can develop this work by integrating cultural elements into the teaching of discrete mathematics to enhance the 21st-century mathematical competencies, such as reflective thinking (Sa'dijah et al., 2020). Even ethnography can be integrated with the STEAM approach and the flip-flop model (Ishartono et al., 2024).

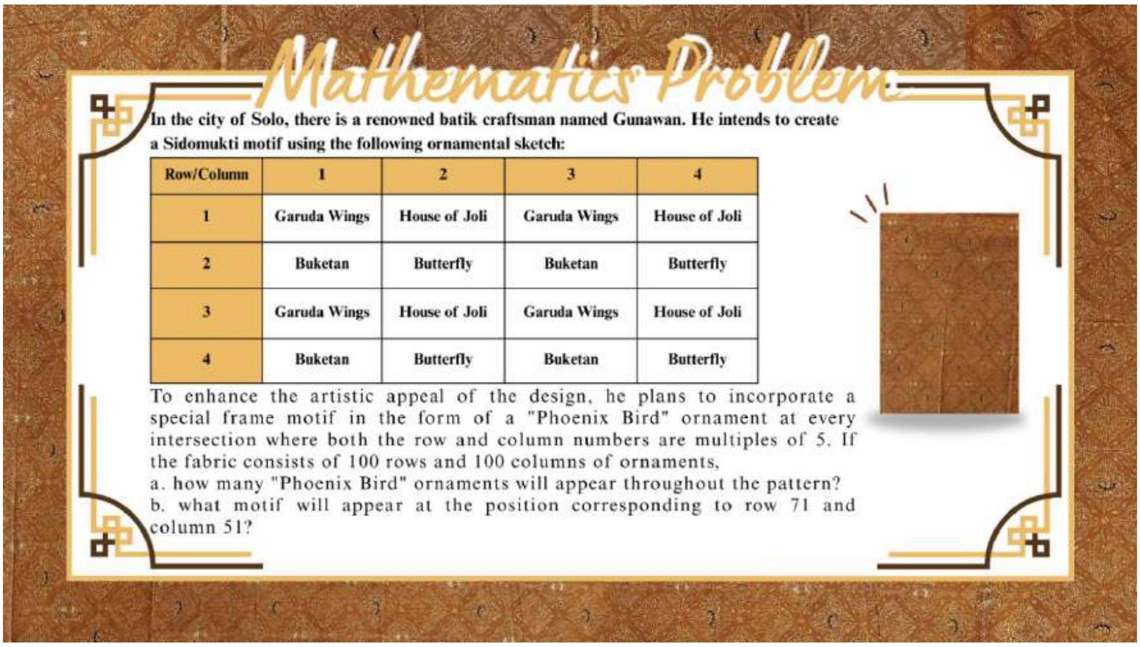

Figure 17. Mathematics problem

CONCLUSION

Preserving batik heritage, including Batik *Sidomukti*, is essential and one effective strategy is integrating it into mathematics education for younger generations through the lens of ethnomathematics. This approach enables researchers to investigate the arithmetic and discrete mathematics concepts embedded within Batik *Sidomukti* by addressing four guiding questions: “Where do I start looking?”, “How do I do it?”, “How do I know that I have found something significant?”, and “How do I understand it?”. The identified mathematical concepts include modular arithmetic, tiling arithmetic, graph theory, and combinatorics. Incorporating these mathematical concepts through Batik *Sidomukti* in educational settings not only enhances students’ understanding of arithmetic and discrete mathematics concepts but also contributes to the preservation of cultural heritage. This study is expected to serve as a valuable reference for future interdisciplinary research, particularly at the intersection of culture and mathematics.

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