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LEVERAGING JAVANESE BATIK MOTIVES IN TEACHING NUMBER PATTERNS: THE PRELIMINARY PHASE IN ETHNO-REALISTIC MATHEMATICS EDUCATION APPROACH

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ABSTRACT

Traditional textiles, such as Javanese Batik in Indonesia, are not only cultural artifacts but also repositories of mathematical knowledge. While previous studies have explored the geometric transformations embedded in Batik motives, little attention has been paid to their numerical patterns and educational potential beyond geometry. Addressing this gap, the present study investigates the mathematical structures—particularly numerical patterns—and ethical values inherent in Javanese Batik motives. The novelty of this research lies in uncovering the integration of cultural heritage and mathematics through ethnomathematical analysis, which remains underexplored in existing literature. Utilizing an ethnographic approach, including literature review, documentation, and field observations, the study identifies recurring numerical patterns and embedded cultural philosophies within Batik designs. These findings reveal that Javanese Batik offers meaningful contexts not only for teaching mathematical concepts but also for fostering character education through values such as discipline, patience, and harmony. The results suggest that these motives can be transformed into culturally responsive teaching materials, particularly e-modules for learning numerical patterns. This study contributes to the broader field of mathematics education by demonstrating how local cultural artifacts can support cognitive and affective learning goals, thus offering a novel pathway for integrating mathematics with cultural and moral education.

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1. INTRODUCTION

Indonesia's diverse cultural heritage provides a unique and fertile ground for contextualizing mathematics education. Integrating mathematical concepts with local cultural contexts offers a promising direction in response to the need for more relevant and meaningful learning experiences. Such integration not only enhances the accessibility of mathematics across different societal groups but also aligns with contemporary educational paradigms that emphasize inclusivity and contextual learning [1], [2]. Ethnomathematics, a concept introduced by D'Ambrosio [3], serves as a theoretical framework for understanding mathematical practices embedded in various cultural systems. This approach emphasizes that mathematical knowledge is not universal in form but can be manifested through culturally specific representations, processes, and problem-solving strategies.

Reframing mathematics through cultural perspectives fosters an inclusive learning environment that supports the development of students as critical, reflective, and culturally aware thinkers. The incorporation of ethnomathematical elements into classroom practices has demonstrated positive outcomes in fostering engagement, improving comprehension, and bridging the gap between abstract mathematical ideas and learners lived experiences. For instance, using Batik motives as a context for geometric transformation or employing traditional games for teaching arithmetic operations illustrates how mathematics can be grounded in culturally familiar settings [4], [5], [6]. These practices deepen conceptual understanding and cultivate students' appreciation for the cultural relevance of mathematics.

Despite these advances, the integration of culture into mathematics instruction remains underdeveloped in many educational systems. There is a pressing need for pedagogical models that effectively connect mathematical content with students' cultural backgrounds, cognitive development stages, and real-life experiences. Ethno-Realistic Mathematics Education (Ethno-RME), which synthesizes the principles of Ethnomathematics and Realistic Mathematics Education (RME), addresses this need by offering a dual framework that supports both cultural contextualization and conceptual development [7]. This approach aligns with the core tenets of meaningful learning, emphasizing the role of context, relevance, and student-centered exploration in mathematics education.

In this study, the cultural artifact of Javanese Batik serves as a focal point for developing context-based learning materials. As a rich representation of Javanese philosophy, symbolism, and aesthetics, Batik provides multiple entry points for mathematical exploration, particularly in numerical patterns and geometric transformations. By drawing comparisons with other ethnomathematical studies across Indonesia, this research seeks to identify culturally grounded mathematical insights that can inform the design of innovative teaching materials.

Finally, the primary objective of this study is to contribute to the advancement of mathematics education by developing a local instructional theory for number pattern learning grounded in the principles of Ethno-Realistic Mathematics Education (Ethno-RME). This instructional theory aims to enhance students' conceptual understanding of mathematical content while simultaneously affirming and valuing their cultural identities. The findings presented in this paper represent the initial phase in the implementation of the Ethno-RME approach toward constructing a contextually relevant instructional theory in mathematics. Through this effort, the research highlights the significance of cultural sustainability in education and positions Ethnomathematics as a vital field within the global discourse on equitable, inclusive, and contextually responsive mathematics education.

2. RESEARCH METHODS

This study employs a qualitative ethnographic research design to investigate the mathematical concepts embedded within Javanese Batik motives. The approach is grounded in the principles of Ethnomathematics [8] and aims to uncover the mathematical reasoning, techniques, and socio-cultural meanings reflected in traditional Batik designs [9]. The methodological framework is informed by Alangui's model [10], which emphasizes the integration of cultural context into mathematical inquiry. Additionally, the ethnographic process is guided by four foundational questions, as Spradley [5]: suggested: (1) Where should the investigation begin? (2) How should observations be conducted? (3) How can significant findings be identified? Moreover, (4) How can these findings be understood?

To operationalize these questions, the research design included specific activities outlined in Table 1.

Table 1. Ethnographic Questions and Research Activities

Ethnographic Question	Research Activity
Where should the investigation begin?	Conducting interviews with cultural experts and community informants in Yogyakarta to explore the underlying philosophy and symbolism of Batik motives.
How should observations be conducted?	Identifying and analyzing the quantitative, relational, and spatial attributes of Batik motives and associating them with relevant mathematical ideas.
How can significant findings be identified?	Systematic observation and documentation of Batik motives, supplemented by a literature review to extract embedded mathematical concepts.
How can these findings be understood?	Interpreting the connection between mathematical structures and the cultural significance of Javanese Batik motives.

Data collection involved systematic observation and detailed documentation of cultural artifacts in Javanese Batik, explicitly focusing on numerical patterns. The methods employed included structured non-participatory observation, semi-structured interviews, and artifact documentation. Structured non-participatory observation was chosen to ensure the researcher maintained objectivity by not engaging directly in the observed activities. A comprehensive literature review on Batik supplemented these observations and interviews.

All data were meticulously recorded through photographs, videos, and field notes, and subsequently analyzed using source triangulation to ensure the reliability and validity of the findings. The triangulation process was conducted by comparing data from various sources, including images of Batik motives to identify embedded mathematical concepts, video recordings of interviews, and field notes to uncover the cultural meanings associated with the motives. The analysis focused on uncovering and describing each significant element in alignment with the study's objectives.

The findings of this research are expected to provide valuable insights for educators and researchers, advocating for the integration of Ethnomathematics into mathematics education. For the Yogyakarta community, the findings may foster a sense of ownership and pride in their cultural heritage. They not only perceive Batik as an aesthetic artifact but also recognize the mathematical and cultural values embedded within its unique patterns. By connecting mathematical concepts to students' everyday experiences, this approach strengthens cultural identity and facilitates the transmission of social values through the incorporation of local culture into educational practice.

3. RESULTS AND DISCUSSION

This section presents the findings of the study, which highlight the integration of mathematical principles within Javanese Batik motives and their pedagogical potential in contextual mathematics education. Each motive is a repository of mathematical content intertwined with rich cultural narratives, offering learners invaluable insights and life lessons. Therefore, this research is dedicated to a detailed exploration of the numerical patterns inherent in Javanese Batik motives, which will serve as foundational contexts for developing a local instructional theory for number pattern learning grounded in the principles of Ethno-RME. This instructional theory aims to enhance students' conceptual understanding of number pattern content while simultaneously affirming and valuing their cultural identities. These findings substantiate the feasibility of using Batik designs as contextual tools for introducing and deepening students' understanding of number patterns.

Moreover, beyond their mathematical significance, these motives impart a plethora of cultural values intended to foster ethical character development and instill positive societal values among students. By integrating these cultural dimensions into the learning process, the study aims to enrich mathematics education with broader cultural perspectives, thereby promoting a deeper understanding and appreciation of mathematical concepts and cultural heritage. Please refer to the forthcoming section for a more detailed exposition of the exploration results.

3.1 Batik Motive of *Grompol*

The name "*Grompol*" holds significance in Javanese culture, which translates to "gathering." Furthermore, **Figure 1** illustrates a *Grompol* Batik motive commonly adorned on fabrics for weddings and family gatherings, symbolizing the unity of families and aspirations for happiness and prosperity. The *Grompol* motives in Javanese Batik often feature repetitive geometric elements arranged in a square or grid-like pattern. This structured arrangement serves as a visual representation of square numbers within the motive.

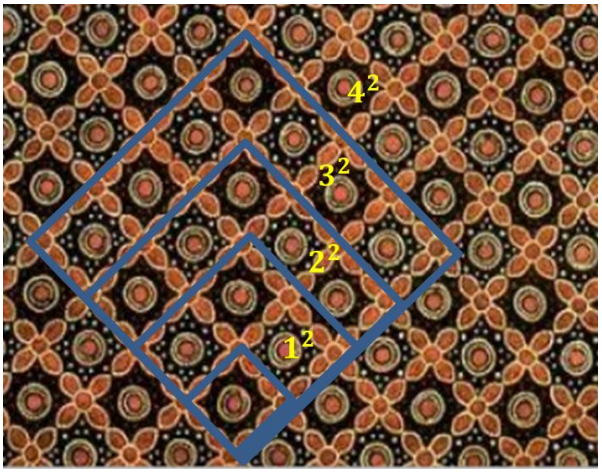

Figure 1. The Representation of Square Numbers in Batik Motive of *Grompol*

Figure 1 demonstrates that square numbers in mathematics are generated by squaring positive integers, yielding perfect squares such as 1, 4, 9, 16, and so forth (derived from 12, 22, 32, 42, etc.). These numerical values represent the squares' areas with corresponding side lengths and are fundamental expressions of geometric regularity. The consistent pattern and structure inherent in square numbers reveal a mathematical order that is visually and conceptually coherent, making them particularly relevant for applications in visual art and design.

Integrating square number patterns into the *Grompol* motive in Javanese Batik exemplifies the intersection of mathematical reasoning and cultural expression. This motive, characterized by its symmetrical and repetitive structures, mirrors the conceptual essence of square numbers, thereby reflecting traditional values of harmony and balance within the Javanese community. Such integration enhances the cultural richness and pedagogical potential of Batik, providing a meaningful context for exploring mathematical ideas through indigenous art forms. As a result, Batik functions as a medium of artistic heritage and serves as a dynamic platform for interdisciplinary learning, where mathematics is contextualized within local wisdom and cultural identity.

3.2 Batik Motive of *Kawung*

Figure 2 presents the *Kawung* Batik motive, which holds significant cultural value in Javanese tradition as a symbol of purity, eternity, and spiritual insight. Historically reserved for the royal court, this motive embodies philosophical ideals such as wisdom, self-control, and inner balance. It is enduring use and symbolic richness reflect the integration of cultural beliefs and aesthetic principles, underscoring the depth of meaning embedded within traditional Batik patterns.

Mathematically, the *Kawung* motive often features repeated oval shapes systematically arranged within a rectangular framework. This structured repetition can be interpreted as a visual embodiment of rectangular numbers, wherein elements are organized into rows and columns forming complete rectangles. Such configurations enhance the motive's visual harmony and reveal an implicit understanding of mathematical principles embedded in artistic expressions. Consequently, the *Kawung* motive exemplifies how cultural artifacts can serve as meaningful contexts for exploring mathematical structures, particularly in ethnomathematics and culturally responsive mathematics education.

Figure 2. Batik Motive of *Kawung*

Furthermore, rectangular numbers are formed by multiplying two positive integers that need not be equal, resulting in numbers that can form a rectangular shape. Examples include pairs like 2×3, 3×4, 4×5, and so forth. These numbers correspond to the rectangles with sides of those lengths and symbolize the geometric harmony and symmetry inherent in traditional Javanese art. The incorporation of rectangular number patterns into *Kawung* motives highlights the intersection of mathematical concepts with cultural symbolism, enhancing the aesthetic and educational dimensions of Javanese Batik.

Figure 3. Oval Direction and Pattern Sequence in *Kawung* Batik Motives

On the other hand, Repiyan et al. [11] identified that the arrangement of *Kawung* Batik motives, when analyzed from the orientation of the design elements, reveals a discernible arithmetic sequence. As illustrated in Figure 3, the oval shapes forming the motive follow an ordered numerical pattern based on their spatial direction. Specifically, the leftward oblique orientation of the oval elements corresponds to the sequence 1, 3, 4, 5, 7, 9, and so forth, indicating the presence of arithmetic sequences in which each successive term increases by a common difference of 2. Consequently, this pattern can be generalized using the standard formula for the nth term of an arithmetic sequence, as presented in Equation (1).

$$U_n = 2n - 1 \tag{1}$$

Let n denote a positive integer representing the position or index of a term in a numerical sequence and let U_n represent the $n-th$ term of the sequence.

Similarly, the rightward oblique orientation of the motive demonstrates a different but consistent arithmetic pattern, characterized by the sequence 2, 4, 6, 8, 10, 12, and so on. This sequence also exhibits a constant difference of 2 between consecutive terms, further reinforcing the presence of an underlying mathematical structure in the motive's design. Accordingly, this arrangement can be modeled using a second arithmetic sequence formula, shown in Equation (2). These observations underscore the mathematical depth embedded in traditional Batik motives, revealing how visual cultural artifacts can reflect systematic numerical principles and support culturally contextualized mathematics learning.

$$U_n = 2n \tag{2}$$

3.3 Batik Motive of *Truntum*

The term "*Truntum*" originates from the Javanese word *Tumaruntum*, which translates to "to grow back" or "to spring back." This etymological root reflects the underlying philosophy of the *Truntum* Batik motive, which is traditionally associated with enduring love and strengthening emotional bonds. As depicted in **Figure 4**, the *Truntum* motive holds significant symbolic value, particularly within matrimonial contexts, where it represents affection that continuously flourishes and renews. Its presence in wedding ceremonies highlights its role as a visual metaphor for constancy, loyalty, and the cyclical nature of love and commitment.

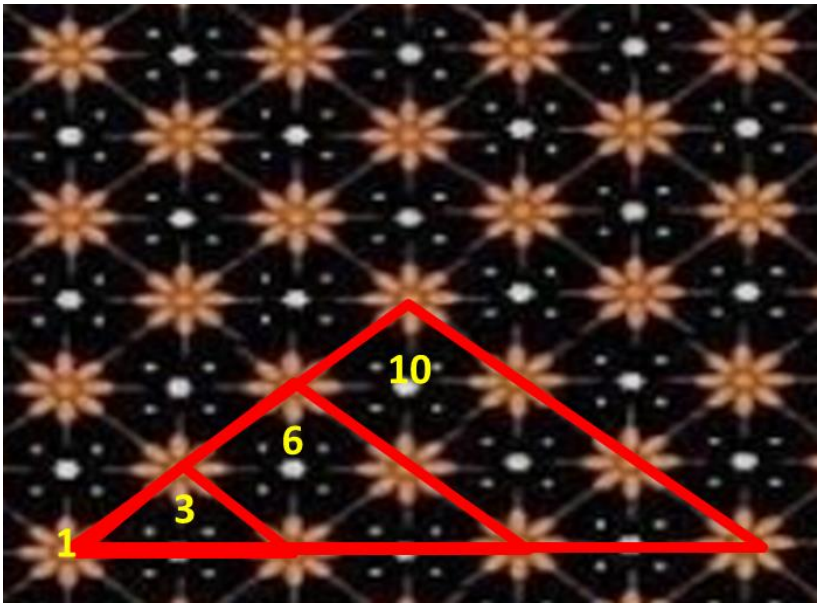

Figure 4. Representation of Triangular Patterns in Batik Motive of *Truntum*

From a mathematical perspective, the structural arrangement of the *Truntum* motive demonstrates a high degree of regularity and repetition. The design typically comprises numerous small, uniformly repeated elements that coalesce into more complex and aesthetically intricate patterns. Observations of **Figure 4** suggest that these repeated units often form triangular configurations, either explicitly or implicitly, within the overall design. This characteristic introduces a geometric dimension to the motive, revealing an embedded triangular number pattern. Integrating such mathematical structure within traditional Batik artistry exemplifies the potential for cultural artifacts to serve as pedagogical tools, linking mathematical concepts with culturally meaningful visual representations.

Mathematically, a triangular number pattern is characterized by numbers arranged in a way that forms a triangle. The $n-th$ triangular number is the sum of the first n positive integers, represented by the formula, as presented in **Equation (3)**. For example, the first few triangular numbers are 1, 3, 6, 10, and so on, corresponding to the sums $1, 1+2, 1+2+3, 1+2+3+4,$ etc. The use of such patterns in *Truntum* motives not only enhances their aesthetic appeal but also reflects the deep mathematical and cultural symbolism embedded in traditional Javanese batik artistry.

$$T_n = \frac{n(n+1)}{2} \tag{3}$$

3.4 Batik Motive of *Nitik*

Nitik, meaning "dot" in Javanese, is a foundational motive in batik design. The *Nitik* batik motive, as shown in **Figure 5**, is characterized by its pattern of regularly arranged dots. It is often associated with sequences of odd numbers, either in the number of dots per row or in the overall arrangement of the motive.

Mathematically, an odd number pattern consists of numbers not divisible by two, such as 1, 3, 5, 7, 9, and so on. These odd numbers create a distinctive sequence, contributing to the unique aesthetic and cultural significance of the *Nitik* motive. The consistent use of odd numbers in the *Nitik* motive reflects a deliberate choice that aligns with both artistic and mathematical principles, further enriching the cultural heritage embodied in traditional Javanese batik.

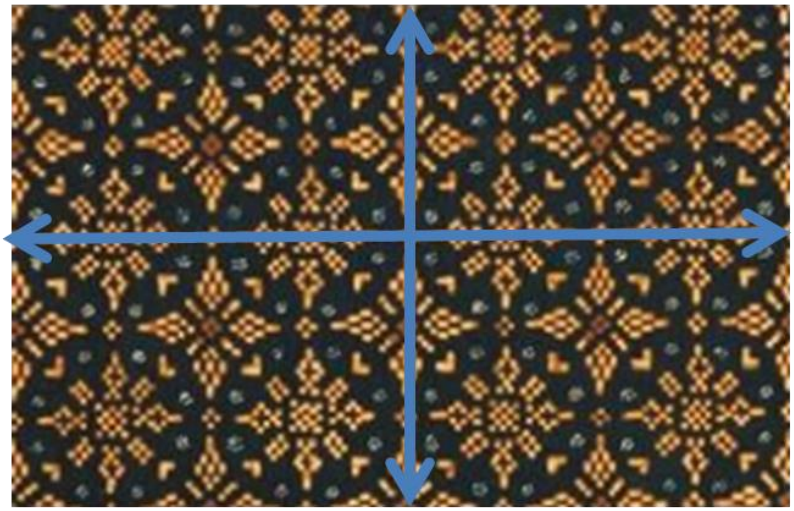

Figure 5. Batik Motive of *Nitik*

In addition, the *Nitik* Batik motive represents a visual arrangement of discrete dots that collectively form a symmetrical and aesthetically coherent pattern. As illustrated in **Figure 5**, a prominent axis of symmetry, indicated by a thick line, divides the motive into two mirrored halves. This symmetrical configuration is not merely decorative but carries profound philosophical significance rooted in Javanese cultural values, particularly the ideals of balance, harmony, and order in life. The motive's design reflects the Javanese worldview, where visual symmetry symbolizes inner equilibrium and social harmony.

From a mathematical standpoint, the motive begins with the fundamental element of a dot—one of the most basic and abstract concepts in mathematics. Despite its simplicity, the repeated and structured arrangement of dots in the *Nitik* motive yields complex, organized, and visually compelling geometric forms. This transformation from simplicity to structured complexity highlights the aesthetic potential of mathematical ideas when applied within cultural contexts. Thus, the Nitik motive is a powerful example of how traditional art can encapsulate mathematical principles, offering valuable insights for culturally responsive mathematics education and promoting the integration of ethnomathematics into contemporary learning environments.

3.5 Batik Motive of *Sekar Jeram*

Literally, "*Sekar*" means flower, and "*Jeram*" refers to bushes or shrubs. In the context of *Sekar Jeram* batik motives, presented in **Figure 6**, floral patterns or other elements are often arranged in even numbers, creating a harmonious symmetry and balance. This even number pattern emphasizes order and completeness, reflecting the philosophical meaning of *Sekar Jeram* Batik, which depicts the beauty of nature and the balance in life.

An even number pattern is a sequence of numbers divisible by two. Examples of even numbers include 2, 4, 6, 8, 10, and so on. The deliberate use of even numbers in *Sekar Jeram* motives symbolizes the structured growth and balanced harmony found in nature, enhancing the cultural and aesthetic value of the design. Incorporating mathematical principles into the motive underscores the intricate relationship between art and mathematics in traditional Javanese Batik, celebrating natural beauty and mathematical order.

The repetition of geometric elements characterizes the Sekar Jeram motive in Javanese Batik, systematically arranged in a square-based pattern. This structured configuration contributes to the motive's visual appeal and serves as a mathematical representation of square numbers. As shown in **Figure 7**, the consistent layout of these repeated elements reflects an underlying numerical regularity, aligning with the traditional design principles of symmetry and proportion commonly found in Javanese textile art.

Figure 6. Batik Motive of *Sekar Jeram*

Mathematically, the square numbers illustrated in **Figure 7** are generated by squaring positive integers, resulting in perfect squares such as 1, 4, 9, 16, and so on, corresponding to 1^2, 2^2, 3^2, 4^2, etc. These numbers can be visualized as square arrays, where each value represents the total number of units arranged in equal numbers of rows and columns. This mathematical structure can be interpreted as a symbol of growth, balance, and progressive harmony, aligning with the Javanese philosophical worldview that emphasizes equilibrium between physical and spiritual dimensions. Such numerical patterns within the *Sekar Jeram* Batik motive exemplify the natural intersection between cultural expression and mathematical structure. It illustrates how traditional batik designs can serve as meaningful contexts for exploring mathematical ideas—particularly in number sense—within culturally responsive and context-based mathematics education frameworks.

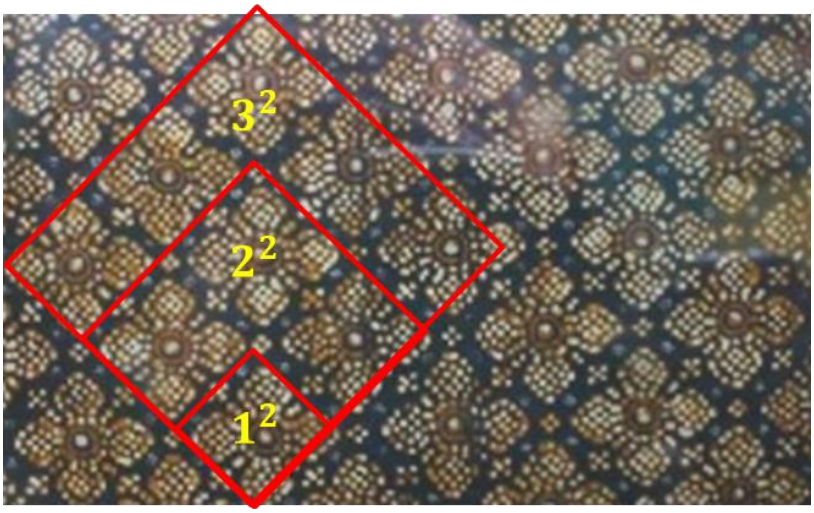

Figure 7. The Representation of Square Numbers in *Sekar Jeram* Batik Motives

This visual orderliness embodies the cultural philosophy of Javanese society, which strongly emphasizes harmony, balance, and aesthetic discipline. By incorporating principles of geometry into its artistic expression, the *Sekar Jeram* motive exemplifies how traditional cultural designs can be rich sources of mathematical insight, offering opportunities to connect visual art with formal mathematical understanding in culturally grounded educational settings.

3.6 Numbers Patterns

Mathematical number patterns are systematically arranged sequences or configurations formed through specific numerical relationships. These patterns may range from simple arithmetic and geometric sequences to more complex structures, and they frequently appear across various domains of mathematics and related scientific disciplines. The study of number patterns is essential for uncovering underlying mathematical structures and relationships, providing valuable insights for theoretical exploration and practical application. In this article, the following section presents five key number pattern concepts identified through the research findings, as outlined below:

3.6.1 Square Number Pattern

This pattern is a type of number sequence that produces numbers forming a square or rectangular shape. A square number pattern starts from 1, where the nth square number is the result of n multiplied by itself (n^2). Simple examples of a square number pattern include 1, 4, 9, 16, and so on, corresponding to $1^2, 2^2, 3^2, 4^2$, etc. Thus, this pattern can be formulated as $U_n = n^2$. Similarly, a rectangular number pattern is formed by multiplying two distinct positive integers, resulting in numbers like 2, 6, 12, and so forth. These patterns visually and numerically represent the structured, geometric properties inherent in mathematical sequences.

The philosophy of this pattern begins with the number one, symbolizing the origin of everything—birth or inception. In the context of *Grompol* Batik motives, this initial point can represent the beginning of a family or association. Furthermore, four interconnected *Grompol* motives symbolize the four pillars of a family: father, mother, son, and daughter, illustrating how they collectively form the foundation of a strong and united family.

Additionally, nine orderly motives in *Grompol* Batik reflect the spiritual journey and the pursuit of perfection. This number symbolizes the completeness and continuous growth in one's spiritual endeavors. Lastly, the sixteen motives in *Grompol* Batik can represent a more profound sense of togetherness and a multiplication of fortune within the family, indicating prosperity and closer familial bonds. This intricate symbolism within the *Grompol* Batik motives underscores traditional Javanese art's profound cultural and philosophical meanings.

3.6.2 Rectangular Number Pattern

This number pattern produces numbers that form rectangles or quadrilaterals with different lengths and widths. A simple example is the number sequence 2, 6, 12, and so on. This pattern can be mathematically formulated as $U_n = n(n+1)$, where U_n, represents the n-th rectangular number. In this sequence, each term is generated by multiplying a positive integer n by its successive integer $n+1$, resulting in numbers that represent the areas of rectangles with sides of lengths n and $n+1$.

In the context of *Kawung* Batik, the philosophy of this number pattern symbolizes the balance and harmony between two different elements. The opposing circular motives in *Kawung* Batik reflect this duality and balance, representing the interconnectedness of contrasting forces. Moreover, six *Kawung* Batik circle motives can symbolize completeness within a family or community, illustrating how each member complements and supports one another. This arrangement emphasizes unity and cohesion. Additionally, twelve symmetrical *Kawung* Batik circle motives can represent the perfect cycle of life and sustainability. This number reflects the cyclical nature of life, emphasizing continuity and renewal.

Lastly, twenty *Kawung* Batik circle motives can symbolize the abundance of sustenance, happiness, and wisdom that continues to grow. This pattern conveys a sense of prosperity and ongoing enrichment, highlighting the positive outcomes of harmony and balance within a community or family.

3.6.3 Triangle Number Pattern

This number pattern is an arrangement of numbers that forms an equilateral triangle. The pattern begins with 1, following the concept of sequentially adding positive integers. Simple examples of this pattern include the numbers 1, 3, 6, and so on. This sequence can be summarized as U_n, where U_n represents the n-th triangular number. Mathematically, the n-th triangular number is the sum of the first n positive integers and is given by the formula $T_n = \frac{n(n+1)}{2}$.

The philosophy of this number pattern centers around the number one, symbolizing beginnings or new starts. In the context of *Truntum* Batik motives, this can represent the inception of a new love or relationship. A single star or flower motive within *Truntum* Batik signifies the initial stages of love and the hopeful anticipation of growth. Furthermore, the presence of three-star or flower motives in *Truntum* Batik reflects the balance and harmony sought in relationships. This arrangement symbolizes mutual understanding and equilibrium in love. Moreover, six-star or flower motives in *Truntum* Batik denote the strength and depth of a love that has matured and grown robustly. This number signifies resilience and steadfastness in relationships.

Lastly, ten-star or flower motives in *Truntum* Batik symbolize perfect love and a relationship that has reached full depth and understanding. This pattern signifies completeness and fulfillment in love, representing a harmonious and profound connection between individuals. These interpretations highlight the symbolic richness embedded in *Truntum* Batik motives, illustrating how numerical patterns can convey profound philosophical meanings related to love, relationships, and personal growth.

3.6.4 Odd Number Pattern

This number pattern consists of odd numbers. A simple example of this number pattern is 1, 3, 5, and so on, and it can be mathematically formulated as $U_n = 2n - 1$, where n is a positive integer. The philosophy of this number pattern, where the number one symbolizes unity or wholeness, is deeply significant in the context of *Nitik* Batik motives. A single dot can represent the focus or core of an idea or design, serving as the foundation or starting point of a larger pattern.

Additionally, the arrangement of three neatly placed dots can reflect balance and harmony within the *Nitik* Batik motive, symbolizing equilibrium and a well-structured composition. Furthermore, five symmetrically arranged dots can convey protection and luck in life, highlighting the importance of symmetry and orderly arrangements in the art of *Nitik* Batik.

Lastly, seven dots arranged in a symmetrical pattern within *Nitik* Batik can depict spiritual depth and an aspiration for prosperity. This number often carries connotations of spiritual significance and completeness, symbolizing hope and the pursuit of well-being. These philosophical interpretations demonstrate how the *Nitik* Batik motives leverage odd number patterns to convey profound meanings related to unity, balance, protection, and spiritual depth.

3.6.5 Even Number Pattern

This number pattern is composed of even numbers divisible by 2. A simple example of this number pattern includes 2, 4, 6, and so on, and it can be mathematically formulated as $U_n = 2n$, where n is a positive integer. The philosophy of this pattern, as interpreted in the *Sekar Jeram* Batik motive, symbolizes the balance and harmony between two complementary or contrasting elements. In the *Sekar Jeram* Batik motive, two geometric elements that are opposite or complementary reflect the duality and harmony present in nature.

Lastly, the philosophy of this pattern in motives with eight symmetrically arranged geometric elements reflects completeness and harmony in life. This arrangement represents wholeness and the interconnectedness of all parts, symbolizing perfect balance and unity. These interpretations highlight the profound symbolic meanings embedded in the *Sekar Jeram* Batik motives, showcasing how even number patterns can convey messages of duality, stability, harmony, and completeness.

3.7 Discussion

The exploration of mathematical concepts embedded in Javanese Batik motives underscores these patterns' profound historical and cultural significance. Javanese society, particularly during the Mataram Kingdom era in Yogyakarta, utilized intrinsic number patterns derived from intuitive learning and creative experiences in their Batik motives. This historical context highlights a society deeply rooted in values, norms, manners, and ethics integral to daily life [5], [12]. The Mataram community's efforts to preserve their cultural heritage and social order through Batik motives ensured the transmission of their beliefs and ideologies to subsequent generations. This cultural perpetuation via Batik maintained social constructs and embedded complex mathematical ideas within these artistic expressions.

Our findings reveal that Javanese Batik motives are not merely artistic but are laden with profound moral messages and ideologies [5], [12]. Each motive encapsulates values, norms, and ethical guidelines, reflecting the Javanese people's interactions with each other, nature, and governance. These embedded messages serve as conduits for cultural transmission, reinforcing ethical behavior, social harmony, and respect for nature within the community. The intricate relationship between cultural artifacts and mathematical concepts provides a unique perspective on the educational potential of traditional arts in conveying complex societal values. This perspective enhances the understanding of how cultural artifacts can serve as educational tools in modern settings.

The integration of ethnomathematics into mathematics education has significantly altered students' perceptions of the relationship between mathematics, reality, and their cultural context. Previous research has

demonstrated the efficacy of using ethnomathematical contexts to enhance mathematics learning [13], [14]. Curricula incorporating ethnomathematics have increased student understanding and a more meaningful connection to the mathematics they study [15]. This approach underscores the indispensable role of mathematics as a fundamental aspect of human comprehension, suggesting that the current practice of mathematics education in many countries and cultures is limited compared to its broader potential.

Mathematics education aims to foster comprehensive understanding for all students, necessitating a reevaluation of the status and roles of mathematics in society [16], [17]. An ethnomathematical perspective facilitates this transition by bridging the gap between abstract mathematical concepts and students' cultural experiences [18], [19]. This paradigm shift enriches students' learning experiences and underscores the importance of contextualizing mathematics within the cultural and real-world contexts that students encounter daily. Through this integration, mathematics becomes a more accessible and relevant discipline, fostering a deeper appreciation and understanding among students.

To provide a detailed analysis of the ethical, cultural, and ecological values conveyed by Javanese batik motives, it is essential first to contextualize the motives within their historical and cultural background [20], [21]. Students can reveal the rich cultural narratives embedded in these patterns by exploring their origins, traditional uses, and significance in Javanese society. Analyzing the motives through an Ethno-RME lens allows for an understanding of how they reflect mathematical thinking and contribute to teaching mathematical concepts, thereby preserving cultural identity and promoting ethical values such as balance, harmony, and respect for nature [7], [13], [22].

In examining the cultural values of batik motives, it is important to interpret the symbols and patterns that represent Javanese worldviews, beliefs, and social structures [23]. These motives reinforce community identity and intergenerational knowledge and serve as a medium for passing down cultural philosophies [5]. Additionally, the motives' connection to nature and their representation of ecological elements highlight a deep respect for the environment, reflecting sustainable practices and promoting environmental awareness [24]. This connection underscores the importance of preserving traditional ecological knowledge within contemporary environmental ethics.

Integrating socio-ecological perspectives into this analysis further enhances understanding of human-nature interactions as reflected in the motives [25]. By exploring how these patterns represent ecological balance and sustainability, the analysis can address current and future implications for cultural preservation and environmental stewardship [23]. Including specific case studies and fieldwork insights grounded in ethnographic research will provide concrete examples of how these values are conveyed through batik motives, ultimately enriching educational practices and fostering a deeper appreciation for cultural heritage and environmental sustainability.

Furthermore, the findings of this research offer significant contributions to the field of mathematics education. Educators and researchers can leverage these results to develop ethnomathematical learning approaches that integrate mathematical concepts with students' cultural backgrounds, reinforcing their cultural and social identities. Such approaches support students in understanding and internalizing the values of nationalism and patriotism through meaningful engagement with Javanese Batik motives.

Finally, the findings provide tangible benefits for the Javanese community, particularly in Yogyakarta, by fostering a sense of pride in local cultural heritage and strengthening communal identity. In addition, this study offers valuable insights into the contextual application of mathematics across diverse cultural settings, enriching students' learning experiences and promoting a more inclusive and holistic educational paradigm. By integrating mathematics with local culture, students can develop a greater appreciation for their cultural values while understanding the cultural diversity surrounding them [26], [27]. This research provides a more relevant, engaging, and meaningful mathematics education. The ethnomathematical approach exemplified by the study of Javanese Batik motives is an inspiring model for integrating mathematics into real-life contexts [5], [28]. Such an approach allows students to experience mathematics in practical settings, fostering a deeper appreciation for the cultural and historical values inherent in their heritage. This model can be adapted and applied to various cultural contexts, enhancing the global understanding and appreciation of the interconnectedness between mathematics and culture.

4. CONCLUSION

This study underscores the profound impact of integrating ethnomathematics in mathematics education as an application of Ethno-RME with Javanese Batik motives in enhancing mathematics education through cultural contexts. Our exploration has revealed how these cultural artifacts convey mathematical principles and instill essential values and philosophies among students. By embedding numerical patterns such as square, rectangular, triangular, odd, and even numbers within Batik motives, we have demonstrated their potential to nurture positive character traits such as resilience, appreciation for diversity, and cultural identity. This approach enriches students' understanding of mathematics and cultural heritage, offering a holistic educational experience. However, it is essential to acknowledge the limitations of this study, particularly its focus on Javanese Batik motives, which may limit the generalizability of our findings to other cultural contexts within Indonesia and beyond. Future research should expand this scope to include a broader spectrum of Indonesian cultural artifacts, allowing for a more comprehensive understanding of how diverse cultural contexts can enrich mathematics education. Looking forward, this research proposes a promising avenue for developing e-modules to enhance the teaching of numerical patterns through ethnomathematical approaches. By integrating cultural values and philosophies inherent in Batik motives into educational technologies, such as e-modules, educators can create engaging learning experiences that resonate with students' cultural identities. This approach fosters a deeper appreciation for Javanese and Indonesian rich cultural heritage and enhances students' mathematical proficiency and character development.

AUTHOR CONTRIBUTIONS

Binti Anisaul Khasanah: Data Curation, Formal Analysis, Visualization, and Writing - Original Draft. Rully Charitas Indra Prahmana: Investigation, Methodology, Writing - Original Draft, Supervision, and Writing - Review and Editing. Sofwan Adiputra: Supervision, Resources, and Writing - Review and Editing. Ibrahim Alhussain Khalil: Validation and Writing - Review and Editing. Lekë Pepkolaj: Validation and Writing - Review and Editing. All authors discussed the results and contributed to the final manuscript.

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CONFLICT OF INTEREST

The authors declare that no conflicts of interest exist in the study.

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