Curricula: Journal of Teaching and Learning
http://dx.doi.org/10.22216/jcc.2025.v10.i1-3491
Published by Lembaga Layanan Pendidikan Tinggi (LLDIKTI) Wilayah X

RESEARCH ARTICLE

OPEN ACCESS

EXPLORING THE ETHNOMATHEMATICS FRACTAL CONCEPTS TOWARDS MINANGKABAU "SONGKET" TEXTILES": A CASE STUDY IN WEST SUMATRA

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Article History
Received 27 February 2025
Revised 19 March 2025
Accepted 28 April 2025

Keywords
Ethnomathematics, Fractal Concepts, Minangkabau, West Sumatra

ABSTRACT
Mathematics is often perceived as an abstract, universal, and culture-free discipline, presented in formal symbols and rigid procedures that appear distant from learners' everyday realities. This research investigated fractal concepts in ethnomathematics in relation to the Minangkabau songket textile. This research employed a qualitative case study design. Data were collected using a document checklist of the songket and a semi-structured interview. Data were analyzed using document analysis and thematic analysis. The research population was the Minangkabau songket textile, and the sampling method was purposive; three songket motifs from Pandai Sikek, West Sumatra, were selected. The findings show consistent manifestations of self-similarity, iteration, recursion, symmetry, and statistical variation, reflecting fractal structures comparable to those found in natural systems. These patterns are not the result of formal mathematical calculation but arise from indigenous knowledge grounded in the Minangkabau philosophy *alam takambang jadi guru*, where nature serves as the primary source of learning. Beyond their aesthetic function, the fractal properties of songket motifs serve as visual metaphors for cultural continuity, social harmony, and the intergenerational transmission of values. This research is limited to songket produced by Pandai Sikek in West Sumatra. This study reinforces the notion that traditional cultural products are not only artistic expressions but also repositories of sophisticated mathematical knowledge.

Introduction

Mathematics is often perceived as an abstract, universal, and culture-free discipline, presented in formal symbols and rigid procedures that appear distant from learners' everyday realities (Fouze & Amit, 2018) . This dominant perception tends to position mathematics as neutral and detached from social and cultural contexts, resulting in learning experiences that are less meaningful for students. When mathematical knowledge is taught without reference to learners' cultural backgrounds, it can limit students' ability to connect concepts with real-life practices, reduce motivation, and reinforce the idea that mathematics exists only within textbooks and classrooms rather than as part of human activity (d'Entremont, 2015; Kabuye Batiibwe, 2024). Mosimege & Egara, (2023) stated that perception has contributed to a persistent learning gap, particularly in culturally rich regions where mathematical ideas are deeply embedded in traditional practices but remain largely unrecognized within formal education. Indigenous crafts, architectural designs, textile patterns, and daily problem-solving activities often involve sophisticated mathematical reasoning, yet these forms of knowledge are rarely acknowledged as legitimate mathematics. March et al., (2014) informed that societies may struggle to see the relevance of mathematics to their own cultural environments, while valuable local wisdom remains marginalized. Jaber & Daana, (2020) argued that addressing this gap requires recontextualizing mathematics education by integrating cultural practices into learning processes, allowing

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mathematics to be understood as a dynamic body of knowledge that emerges from, and is shaped by, human culture.

In response to this issue, ethnomathematics has emerged as a critical field of study that seeks to uncover and analyze mathematical ideas embedded in cultural artifacts, social practices, and traditional knowledge systems (Turmuzi et al., 2023; Nur et al., 2021) This perspective challenges the view of mathematics as a value-free and context-independent discipline by emphasizing that mathematical thinking is shaped by cultural experiences and collective practices. Through the study of weaving patterns, architectural forms, measurement systems, and symbolic designs, ethnomathematics highlights how communities generate and apply mathematical reasoning in ways that are meaningful within their own cultural contexts (Kabuye Batiibwe, 2024). By bridging mathematics and culture, ethnomathematics not only enhances students' conceptual understanding but also promotes cultural relevance and inclusivity in mathematics education (Cesaria et al., 2022). Learning mathematics through familiar cultural practices enables students to construct knowledge more meaningfully, as abstract concepts are connected to tangible experiences (Rosa & Orey, 2021). At the same time, this approach strengthens cultural identity by validating local wisdom as a legitimate source of mathematical knowledge (Sari et al., 2023). Consequently, ethnomathematics supports contextual learning that respects cultural diversity, fosters learner engagement, and contributes to more equitable and culturally responsive educational practices (Iriandre et al., 2025).

One cultural artifact that embodies rich mathematical structures is Minangkabau *songket* textiles from West Sumatra, Indonesia. *Songket* is a traditional woven fabric distinguished by its intricate geometric motifs, systematic repetition, and complex pattern arrangements produced through meticulous weaving techniques (Enmufida, Turmudi, 2021). These visual structures reveal underlying mathematical ideas such as symmetry, proportionality, transformation, and pattern regularity, which are intuitively applied by artisans during the design and weaving processes. Although primarily appreciated for their aesthetic qualities, *songket* motifs also function as visual representations of structured mathematical thinking embedded in traditional craftsmanship (Kabuye Batiibwe, 2024)

Regarding their formal patterns, Minangkabau *songket* textiles carry deep symbolic meanings that reflect Minangkabau philosophy, social values, and cosmological views. Each motif is not merely decorative but conveys messages related to harmony, balance, social hierarchy, and the relationship between humans, nature, and the spiritual realm (Amelia et al., 2023). The recurrence and organization of these motifs across the textile surface demonstrate how cultural symbolism and mathematical structure are intertwined. This integration positions *songket* not only as a cultural heritage artifact but also as a valuable source of ethnomathematical knowledge that can be explored to enrich both cultural understanding and mathematics education (Aurora et al., 2023). Beyond their aesthetic and cultural significance, the motifs found in Minangkabau songket textiles exhibit mathematical properties such as symmetry, repetition, scaling, and self-similarity, which closely align with key concepts in fractal geometry (Cesaria et al., 2019). The recurring arrangements of motifs across different sections of the fabric, along with variations in size and pattern density, reflect principles of recursive design and structural consistency across scales (Christyawaty, 2011). These characteristics suggest that *songket* patterns can be interpreted as visual manifestations of fractal thinking, where complex forms emerge from the repetition and transformation of simple geometric elements (Yandri, 2014).

However, these embedded mathematical structures are typically produced intuitively by artisans through inherited knowledge and long-standing weaving traditions, rather than through explicit mathematical formulations. As a result, the sophisticated mathematical reasoning underlying these designs remains largely implicit and is rarely recognized within formal mathematics education. This condition has led to an underexplored area of research, particularly in understanding how traditional textile patterns can be systematically analyzed using fractal concepts and integrated into instructional frameworks. Exploring this intersection offers valuable opportunities to enrich mathematics education while simultaneously preserving and valuing local cultural knowledge (Yang & Wang, 2016). Fractal geometry, formally introduced by Benoît Mandelbrot, provides a powerful theoretical framework for analyzing complex patterns characterized by self-similarity across different scales. Unlike classical Euclidean geometry, fractal geometry is particularly effective in describing irregular, recursive, and fragmented forms that cannot be adequately explained

through simple geometric shapes. Its principles have been extensively applied in various fields, including natural sciences to model phenomena such as coastlines and plant structures, as well as in digital imaging, computer graphics, and contemporary design to generate intricate and scalable visual patterns (Falconer, 2013).

Despite its broad applicability, Alghar, (2023) stated that the presence of fractal concepts in traditional cultural products remains insufficiently documented and systematically analyzed. Many cultural artifacts, such as textiles, architectural ornaments, and indigenous artworks, display repetitive and scalable patterns that resonate with fractal characteristics, yet they are often examined solely from aesthetic or anthropological perspectives. The lack of mathematical interpretation of these artifacts limits the recognition of traditional knowledge systems as sources of sophisticated mathematical ideas. Consequently, there is a need for research that applies fractal geometry to cultural contexts, enabling a deeper understanding of how complex mathematical thinking is embedded within traditional artistic practices. In the context of ethnomathematics, fractal analysis offers a valuable lens for reinterpreting traditional patterns as sophisticated mathematical constructs rather than merely decorative elements. Through this perspective, repetitive motifs, recursive arrangements, and scaling variations found in cultural artifacts can be understood as representations of complex mathematical reasoning embedded within traditional knowledge systems. Fractal analysis allows researchers to uncover hidden structures and organizing principles in cultural designs, thereby positioning indigenous craftsmanship as a legitimate and rich source of mathematical insight (Rini, 2024).

Despite the growing global interest in ethnomathematics, Fitriza et al., (2018) informed that empirical studies that explicitly connect fractal concepts to Indonesian textile traditions remain limited, particularly those focusing on Minangkabau *songket*. Existing research on Indonesian ethnomathematics has largely emphasized basic geometric forms or symbolic interpretations, while in-depth analyses of fractal characteristics such as self-similarity, recursion, and pattern scaling are still scarce. This gap highlights the need for systematic investigations that integrate fractal geometry with ethnomathematical approaches to better understand the mathematical complexity of traditional textiles and to expand culturally responsive mathematics education frameworks .

There have been some studies analyzing the ethnomathematics. First, Enmufida & Turmudi, (2021), who analyzed the relation between mathematics and culture. The research took place in Pandai Sikek, Tanah Datar Regency, West Sumatera. This research focused on revealing a mathematical idea beyond traditional *songket* Minangkabau at Pandai Sikek. This study of ethnomathematics uses a qualitative approaching of an ethnography method. The data were collected through observation, interview and study documentation. The result of the research is to reveal a mathematical idea that is used by Pandai Sikek people on manufacturing songket that there are mathematic activities and geometry patterns in traditional *songket* pattern of Minangkabau. Second is Fitriza & Hadaina, (2024) who examined mathematical concepts that exist in livelihood systems, living equipment, and technology and their use in mathematics learning. It used a qualitative approach with an Alangui ethnomathematics research design. The research was conducted in Nagari Pariangan and Nagari Sijunjung, West Sumatra Province. The informants for this research are traditional leaders, clever *cadiak*, and cultural actors. Data collection techniques were observation, interviews, documentation, and field notes. Data analysis with stages of data reduction, data presentation, and conclusion. The results of the research show that in the livelihood system, living equipment, and technology of the Minangkabau indigenous people there are concepts of comparison, measurement with traditional units, transformation geometry, geometric shapes, and calculus and optimization. The activities and equipment of life and technology in indigenous communities in Minangkabau can be used as a context for learning mathematics. Third is Miftahurrahmi Miftahurrahmi, Is Oktaria Pratiwi, Fajrul Huda, (2024) investigating mathematical elements in the traditional Minangkabau art form of *Randai*. The methodology employed in this study is qualitative descriptive, utilizing a library research approach. The research relied solely on a literature review. The data utilized comprises documents derived from studies of *Randai* art and other written references relevant to the research problem. The researcher serves as the primary instrument, indispensable to this study. Data collection methods include documentation and an extensive literature review. The findings reveal that traditional Minangkabau *randai* art encompasses not only artistic expression

but also philosophical insights, cultural values, and mathematical elements, known as ethnomathematics (Cesaria, 2025). Ethnomathematics manifests in *Randai* art through its form, spatial dimensions, and musical instruments.

If it is compared into the researchers' study, the researchers analyzed the ethnomathematics fractal concepts of *Songket* Textile of Minangkabau culture by using case study design. The researcher's documentation checklist, from image of *songket*, and semi-structured interview. Data were analyzed by using thematic analysis. The previous studies on Minangkabau ethnomathematics have made important contributions by demonstrating that mathematical concepts are embedded in cultural practices and traditional arts. However, these studies still leave several theoretical and methodological gaps. First, studies such as Enmufida & Turmudi (2021) focus primarily on identifying general mathematical activities and geometric patterns in Pandai Sikek *songket* production. While this research successfully reveals the presence of mathematical ideas, particularly geometry, it remains at a descriptive and surface level, without engaging with more advanced or contemporary mathematical frameworks. The study does not explore pattern complexity, self-similarity, or scaling properties, which are central to understanding intricate textile designs. Second, Fitriza & Hadaina (2024) broaden the scope of ethnomathematics by examining mathematical concepts across livelihood systems, tools, and technology in Minangkabau society. Although this research identifies a wide range of concepts (comparison, measurement, geometry, calculus, and optimization), its emphasis is contextual and pedagogical, aiming to support mathematics learning. It does not provide an in-depth analytical focus on specific visual artifacts, such as *songket* motifs, nor does it apply formal mathematical theories to analyze cultural patterns. Third, Miftahurrahmi et al. (2024) investigate ethnomathematics in *Randai* art through a library-based qualitative approach. This study contributes philosophically and conceptually but relies solely on secondary data. As a result, it lacks empirical validation, visual analysis, and direct engagement with cultural artifacts or practitioners.

Clearly, these studies show that ethnomathematics research on Minangkabau culture has largely focused on basic geometry and arithmetic concepts; there is a lack of research applying advanced mathematical theories, particularly fractal geometry, to traditional textiles. Existing studies either emphasize pedagogical contexts or conceptual descriptions, rather than structural pattern analysis of *songket* motifs, and empirical studies that combine visual artifact analysis with thematic interpretation remain limited. Meanwhile, for the research novelty, this research addresses the gaps by introducing both theoretical and methodological novelty. The main novelty lies in the application of fractal concepts to the analysis of Minangkabau songket textiles. Unlike previous studies that identify general geometric patterns, this research interprets songket motifs as fractal-like structures, characterized by repetition, self-similarity, and scaling across different levels of design. This approach positions songket not merely as a cultural artifact but as a complex mathematical construct, aligning traditional craftsmanship with modern mathematical theory. Methodologically, this study adopts a case study design that integrates; a documentation checklist based on visual analysis of *songket* images, semi-structured interviews with cultural practitioners, and thematic analysis to interpret recurring fractal characteristics. This triangulated approach allows for a deeper empirical engagement with both the visual patterns and the cultural meanings underlying *songket* production, something not achieved in prior studies.

Conceptually, the study extends ethnomathematics beyond its common role as a pedagogical resource and reframes it as a theoretical bridge between indigenous knowledge systems and contemporary mathematics. By focusing on fractal geometry, the research contributes to the global discourse on ethnomathematics, offering a novel perspective that elevates Minangkabau songket within interdisciplinary studies of mathematics, culture, and design. Previous studies on ethnomathematics in Indonesia have predominantly focused on architectural forms, traditional games, and basic geometric patterns. Research addressing fractal dimensions, recursive motifs, and scaling principles within woven textiles is scarce, especially studies grounded in qualitative case study approaches involving local artisans and authentic production contexts. This gap indicates the need for in-depth exploration that integrates mathematical analysis with cultural interpretation, ensuring that local knowledge systems are respected and accurately represented.

Therefore, this study aims to explore fractal concepts embedded in Minangkabau *songket* textiles through an ethnomathematical perspective. By employing a case study in West Sumatra, this

research seeks to identify forms of self-similarity, repetition, and scaling within *songket* motifs and to interpret their mathematical meanings alongside their cultural significance. The findings are expected to contribute to ethnomathematics literature, support culturally responsive mathematics education, and provide alternative learning resources that connect formal mathematical concepts with local heritage. Ultimately, this study reinforces the notion that traditional cultural products are not only artistic expressions but also repositories of sophisticated mathematical knowledge. This research had question " how are the ethnomathematics fractal concepts towards minangkabau "songket" textiles?

Materials and Methods

This study investigates the manifestation of fractal concepts within Minangkabau *songket* textiles, framing these traditional artifacts as culturally embedded expressions of mathematical knowledge rather than purely decorative objects. Drawing on the theoretical perspective of ethnomathematics, the research examines how recursive patterns, self-similarity, and proportional organization are systematically realized in *songket* motifs produced by Minangkabau weaving communities in West Sumatra. By foregrounding indigenous design practices, the study challenges the dominance of formalist mathematical paradigms and emphasizes the culturally situated nature of mathematical reasoning.

A qualitative research approach employing a case study design was adopted to enable an in-depth and contextualized analysis of *songket* production. This methodological choice is justified by the non-formalized character of the mathematical concepts under investigation, which are embedded in visual structures, material practices, and intergenerational knowledge transmission (Creswell et al., 2007; Coates et al., 2021). The case study design allows for a holistic examination of both the structural properties of textile motifs and the cultural meanings attributed to them by local practitioners (Symonds & Symonds, 2016).

Data were collected through qualitative documentation and in-depth interviews. Bowen, (2009) stated that documentation involved the systematic collection and analysis of *songket* motifs, visual records of textile patterns, and archival materials related to Minangkabau weaving traditions. The selected songket motives were *'pucuak rabuang'*, '*siriah gadang*, and *bungo melati.* This method enabled a detailed examination of structural features such as repetition, scaling, and motif variation that are central to fractal analysis. In addition, semi-structured interview questions were conducted with traditional weavers and cultural practitioners to elicit insights into the meanings, production processes, and cultural philosophies underlying *songket* design (Alshenqeeti, 2014). The interviews provided contextual explanations that complemented the visual data, allowing the mathematical characteristics of the motifs to be interpreted within the Minangkabau cultural framework. The combination of documentation and interviews ensured methodological triangulation and enhanced the credibility of the findings.

The document checklist of *songket* textiles consisted of several key analytical components to support systematic documentation and analysis. These components included: (1) the name and origin of the *songket* motif; (2) visual documentation of the motif pattern; (3) dominant geometric forms and structural elements; (4) repetition and scaling patterns indicative of fractal characteristics; (5) symmetry and proportional relationships; (6) motif layering and recursive arrangements; and (7) contextual notes on cultural meaning and usage. This checklist was used to ensure consistency in documenting *songket* motifs and to facilitate comparative analysis across different textiles.

Population of the research was the traditional Minangkabau *songket* weaving communities in West Sumatra. The sampling was the pictures of Traditional Minangkabau *Songket from Pandai Sikek Agam Tanah Datar,* West Sumatra Province. The purposive sampling was also employed to select participant who was considered information-rich and directly relevant to the research objectives. The sampling criteria included (1) active involvement in *songket* weaving, (2) a minimum level of experience in producing or teaching traditional motifs, and (3) recognized cultural knowledge related to the philosophical meanings of *songket* patterns. This approach enabled the researcher to focus on participants capable of providing in-depth insights into the fractal characteristics of *songket* motifs and their cultural foundations.

Data analysis was conducted using a qualitative thematic analysis approach. Documentary data, including visual records of *songket* motifs and archival materials, were first organized and coded to

identify recurring structural features such as repetition, scaling, symmetry, and recursive patterning associated with fractal concepts. These features were analyzed across motifs to examine patterns of consistency and variation. Interview data were transcribed verbatim and analyzed through an iterative coding process. Initial codes were generated inductively from the data, followed by axial coding to connect mathematical characteristics with culturally grounded meanings articulated by the participants. The analytical process involved constant comparison between documentary and interview data to ensure interpretive coherence and triangulation (Vaismoradi et al., 2013; Abedi, 2024). The integration of visual motif analysis and thematic interpretation enabled the identification of fractal properties within *songket* designs while situating these properties within the Minangkabau cultural and philosophical context. This analytical strategy strengthened the validity of the findings by ensuring that mathematical interpretations remained grounded in participants' perspectives and local knowledge systems.

Results and Discussion

1. *Pucuak Rabuang Songket* Motive

Picture 1. Pucuak Rabuang Songket Motive

1	Name and Origin of the Songket Motif

The *songket* motif depicted in the image is commonly identified as *Pucuak Rabuang*, a well-known traditional motif originating from Minangkabau weaving centers in West Sumatra, particularly Pandai Sikek and Silungkang. This motif is deeply embedded in Minangkabau cultural philosophy and is widely used in ceremonial textiles.

2	Visual Documentation of the Motif Pattern

Visually, the textile displays a structured composition dominated by a central vertical panel flanked by symmetrical lateral sections. The color contrast between the deep blue background and the gold threads enhances motif clarity and emphasizes structural repetition. The arrangement reflects deliberate planning and precision in weaving, suggesting an underlying design logic rather than spontaneous ornamentation.

3	Dominant Geometric Forms and Structural Elements

The motif is composed primarily of triangular and diamond-shaped geometric forms. In the central panel, elongated triangular shapes are arranged tip-to-base, forming a vertical sequence reminiscent of a growing shoot. The lateral sections consist of repeated intersecting diagonal forms arranged within rectangular grids. These geometric configurations form the foundational structure upon which more intricate patterns are layered.

4	Repetition and Scaling Patterns Indicative of Fractal Characteristics

Clear fractal-like characteristics are observable through repeated motif units across different scales. Smaller floral or star-like elements are nested within larger geometric forms, while the triangular units in the central panel are replicated consistently along the vertical axis. This recursive repetition across scales reflects self-similarity, a key principle of fractal geometry, although realized through manual craftsmanship rather than formal mathematical abstraction.

5	Symmetry and Proportional Relationships

The textile exhibits strong bilateral symmetry, particularly across the vertical axis of the central panel. Proportional balance is maintained between the central motif and the surrounding side panels, creating visual harmony. The consistent spacing and proportional alignment of motif units indicate an implicit understanding of ratio and balance, reinforcing the mathematical coherence of the design.

6	Motif Layering and Recursive Arrangements

Motif layering is evident in the way smaller decorative elements are embedded within larger geometric frames. This hierarchical organization creates depth and visual complexity, where patterns recur at multiple structural levels. The recursive arrangement of motifs suggests a design principle in which a basic unit is repeatedly transformed and expanded, aligning closely with ethnomathematical interpretations of fractal construction.

7	Cultural Meaning and Usage

Culturally, the *Pucuak Rabuang* motif symbolizes growth, resilience, and moral development, drawing inspiration from the bamboo shoot as a metaphor for human maturity within Minangkabau society. Its structured upward progression reflects the Minangkabau philosophy of *alam takambang jadi guru*, where natural forms inform cultural knowledge. The integration of fractal-like structures within this motif demonstrates how mathematical reasoning is culturally encoded and transmitted through textile traditions. Furthermore, from the fractal concept analysis of the Pucuak Rabuang Motive, the *Pucuak Rebung* motif in Minangkabau *songket* textiles demonstrates several core fractal concepts, revealing how mathematical thinking is culturally embedded in traditional weaving practices. Although the motif is not constructed through formal mathematical equations, its visual structure reflects principles that closely align with fractal geometry. One of the most prominent fractal characteristics of the *Pucuak Rebung* motif is self-similarity. The triangular forms that symbolize bamboo shoots are repeated consistently along the vertical axis, while smaller decorative elements embedded within these forms replicate similar geometric configurations. This repetition across different scales indicates an intuitive application of self-similar patterning, where the same structural idea is reproduced in both macro- and micro-level designs.

The motif is generated through a recursive design process, in which a basic triangular unit serves as the foundational element. This unit is repeatedly reproduced and arranged tip-to-base, forming an extended vertical sequence that suggests continuous growth. Each repetition follows the same structural rule, illustrating recursion as a culturally transmitted pattern-making strategy rather than a formal algorithm. Scaling is evident in the way the triangular units vary in size while maintaining proportional relationships. Larger *pucuak* forms frame the composition, while smaller motifs appear within and between them without disrupting visual coherence. This proportional consistency reflects an embodied understanding of scaling, a key component of fractal geometry, achieved through traditional craftsmanship.

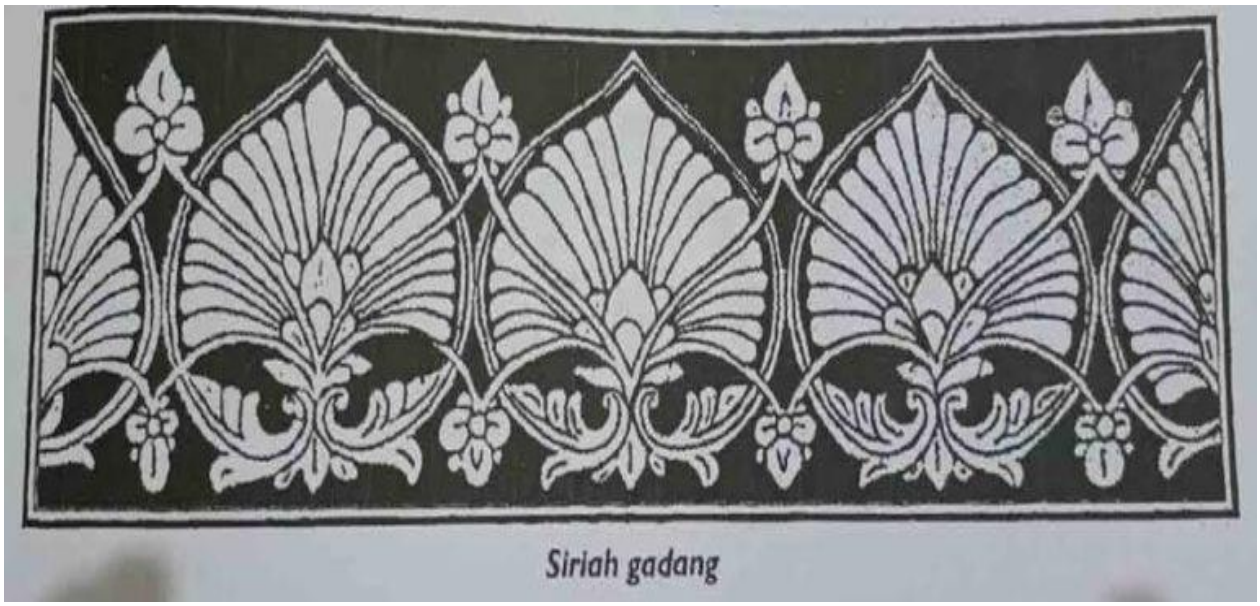
The *Pucuak Rebung* motif exhibits a hierarchical structure in which simple geometric units combine to form increasingly complex patterns. At the lowest level, small floral or star-like elements fill the interior of triangular forms. These triangles then aggregate into larger vertical compositions, creating a multi-level organization typical of fractal structures. Each hierarchical level retains a recognizable relationship to the others. Bilateral symmetry is maintained throughout the motif, particularly along the central vertical axis. More importantly, symmetry is not limited to a single level but recurs across multiple scales of the design. This iterative symmetry enhances visual balance and reinforces the fractal nature of the motif by repeating structural harmony at different hierarchical levels. The motif reflects a rule-based construction process, where weavers follow inherited principles governing motif placement, spacing, and repetition. These rules function as cultural algorithms that, when applied iteratively, produce complex fractal-like patterns. The consistency observed across different *Pucuak Rebung* textiles suggests shared generative rules within the

Minangkabau weaving tradition. The fractal properties of the *Pucuak Rebung* motif are closely tied to its natural inspiration. Bamboo growth itself exhibits fractal characteristics, such as modular repetition and scaling. By modeling the motif on the bamboo shoot, the weavers translate natural fractal processes into textile form, aligning mathematical structure with the Minangkabau philosophy of *alam takambang jadi guru*.

This information is also supported by the research participant where she also explained about the fractual concept of *Pucuak Rabuang Songket* motive. She said that "*the bamboo shoot symbolizes a young person growing. The bamboo shoot is small at the bottom, becoming stronger and more upright as it rises. In Minangkabau tradition, it signifies that humans must develop slowly, understand the rules, know their limits, and know their direction in life. This pattern was not created haphazardly. It has long been a rule. One triangle is arranged upwards, then repeated, with the same shape and the same spacing. If the spacing is incorrect, it looks unbalanced. So, it must be repeated with the right dimensions, from bottom to top".* It can be concluded that the analysis of the *Pucuak Rebung* songket motif demonstrates that fractal concepts are deeply embedded within Minangkabau textile traditions as culturally situated forms of mathematical knowledge. The motif exhibits key fractal characteristics, including self-similarity, recursive pattern formation, proportional scaling, hierarchical organization, and iterative symmetry. These features emerge through repeated triangular structures that mirror bamboo growth patterns, reflecting an intuitive yet systematic approach to design grounded in cultural experience rather than formal mathematical abstraction.

From an ethnomathematical perspective, the *Pucuak Rebung* motif confirms that mathematical reasoning is not limited to symbolic or numerical representation but can be expressed through artistic and material practices. The weavers' adherence to inherited design rules functions as a cultural algorithm that governs motif repetition, spacing, and proportion, resulting in fractal-like structures produced through embodied knowledge and intergenerational transmission. Furthermore, the fractal logic of the *Pucuak Rebung* motif is inseparable from its cultural meaning. The upward, recursive growth of the pattern symbolizes moral development, balance, and continuity in Minangkabau philosophy, aligning with the principle of *alam takambang jadi guru*. This integration of mathematical structure and cultural values highlights the epistemic richness of indigenous knowledge systems. Overall, the *Pucuak Rebung* songket motif illustrates how fractal geometry can be reinterpreted through ethnomathematics as a culturally grounded mode of mathematical thinking. Recognizing these fractal concepts not only expands the understanding of mathematics beyond formal systems but also supports the preservation and educational integration of local cultural heritage in contemporary contexts.

2. Siriah Gadang Songket Motive



Picture 2. Siriah Gadang

1	Name and Origin of the Songket Motif

The motif is labeled "Siriah gadang," which is likely a Minangkabau term. In Minangkabau culture, "siriah" refers to the areca nut tree, and "gadang" means large or great. Therefore, "Siriah gadang" likely translates to "large areca nut tree" or "great areca nut." This motif is probably inspired by the areca nut tree, which holds cultural significance in Minangkabau society. The areca nut tree is often associated with hospitality, tradition, and social ceremonies.

2	Visual Documentation of the Motif Pattern

The image shows a black-and-white illustration of the "Siriah gadang" motif. The pattern consists of a repeating band with large, fan-shaped elements that resemble the leaves or fruit of the areca nut tree. Each fan shape contains smaller floral or leaf-like details, and the entire design is framed within a pointed arch or diamond-like structure. Small flower motifs are placed between the large fan shapes, adding to the overall complexity and beauty of the pattern.

3	Dominant Geometric Forms and Structural Elements

The dominant geometric forms in this motif are fan-shaped or shell-like elements. These are the central focus of the design and resemble the leaves or fruit of the areca nut tree. Then, pointed arches or diamond frames: These enclose each fan-shaped element, providing structure and definition. Swirling vine-like elements where it connects the fan shapes to the base and add a sense of movement and fluidity. Small flower motifs mean place between the large fan shapes and add decorative detail. The structural elements include horizontal repetition where the motif repeats horizontally in a continuous band. Vertical symmetry is bilaterally symmetrical along a vertical axis. Interconnected lattices are interconnected, forming a cohesive and harmonious design.

4	Repetition and Scaling Patterns Indicative of Fractal Characteristics

The "Siriah gadang" motif exhibits a high degree of repetition, with each unit being identical and symmetrically arranged. However, there is no evidence of scaling patterns or self-similarity at different levels, which are key characteristics of fractals. The motif does not show smaller versions of itself within larger versions, nor does it exhibit recursive scaling. Therefore, while the motif is highly repetitive, it does not display fractal characteristics.

5	Symmetry and Proportional Relationships

The motif is bilaterally symmetrical along a vertical axis. Each fan-shaped element is mirrored on both sides, with identical radiating lines and internal floral details. The swirling vine-like elements at the base are also mirrored, creating a balanced and harmonious design. The small flower motifs above and to the sides are symmetrically placed, further enhancing the overall symmetry. The proportional relationships between the elements are carefully maintained, with each component fitting seamlessly into the overall design.

6	Motif Layering and Recursive Arrangements

The "Siriah gadang" motif does not exhibit recursive arrangements, as there are no smaller versions of the motif within larger versions. However, there is a clear layering of elements within each unit. Outer layer is the pointed arch or diamond frame encloses the entire unit. Middle layer is the large fan-shaped element with radiating lines. Then, inner layer is the smaller floral or leaf-like details within the fan shape. And decorative layer is the small flower motifs placed between the large fan shapes. This layering adds depth and complexity to the design, but it is not recursive.

7	Contextual Notes on Cultural Meaning and Usage

The "Siriah gadang" motif is likely inspired by the areca nut tree, which holds cultural significance in Minangkabau society. The areca nut tree is often associated with hospitality, tradition, and social ceremonies. In Minangkabau culture, the areca nut is used in various rituals and ceremonies, including weddings and other important social events. The motif may symbolize prosperity, growth, and the importance of tradition and community. The intricate design and careful attention to detail reflect the skill and artistry of Minangkabau weavers, who use songket textiles to express cultural identity and social status.

In addition, the *Siriah Gadang* motif in Minangkabau songket reflects key fractal principles when viewed through an ethnomathematical perspective. Beyond its decorative function, the motif represents a culturally grounded system of patterning characterized by self-similarity, symmetry, iteration, and scaling. Fractal self-similarity is evident in the repeated *siriah* (betel leaf) units arranged along the textile border. Each unit

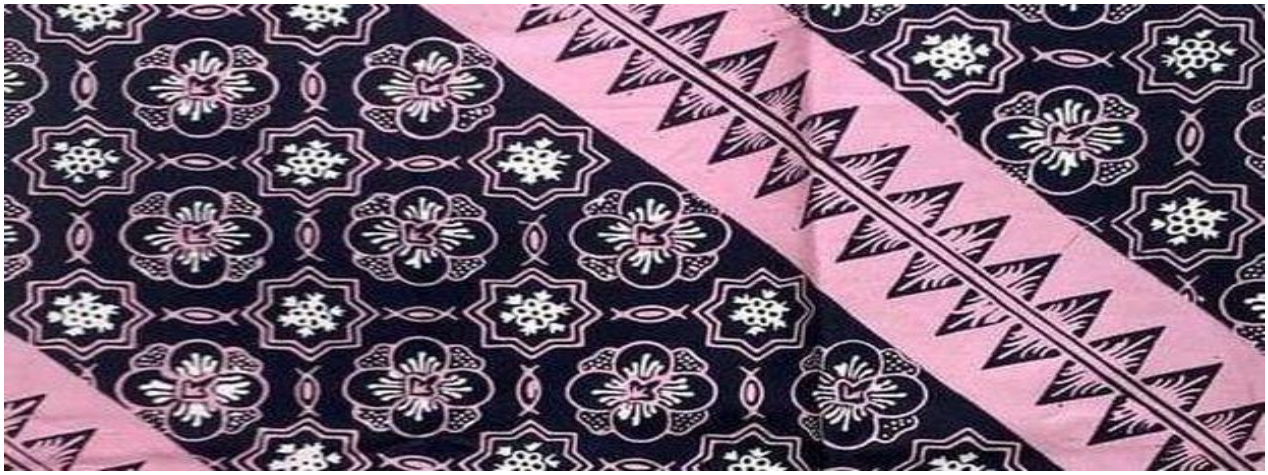
maintains a consistent structural form, demonstrating recursive repetition that parallels fractal generation processes. This repetition also symbolizes cultural continuity in Minangkabau society, where values and traditions are transmitted across generations.

The motif further exhibits bilateral and translational symmetry, creating visual balance and structural harmony. Such symmetry aligns with both fractal aesthetics and Minangkabau philosophical concepts of social order (*tatanan*) and balance (*keseimbangan*). Iterative construction is achieved through the replication of a core motif unit, forming a continuous pattern. Minor variations arising from hand-weaving introduce organic irregularities, reflecting the statistical self-similarity found in natural fractals. Additionally, the dominance of curvilinear forms connects the motif to fractal patterns observed in plant morphology, indicating intuitive mathematical reasoning derived from nature.

The participant also emphasizes the above information from her interview where she said that "Siriah gadang *represents openness and respect in Minangkabau culture. Betel leaves are always present in traditional ceremonies, symbolizing hospitality and harmonious social relations. The motif is arranged continuously to show that these values should never be broken. The same* siriah *shape is repeated because life in Minangkabau follows patterns. What is taught by parents is repeated by children. The form stays the same, even though time changes.*

In conclusion, the *Siriah Gadang* motif in Minangkabau *songket* demonstrates that traditional textile patterns embody sophisticated fractal principles when interpreted through an ethnomathematical lens. The motif's self-similarity, symmetry, iterative construction, and scaling reveal an intuitive understanding of fractal geometry rooted in cultural practice rather than formal mathematics. These mathematical characteristics are inseparable from their cultural meanings: the repeated *siriah* forms symbolize continuity, openness, and the intergenerational transmission of values in Minangkabau society. As reinforced by the participant's narrative, the unbroken repetition of the motif reflects a worldview in which social harmony and cultural teachings are continuously reproduced despite the passage of time. Thus, the *Siriah Gadang* motif is not merely decorative but represents a living synthesis of mathematical reasoning, natural inspiration, and cultural philosophy, highlighting the relevance of ethnomathematics in understanding indigenous knowledge systems.

3. Bungo Melati Songket Motive



Picture.3. Bungo Melati Songket Motive

1	Name and Origin of the Songket Motif

The motif depicted in the image is identified as **Bungo Melati**, a well-known Minangkabau songket motif originating from **West Sumatra**, particularly from traditional weaving centers such as ***Pandai Sikek***. The motif draws inspiration from the melati (jasmine) flower, a plant that holds symbolic significance in Minangkabau culture. As with many Minangkabau motifs, Bungo Melati is derived from natural forms and stylized through customary aesthetic conventions (*alam takambang jadi guru*).

2	Visual Documentation of the Motif Pattern

Visually, the textile presents a dense and orderly arrangement of floral units distributed across a dark background. The primary field is filled with repeated flower motifs arranged in a grid-like structure, while a contrasting diagonal band composed of triangular elements functions as a structural divider or border. The high contrast between the background and motif outlines enhances pattern clarity and repetition.

3	Dominant Geometric Forms and Structural Elements

The dominant geometric forms include **stylized circular and radial shapes** representing the floral core of the melati, combined with **polygonal and triangular elements** along the diagonal border. The floral motifs are constructed from repeated curved lines and petal-like segments, while the border incorporates angular, linear geometry. This combination demonstrates a balance between curvilinear organic forms and rigid geometric structures.

4	Repetition and Scaling Patterns Indicative of Fractal Characteristics

Fractal characteristics are evident through the **systematic repetition of identical floral units** across the textile surface. Each Bungo Melati motif retains the same structural proportions regardless of its position, reflecting **self-similarity**, a key fractal principle. While the scale of the motifs remains relatively uniform, the extensive repetition across the textile creates a perception of infinite extension, analogous to fractal tiling patterns.

5	Symmetry and Proportional Relationships

The motif exhibits strong **translational symmetry**, as the floral units are repeated horizontally and vertically at regular intervals. Elements within each flower also show **radial symmetry**, reinforcing internal proportional balance. The spacing between motifs is consistent, suggesting an implicit proportional system that governs motif placement and contributes to visual harmony.

6	Motif Layering and Recursive Arrangements

The overall design demonstrates **recursive arrangement** through the continuous replication of a single motif unit to construct the larger textile pattern. The diagonal border adds a secondary layer of repetition, where triangular units are iterated in sequence. This layered repetition, motif within motif, reflects recursive structuring similar to fractal composition, where complex patterns emerge from the repeated application of simple rules.

7	Cultural Meaning and Usage

Culturally, the Bungo Melati motif symbolizes purity, sincerity, and moral refinement within Minangkabau philosophy. Its use in songket textiles is commonly associated with ceremonial attire, including weddings and traditional rituals. The continuous and unbroken repetition of the motif visually reinforces the Minangkabau emphasis on cultural continuity, social harmony, and the transmission of values across generations. In this context, the fractal-like patterning functions not only as an aesthetic strategy but also as a symbolic representation of enduring cultural principles.

Furthermore, the songket motif reflects key ethnomathematical fractal concepts through its patterned construction. Self-similarity is evident in the repeated Bungo Melati units, where each motif retains the same structure across the textile surface. Iteration and recursion appear in the weaving process, as a single motif unit is continuously replicated to form a complex overall pattern. The motif also demonstrates symmetry, both internally within each floral form and externally through translational repetition, supporting visual balance and structural order. Minor variations produced by hand-weaving create statistical self-similarity, similar to natural fractals. Although the motif does not vary in size, its pattern can extend indefinitely, reflecting conceptual scaling. Overall, the motif illustrates how fractal ideas are intuitively embedded in Minangkabau textile traditions, linking mathematical structure with cultural meaning.

The information is also supported by the participant information on her interview. She said that *"the motifs are made the same again and again because life follows patterns. What our ancestors taught is repeated by the next generation. The form stays the same so the values are not lost. The flower shape represents purity and good character. Repeating it shows that these qualities should always be present, everywhere in life, not just once".*

It can be inferred that the Bungo Melati *songket* motif represents a meaningful integration of ethnomathematical fractal concepts and Minangkabau cultural values. The motif demonstrates self-similarity through the repeated floral units, iteration and recursion through systematic motif replication, and symmetry through balanced and orderly arrangement. Minor variations arising from the hand-weaving process produce statistical self-similarity, reflecting patterns commonly found in nature. Beyond its mathematical structure, the Bungo Melati motif symbolizes purity, harmony, and continuity, emphasizing the preservation of moral values and cultural teachings across generations. Consequently, the Bungo Melati *songket* motif functions not merely as decorative art but as a cultural expression in which mathematical reasoning, natural forms, and Minangkabau philosophy are intrinsically connected.

Discussion

There are some points that could be highlighted from the research findings in relation to the ethnomathematics fractal concepts. First is about shared-fractal, logic across motives. All three motifs, Pucuak Rabuang, Siriah Gadang, and Bungo Melati, exhibit a common fractal logic based on self-similarity, iteration, and symmetry. Despite differences in visual form, each motif is constructed from a core unit that is repeatedly replicated, indicating that fractal reasoning operates as an underlying design principle in Minangkabau songket rather than as an isolated aesthetic feature.

Second is the variation in fractal expression. The motifs differ in how fractal characteristics are visually expressed. Pucuak Rabuang demonstrates directional and hierarchical repetition**,** reflecting growth-like scaling analogous to natural fractals. Siriah Gadang emphasizes linear continuity and recursive border repetition**,** while Bungo Melati presents uniform self-similarity through evenly distributed floral units. This variation suggests that fractal concepts are adapted flexibly to convey different cultural meanings.

Third is Symmetry as Cultural and Mathematical Order. Symmetry functions as both a mathematical structure and a cultural metaphor. Pucuak Rabuang shows bilateral symmetry associated with balance between maturity and humility, Siriah Gadang employs translational symmetry to symbolize social continuity, and Bungo Melati uses radial and translational symmetry to convey purity and harmony. These findings support the view that symmetry in songket operates simultaneously within mathematical and philosophical domains.

Fourth is Statistical Self-Similarity and Hand-Weaving Practices. Accross all motifs, minor irregularities produced by manual weaving result in statistical self-similarity, aligning the textiles with natural fractal systems rather than idealized geometric models. This reinforces the argument that ethnomathematical fractals in songket are organic and intuitive, shaped by embodied craftsmanship rather than formal calculation.

Fifth is Conceptual Scaling and Infinite Extension**.** Although physical scaling is limited, the motifs demonstrate conceptual scaling, as patterns can theoretically extend indefinitely without altering their structural rules. In Pucuak Rabuang, this reflects continuous personal growth; in Siriah Gadang, unbroken social relations; and in Bungo Melati, enduring moral values. Fractal extensibility thus becomes a visual metaphor for cultural permanence. Sixth is Nature as the Source of Fractal Reasoning**.** The fractal structures observed in all three motifs are rooted in natural forms, such as plant growth, leaf arrangement, and floral symmetry, reflecting the Minangkabau philosophy *alam takambang jadi guru*. This indicates that fractal thinking emerges from sustained engagement with nature and is later formalized through textile design.

Previous ethnomathematics studies on Indonesian textiles have predominantly focused on identifying basic mathematical elements such as symmetry, geometric shapes, counting systems, and measurement embedded in cultural artifacts (e.g., D'Ambrosio, 2001; Rosa & Orey, 2011). In the context of Minangkabau songket, earlier research has largely emphasized the relationship between motifs and cultural symbolism or the presence of elementary geometry, without extending the analysis to more complex mathematical

structures (Enmufida & Turmudi, 2021; Fitriani et al., 2020). As a result, traditional motifs have often been interpreted as static decorative forms rather than as dynamic mathematical systems.

This study advances existing scholarship by explicitly framing Pucuak Rabuang, Siriah Gadang, and Bungo Melati motifs within the conceptual framework of fractal geometry. Unlike prior studies that treat repetition merely as ornamentation, the present findings demonstrate that repetition in these motifs operates as self-similarity and iteration**,** which are core fractal principles (Mandelbrot, 1983). For instance, Pucuak Rabuang exhibits directional and hierarchical repetition resembling growth-based fractals, a feature that has not been systematically discussed in earlier Minangkabau ethnomathematics research.

Furthermore, while symmetry has been widely acknowledged in traditional textile studies, it is often described in isolation from its generative function. This research reconceptualizes symmetry as a fractal-supporting mechanism that enables recursive expansion of motifs across the textile plane. Siriah Gadang's continuous border repetition and Bungo Melati's evenly distributed floral units illustrate how translational and radial symmetry sustain conceptual infinite extension, an aspect largely absent from earlier analyses that focused only on visual balance.Another key contribution lies in recognizing statistical self-similarity arising from hand-weaving practices. Prior ethnomathematics research tends to idealize patterns as mathematically exact, overlooking the significance of small irregularities produced by manual craftsmanship. By contrast, this study interprets these variations as aligning with natural fractals, where similarity is preserved despite local variation (Eglash, 1999). This perspective positions Minangkabau songket closer to organic fractal systems found in nature rather than to rigid Euclidean geometry.

Importantly, this study also extends ethnomathematics discourse by integrating cultural philosophy and fractal logic**.** While earlier works acknowledge the principle of *alam takambang jadi guru*, they rarely connect it explicitly to advanced mathematical reasoning. The fractal structures identified across the three motifs demonstrate that Minangkabau artisans internalize nature-inspired recursive rules, translating them into textile designs that encode cultural continuity, social harmony, and moral values. This synthesis of fractals, culture, and indigenous epistemology represents a conceptual advancement beyond descriptive ethnomathematics.

In summary, the novelty of this research lies in repositioning Minangkabau songket motifs as dynamic fractal systems rather than static cultural symbols. By comparatively analyzing Pucuak Rabuang, Siriah Gadang, and Bungo Melati, this study contributes empirical and theoretical evidence that fractal thinking is an integral component of indigenous mathematical knowledge, thereby expanding the scope of ethnomathematics and challenging Eurocentric narratives of mathematical development.

Conclusions

This research investigates that Minangkabau songket textiles embody a coherent system of ethnomathematical fractal concepts, where mathematical reasoning is intrinsically embedded within cultural practice. Through the analysis of Pucuak Rabuang, Siriah Gadang, and Bungo Melati motifs, the findings reveal consistent manifestations of self-similarity, iteration, recursion, symmetry, and statistical variation**,** reflecting fractal structures comparable to those found in natural systems. These patterns are not the result of formal mathematical calculation but arise from indigenous knowledge grounded in the Minangkabau philosophy *alam takambang jadi guru*, where nature serves as the primary source of learning. Beyond their aesthetic function, the fractal characteristics of songket motifs operate as visual metaphors for cultural continuity, social harmony, and intergenerational transmission of values. By positioning Minangkabau songket as a dynamic fractal system rather than a static decorative artifact, this research extends the scope of ethnomathematics and contributes to a deeper understanding of traditional textiles as sites of sophisticated mathematical and cultural knowledge.

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