An Ethnomathematical Exploration of Geometric Transformations in Torajan *Paruki* Woven Fabrics

Muhammad Nurhusain[1]✉, Nur Asrawati[1], Suri Toding Lembang[2]
(1)✉ Mathematics Education Study Program, STKIP YPUP Makassar, Indonesia
(2) Mathematics Education Study Program, Universitas Kristen Indonesia Toraja

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✉ Corresponding author
(zein.alhusain@gmail.com)
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Abstract

This study explored the ethnomathematical aspects of *Paruki* woven fabrics preserved at the La Galigo Museum by identifying geometric transformations embedded in their motifs and discussing their pedagogical implications for teaching transformation geometry. *Paruki* woven fabric is a traditional Torajan textile historically associated with ceremonial practices, including *Rambu Solo'*. The study employed an exploratory qualitative design informed by ethnographic principles, using artifact observation, semi-structured interviews with museum professionals, and document analysis. The findings revealed that the motifs embodied translation, reflection, rotation, and proportional scaling. Translation was the dominant transformation, while reflection and rotation were observed in symmetrical and repetitive motif arrangements, and proportional scaling was identified through similar geometric figures of different sizes. These mathematical patterns were interpreted alongside their cultural meanings, demonstrating the value of *Paruki* woven fabrics as culturally meaningful contexts for learning transformation geometry. This study extends ethnomathematics research by linking Torajan textile motifs with transformation geometry concepts and highlighting their potential to support culturally responsive mathematics education.

Keywords: *Ethnomathematics; Geometric Transformations; Paruki Woven Fabric; Toraja Culture; Mathematics Education*

1. INTRODUCTION

Mathematics education across diverse global contexts continues to face a persistent challenge: the disconnection between abstract mathematical concepts and students' sociocultural realities. This issue is particularly evident in the teaching of transformation geometry, where instructional practices often emphasize symbolic manipulation rather than meaningful understanding rooted in lived experience. Consequently, students frequently perceive mathematics as distant, decontextualized, and difficult to internalize (Sunzuma & Maharaj, 2019, 2020). In the Indonesian context, this condition is further exacerbated by the limited integration of local cultural knowledge into classroom practices, resulting in low engagement and superficial conceptual comprehension among learners (Mei et al., 2021; Pathuddin et al., 2021).

From the perspective of learners, this abstraction is not merely a pedagogical limitation but also a cultural disconnect. Many students encounter mathematical concepts that are presented without reference to their everyday environments, traditions, or inherited knowledge systems. Preliminary observations and prior studies indicate that such disconnection reduces students' ability to construct meaning, particularly in geometry topics that inherently rely on spatial reasoning and visual representation. This gap underscores the urgent need for instructional approaches that are both cognitively meaningful and culturally grounded.

Ethnomathematics, first introduced by D'Ambrosio (1985), offers a critical framework for addressing this issue by conceptualizing mathematics as a human activity embedded within cultural practices and social interactions. Rather than viewing mathematics as a universal and context-free discipline, ethnomathematics positions it as a dynamic system of knowledge shaped by cultural values, traditions, and everyday problem-solving processes. Building on this foundation, Rosa & Orey (2020) emphasize the importance of culturally relevant mathematics education, advocating for the integration of local knowledge systems into formal learning environments. Such integration not only enhances conceptual understanding but also fosters identity affirmation and cultural appreciation among students. Furthermore, within contemporary STEM education, ethnomathematics is increasingly recognized as a bridge connecting informal cultural knowledge with formal scientific reasoning (Deda et al., 2024; Rosa & Orey, 2021).

In recent years, a growing body of research has explored ethnomathematical elements embedded in Indonesian cultural artifacts. Studies on traditional architecture, such as Sasak houses, Honai of the Dani community, Toraja *Tongkonan* houses and Mekongga traditional houses, revealed the presence of geometric concepts, proportional reasoning, and non-standard measurement systems embedded in indigenous construction practices, highlighting their potential for contextual geometry learning (Hidayati et al., 2025; Kho et al., 2025; Lembang & Ba'ru, 2021; Supiyati et al., 2019). Other studies have identified numerical systems and calendrical calculations in indigenous cultural practices related to determining auspicious days for house construction (Umbara et al., 2021). In addition, traditional foods and textiles, including barongko cakes, Sumedang Tofu, and Lampung tapis, have been found to contain mathematical concepts such as symmetry, congruence, proportionality, measurement, and plane and solid geometry (Pathuddin et al., 2021; Putra & Ramdhani, 2025; Susiana et al., 2020). Ethnomathematical concepts have also been identified in traditional games and transportation technologies, such as the Kolong pigeon game and the Wairon war-boat of the Biak tribe, which embody symmetry, spatial reasoning, angular concepts, and anthropometric measurement systems within culturally situated practices (Sroyer et al., 2025; Zuliana et al., 2025). Furthermore, the integration of local wisdom into education has been shown to strengthen students' social and environmental awareness, as demonstrated through Mandar cultural values that foster empathy, cooperation, and responsibility, as well as the Tegal Deso-Okol tradition in Gresik, which promotes environmental conservation and contextual science learning (Arifin et al., 2025; Firnanda et al., 2025).

More specifically, transformation geometry has been explored through cultural artifacts such as batik patterns in Yogyakarta, demonstrating how translation, rotation, reflection, and dilation are intuitively applied in traditional design processes (Mei et al., 2021; Prahmana & D'Ambrosio, 2020). In the context of Torajan culture, Lembang & Ba'ru (2021) identified geometric transformations embedded in the carvings of *Tongkonan* traditional houses, highlighting the mathematical structures represented in architectural ornamentation. Recent studies have also integrated ethnomathematics with digital technology through the development of the Manarang module based on Mandar culture and Augmented Reality, which was found to effectively improve students' metacognitive abilities in learning transformation geometry (Anaguna & Wardani, 2026). Collectively, these studies demonstrate that embedding cultural contexts into mathematics instruction can significantly enhance students' conceptual understanding, communication skills, attitudes toward mathematics, and engagement in contextual learning (Rosa & Orey, 2021; Sunzuma & Maharaj, 2020).

However, despite these advancements, important gaps remain. Although geometric transformations have been investigated in Torajan cultural artifacts, particularly the carvings of *Tongkonan* houses (Lembang & Ba'ru, 2021), ethnomathematical research on *Paruki* woven fabrics remains limited. Unlike architectural carvings, woven textiles exhibit distinctive repetitive structures and motif arrangements that provide additional opportunities to examine translation, reflection, rotation, and proportional scaling within a textile medium. Moreover, previous studies have focused primarily on identifying mathematical concepts embedded in cultural artifacts, with limited attention to their pedagogical implications for teaching transformation geometry. Accordingly, this study extends previous research by investigating geometric transformations in *Paruki* woven fabrics while discussing their potential as culturally responsive learning resources for secondary school mathematics.

One such underexplored cultural artifact is the *Paruki* woven fabric, preserved in the La Galigo Museum in South Sulawesi. *Paruki* is a relatively complex weaving technique because it is done in reverse, where the motif being created can only be seen from the back side of the fabric being woven. *Paruki* woven fabric is similar to Torajan wood carvings in its use; initially, it was only used in religious ceremonies such as *Rambu Solo'* (Ikramah & Puspitasari, 2022). This traditional textile is characterized by its rectangular form, fringed edges, and intricate motifs, including *tedong* (buffalo), *tongkonan* (traditional houses), human figures, and geometric ornaments arranged in repetitive and symmetrical patterns (UPT Museum dan Taman Budaya, 2002). These visual structures suggest the presence of underlying geometric transformations; however, systematic academic exploration of these patterns, particularly within an ethnomathematical framework, remains limited.

Ethnographic approaches have proven effective in uncovering mathematical knowledge embedded in cultural practices, as they allow researchers to interpret not only structural patterns but also the meanings and values associated with them (Pathuddin & Raehana, 2019; Supiyati et al., 2019). Therefore, an ethnographic investigation of *Paruki* woven fabrics provides a promising pathway to bridge cultural heritage and formal mathematical concepts.

Grounded in D'Ambrosio's ethnomathematical paradigm and the culturally relevant education framework proposed by Rosa and Orey, this study positions *Paruki* woven fabrics as a culturally situated medium for exploring transformation geometry. By linking mathematical abstractions with culturally meaningful representations, this research seeks to contribute both theoretically and pedagogically to mathematics education.

Accordingly, this study aims to: (1) identify and analyze the forms of geometric transformations embedded in the motifs of *Paruki* woven fabrics preserved at the La Galigo Museum, and (2) examine the pedagogical implications of these mathematical patterns for teaching transformation geometry in secondary school mathematics. Through this investigation, the study seeks to deepen understanding of the relationship between culture and mathematics while proposing how the identified motifs may be used as culturally meaningful contexts to support context-based mathematics instruction. These pedagogical implications are derived from the ethnomathematical analysis rather than from empirical classroom investigation.

2. METHODS

2.1. Research Design and Approach

This study employed an exploratory qualitative design informed by ethnographic principles to investigate the ethnomathematical elements of transformation geometry embedded in *Paruki* woven fabrics preserved at the La Galigo Museum. Rather than undertaking a full community-based ethnography, the study focused on the cultural interpretation of traditional textile artifacts through artifact analysis supported by interviews with museum curatorial staff. This methodological approach enabled the researchers to examine the mathematical representations embedded in the motifs while interpreting their cultural meanings within the documented heritage context. By drawing on ethnographic principles, the study sought to understand the relationship between mathematical ideas and cultural practices reflected in the woven motifs, while recognizing that the findings are derived from artifact-based analysis rather than prolonged engagement with the Torajan weaving community. This approach is consistent with ethnomathematics research that emphasizes the interpretation of cultural artifacts as representations of mathematical knowledge (Pathuddin et al., 2021; Spradley, 1979; Supiyati et al., 2019).

2.2. Research Setting and Context

The research was conducted at the La Galigo Museum, located within Fort Rotterdam in Makassar, South Sulawesi, Indonesia. This site was purposively selected due to its role as a cultural repository preserving *Paruki* woven fabrics, which are closely associated with Torajan heritage. The museum context provided access to authentic artifacts as well as contextual information regarding their historical, symbolic, and cultural significance (UPT Museum dan Taman Budaya, 2002).

2.3. Participants and Sampling Strategy

Participants consisted of three museum professionals with extensive expertise in the history, symbolism, and cultural significance of *Paruki* woven fabrics preserved at the La Galigo Museum. A purposive sampling strategy was employed to select information-rich participants who were directly involved in curatorial and cultural interpretation activities. The participants included the

Head Curator (M1), a Museum Curator (M2), and a Museum Guide (M3). Their complementary professional roles provided diverse perspectives on the historical background, symbolic meanings, and educational significance of the *Paruki* woven fabric. This sampling strategy is consistent with qualitative research principles that prioritize information-rich cases over statistical representativeness (Patton, 2015).

2.4. Data Collection Techniques

Data were collected between November 2025 and January 2026 through artifact observation, semi-structured interviews, and document analysis to enhance the credibility of the findings. The observational component focused on one authenticated *Paruki* woven fabric preserved at the La Galigo Museum. The artifact was systematically examined to identify visual structures, including repetition, symmetry, and geometric patterns associated with transformation geometry, with observations documented through field notes and photographic records. For visual presentation, the original photograph was digitally aligned onto a two-dimensional plane using ChatGPT Image (OpenAI) solely to correct image perspective and orientation. The aligned image was verified against the original photograph to ensure that the spacing, proportions, symmetry, and geometric relationships of the motifs were preserved. In addition, ChatGPT Image (OpenAI) was used to generate analytical visualization panels illustrating the inferred composition of geometric transformations presented in Figure 12. These AI-generated visualizations were created solely to support the explanation of the observed geometric relationships and represent analytical reconstructions rather than primary research data or the actual weaving process. All transformation geometry analyses and interpretations were conducted using the original photographic documentation of the artifact, while the AI-assisted images were used exclusively for visual presentation and explanatory purposes. Semi-structured interviews were conducted individually with each participant on one occasion, with each interview lasting approximately 60 minutes. The interviews explored the historical background, symbolic meanings, cultural functions, and mathematical characteristics embedded in the *Paruki* motifs. Additional supporting evidence was obtained from museum archives, exhibition catalogs, and relevant literature (Patton, 2015; Spradley, 1979). Throughout the study, the researcher served as the primary research instrument, supported by observation protocols, semi-structured interview guides, and documentation tools. Considering the focused scope of this artifact-based investigation and the participants' specialized expertise, data collection continued until sufficient thematic coverage was achieved, with no substantively new information emerging regarding the cultural interpretation of the observed motifs.

2.5. Data Analysis Procedures

Data analysis followed the interactive model proposed by Miles et al. (2014), comprising data reduction, data display, and conclusion drawing. The analysis integrated evidence obtained from artifact observation, semi-structured interviews, and documentary sources. Observational and interview data were coded and categorized according to transformation geometry concepts, including translation, reflection, rotation, and dilation. These categories were then interpreted through an artifact-based ethnomathematical analysis to examine how mathematical structures were represented within the cultural context of the *Paruki* woven fabric. The categorized data were presented descriptively and visually to facilitate interpretation and comparison across data sources. Conclusions were developed through an iterative process of data reduction, data display, and verification by systematically relating the identified mathematical patterns to ethnomathematical theory and the documented cultural meanings of the motifs. Continuous cross-checking across observational, interview, and documentary data enhanced the consistency and credibility of the analysis, enabling the identification of both explicit and implicit mathematical structures embedded in the *Paruki* woven motifs.

2.6. Trustworthiness and Validity

To ensure the trustworthiness of the findings, this study adopted the criteria proposed by Lincoln and Guba (1985), including credibility, transferability, dependability, and confirmability. Credibility was strengthened through methodological triangulation by integrating artifact observations, semi-structured interviews, and documentary sources. Preliminary interpretations of the cultural meanings and mathematical representations identified in the *Paruki* motifs were shared with the museum informants to verify the accuracy of the researchers' interpretations. Transferability was supported through detailed descriptions of the research setting, participants, and analytical procedures. Dependability and confirmability were enhanced by maintaining systematic documentation of the research process, including field notes, interview transcripts, analytical coding, and reflective memos, thereby providing a transparent audit trail throughout the study (Lincoln & Guba, 1985; Nowell et al., 2017).

2.7. Ethical Considerations

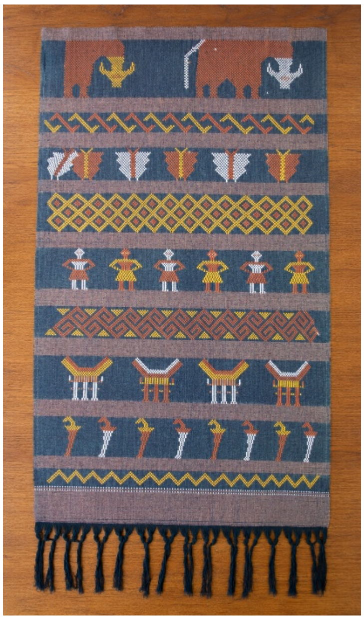
Ethical principles were observed throughout the research process. Prior to data collection, permission to conduct the study was obtained from the management of the La Galigo Museum. All participants received information regarding the objectives of the study, the voluntary nature of their participation, and the intended use of the research data before providing informed consent. To protect participants' privacy, personal identities were not disclosed in the reporting of the findings; instead, the informants were identified using the codes M1, M2, and M3. All interview records and research documents were used solely for academic purposes and handled in accordance with accepted standards of research confidentiality.

3. RESULTS

3.1. Overview of Analytical Framework

The findings of this study are organized into several thematic interpretations that capture both the mathematical structures and the cultural meanings embedded in *Paruki* woven fabrics, as shown in Figure 1.

(a) Source: (UPT Museum dan Taman Budaya, 2002)



(b) Source: Figure 1(b) presents an AI-assisted two-dimensional alignment of the original photograph using ChatGPT Image (OpenAI). The alignment was performed solely to correct image perspective and improve visual presentation without altering the motifs or their geometric properties. The aligned image was verified against the original photograph to ensure that the spacing, proportions, symmetry, and geometric relationships of the motifs were preserved. The transformation geometry analysis presented in this study was conducted using the original photograph, while the aligned image served only as an illustrative aid.

Figure 1. *Paruki* Woven Fabrics

The thematic construction was developed through iterative analysis of the visual motifs of *Paruki* woven fabrics, interpretive observations, and insights obtained from informants, following the qualitative data analysis principles proposed by Miles, Huberman, and Saldaña (2014). The analysis focused on identifying geometric transformation concepts represented in the arrangement of motifs, including translation, reflection, rotation, and dilation.

The visual analysis was conducted by examining the structure, repetition, orientation, and proportional variation of motifs displayed across different sections of the fabric. Each motif was interpreted not only in relation to transformation geometry principles but also through its symbolic and cultural significance within Torajan society. The motifs were analyzed sequentially from the upper to the lower sections of the fabric to provide a systematic understanding of how mathematical patterns are embedded within traditional weaving practices.

3.2. Translation: Repetition as Cultural Order

Repetition is one of the most prominent visual characteristics identified in the *Paruki* woven fabric and provides clear evidence of translational symmetry. The Butterfly Motif, Human Figure Motif, Traditional House Motif (*Tongkonan*), Zigzag Line Motif, and Traditional Weapon Motif (*Badi'*) are arranged in successive horizontal repetitions that preserve the same orientation, shape, and relative spatial relationships, as illustrated in Figures 2–6. Visual examination of the original photographic documentation indicates that the repeated motifs maintain consistent alignment and approximately uniform spacing, supporting their interpretation as translation patterns in accordance with the principles of transformation geometry.

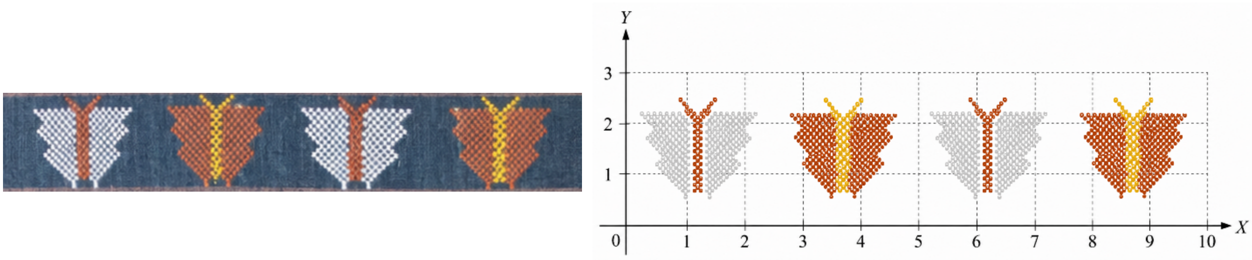


Figure 2. Translation of Butterfly Motif

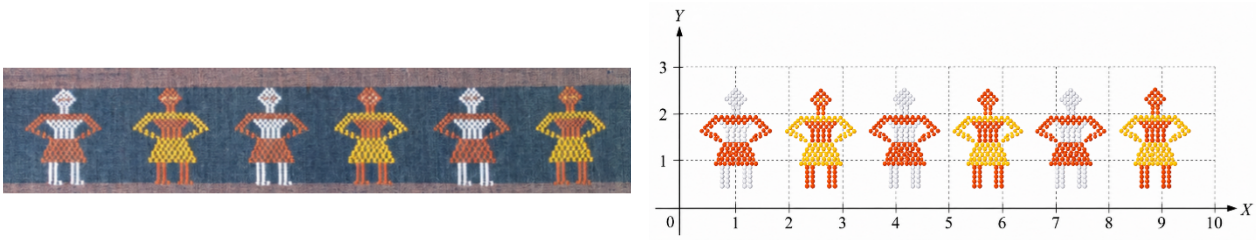


Figure 3. Translation of Human Figure Motif

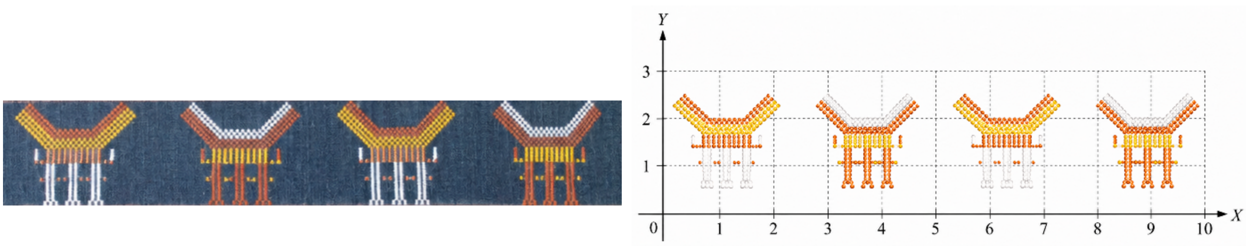


Figure 4. Translation of Traditional House Motif (*Tongkonan*)

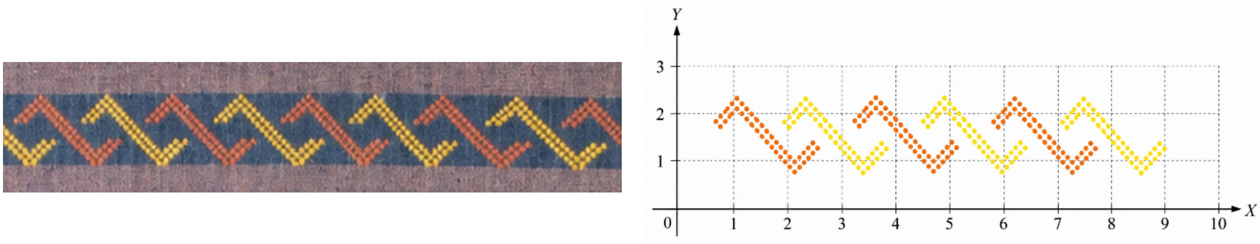


Figure 5. Translation of Zigzag Line Motif

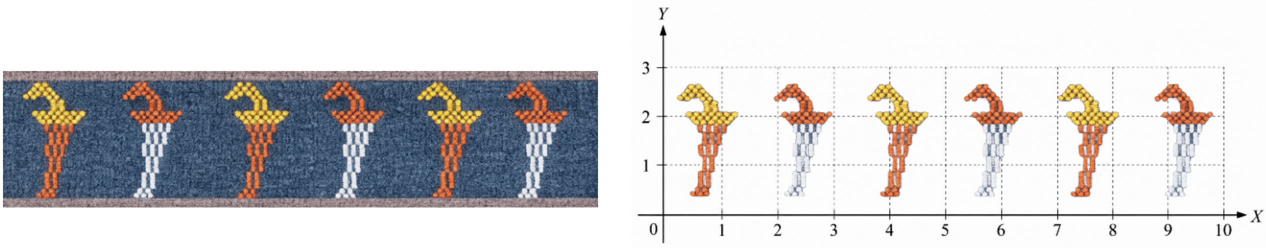


Figure 6. Translation of Traditional Weapons (*Badi'*)

Overall, the motifs in *Paruki* woven fabric, including the butterfly motif in Figure 2, the human figure motif in Figure 3, the *Tongkonan* traditional house motif in Figure 4, the zigzag line motif in Figure 5, and the traditional weapon (*Badi'*) motif in Figure 6, reveal a clear and orderly repetition arranged horizontally, which reflects the concept of translation in geometry. Each motif keeps its original form, size, and direction, while simply shifting position at fairly even distances, creating a sense of visual harmony rather than randomness. This pattern shows that translation plays a fundamental role in organizing the motifs, while at the same time illustrating how traditional artistic expression can naturally align with mathematical principles in the design of woven fabrics. Field observations indicate that the arrangement of motifs follows a structured visual order rather than random placement. This is supported by the statement of an informant who explained that each motif must be repeated at equal distances to maintain the visual balance of the fabric: "*Setiap motif harus berulang dengan jarak yang sama supaya kain terlihat seimbang*" (Informant M1; "Each motif must be repeated at equal intervals to ensure that the fabric appears balanced.").

The repetitive arrangement of the motifs suggests the consistent application of uniform displacement and spatial regularity in the weaving process, as reflected in the preserved *Paruki* woven fabric. From an ethnomathematical perspective, this structural pattern may be interpreted as indicating an implicit application of translation principles rather than explicit formal mathematical knowledge. Accordingly, translation can be understood not only as a geometric transformation but also as a cultural representation of order, harmony, and continuity embodied in the *Paruki* woven tradition. As this interpretation is derived from artifact analysis supported by museum informants rather than direct interviews with Torajan weavers, it should be regarded as an interpretive inference.

3.3. Reflection: Symmetry as Balance and Duality

Reflection symmetry is clearly visible in several motifs found in the *Paruki* woven fabric, particularly in the Buffalo Motif (*Tedong*), especially in the head section, the Butterfly Motif, the Human Figure Motif, and the Traditional House Motif (*Tongkonan*). These motifs demonstrate balanced geometric arrangements along a vertical axis, reflecting the artisans' emphasis on proportional harmony and visual equilibrium within the weaving structure. Reflection in these motifs not only represents geometric symmetry but also conveys symbolic meanings associated with harmony, balance, and social order in Torajan culture.

The Buffalo Motif (*Tedong*), which symbolizes prosperity, social status, and ritual importance in Torajan society, demonstrates bilateral symmetry in the head section through the balanced arrangement of its left and right sides along a central vertical axis. When conceptually reflected across this axis, both sides of the motif align proportionally, indicating the presence of reflection transformation resulting in symmetrical structures, as shown in Figure 7.

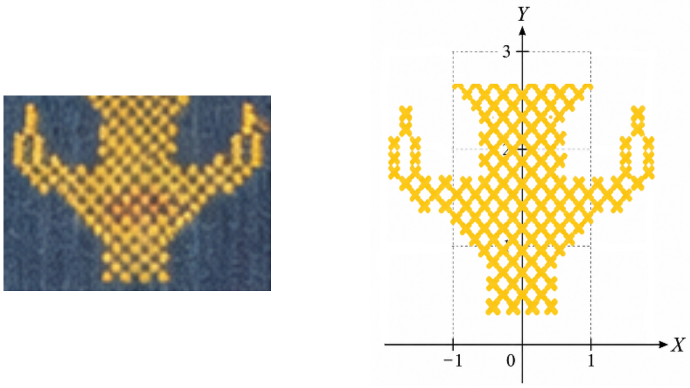


Figure 7. Reflection of Buffalo Head

The buffalo head motif in Figure 7 displays a clear symmetry between its left and right sides, which are separated by a vertical axis at the center. Both sides correspond to each other proportionally, indicating a reflection transformation that creates a balanced visual form. Similarly, the Butterfly Motif consists of two balanced parts positioned on the left and right sides of a vertical axis, forming a clear symmetrical structure, as shown in Figure 8.

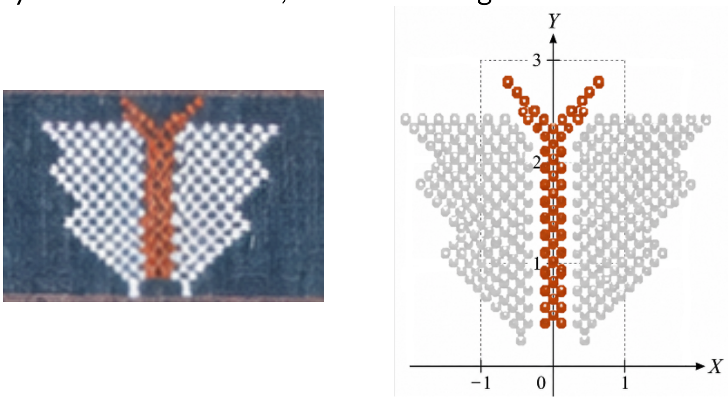


Figure 8. Reflection of Butterfly Motif

The butterfly motif in Figure 8 is composed of two wings that are evenly arranged on the left and right sides of a vertical axis. This structure reflects the concept of reflection, as one side appears as the mirror image of the other with identical shape and size. Similarly, the Human Figure Motif also reflects vertical symmetry through the balanced geometric structure of the body, where the left and right sides appear visually equivalent, as shown in Figure 9.

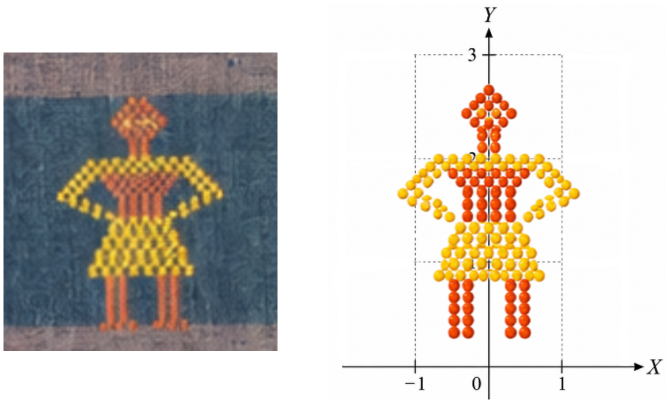


Figure 9. Reflection of Human Figure Motif

The human figure motif in Figure 9 shows a balanced body structure between the left and right sides, arranged in a symmetrical manner. This suggests the presence of reflection across a vertical axis, where both sides of the body exhibit equivalent visual proportions. A similar reflective structure can also be observed in the Traditional House Motif (*Tongkonan*), which represents the traditional house of the Torajan people. The motif is visually organized around a central vertical axis that divides the left and right sides of the house into relatively symmetrical forms. Architectural elements such as the roof structure, supporting lines, and decorative components appear proportionally balanced across this axis, indicating the presence of reflection transformation within the motif, as shown in Figure 10.

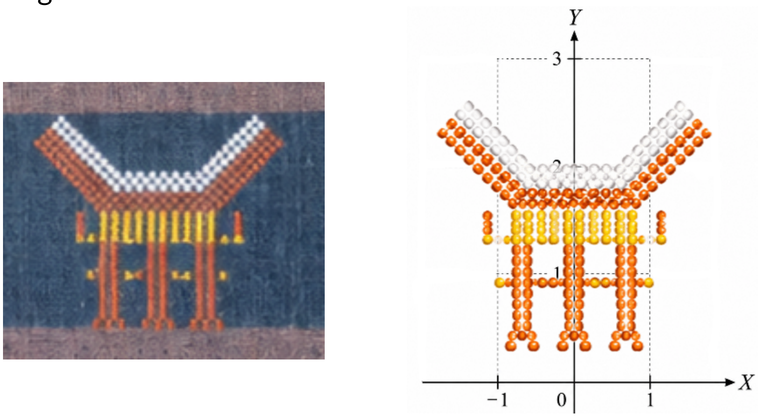


Figure 10. Reflection of Traditional House Motif

The *Tongkonan* house motif in Figure 10 is organized around a vertical axis that divides the left and right sections into nearly identical forms. Elements such as the roof, structural lines, and decorative details appear evenly distributed, illustrating the application of reflection in the motif's composition. The symmetrical composition of the Buffalo Head Motif, the Butterfly Motif, the Human Figure Motif, and the Traditional House Motif not only reflects geometric balance but also symbolizes harmony, stability, and social order within Torajan cultural philosophy. An informant explained that maintaining balance between both sides of the motifs is considered essential for preserving aesthetic harmony: "*Keseimbangan itu penting, kiri dan kanan harus sama*" (Informant M2; "Balance is important, the left and right sides should be symmetrical."). Overall, these findings indicate that reflection transformation resulting in symmetrical structures in *Paruki* weaving embodies both mathematical regularity and cultural representation that are deeply interconnected within the traditional weaving practice.

3.3. Scaling and Proportional Reasoning

The Rhombus Chain Motif exhibits a complex geometric arrangement in which diamond-shaped patterns are systematically repeated along both diagonal and horizontal directions. While the repetitive arrangement primarily represents translation, the motif also displays proportional variations in the size of corresponding rhombus elements, as illustrated in Figure 11. These variations suggest the presence of similar geometric figures and proportional scaling rather than providing conclusive evidence of dilation in the strict geometric sense, which requires the identification of a fixed center of dilation and a constant scale factor. Accordingly, the observed size differences are interpreted as an indication of proportional scaling embedded in the motif design.

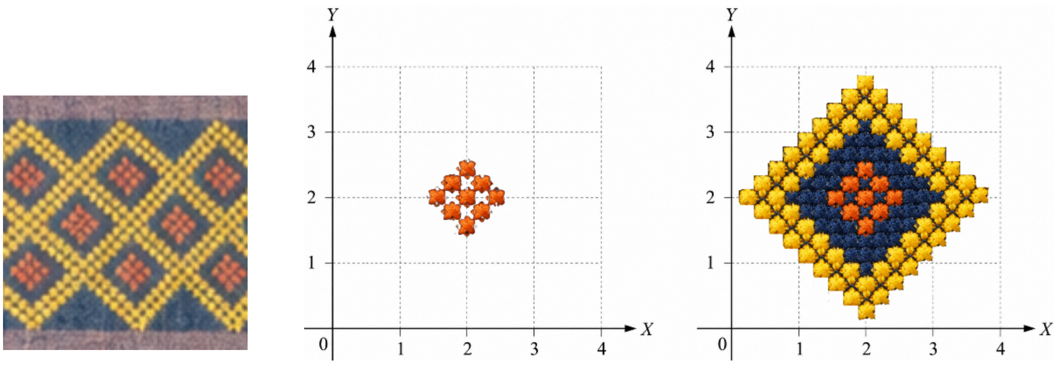


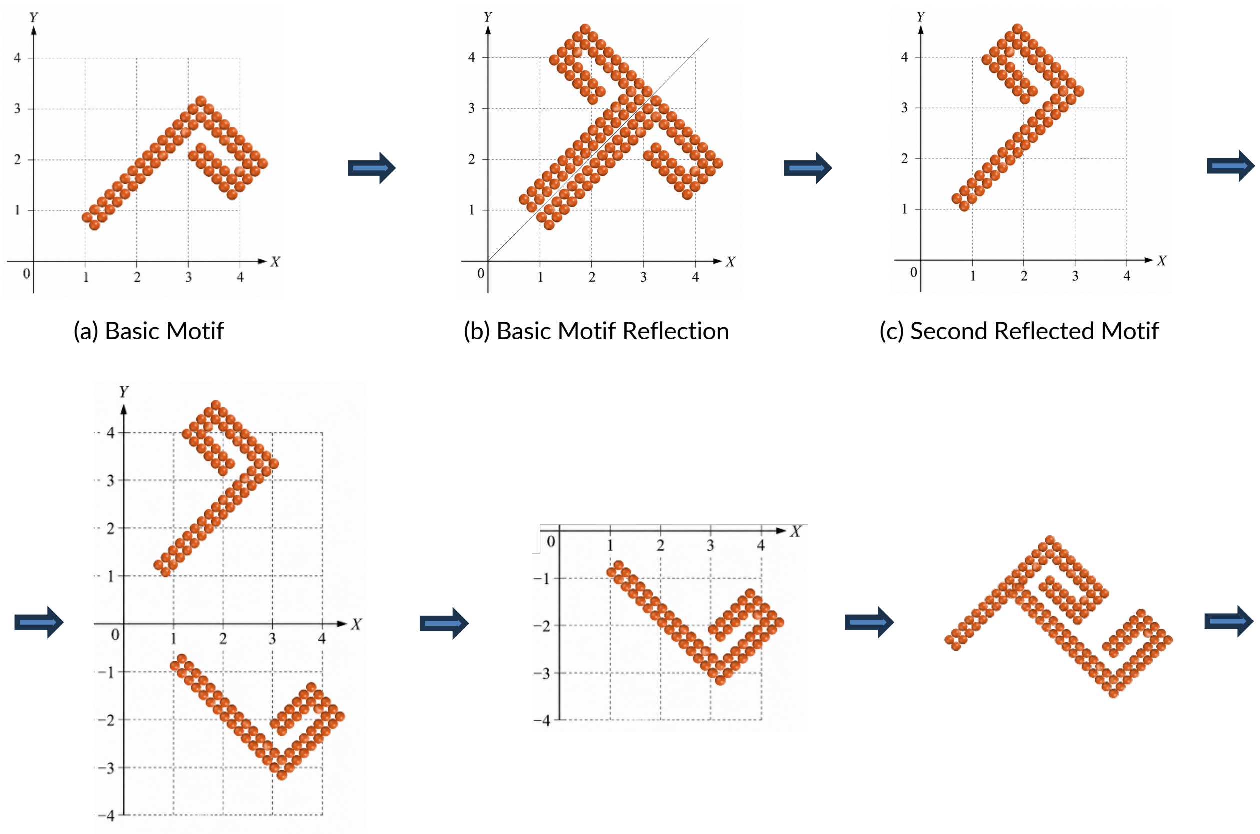
Figure 11. Proportional Scaling in the Rhombus Chain Motif

Figure 11 illustrates the Rhombus Chain Motif, in which diamond-shaped elements are systematically repeated along diagonal and horizontal directions while exhibiting proportional variations in size. Although the motif includes rhombus elements of different dimensions, their overall geometric form remains similar, indicating proportional scaling rather than providing conclusive evidence of dilation in the strict geometric sense. This interpretation is supported by an informant's explanation that certain motif elements are intentionally made larger to emphasize particular visual features within the fabric: "*Kadang motif dibuat lebih besar untuk menonjolkan bagian tertentu*" (Informant M3; "Sometimes motifs are made larger to emphasize particular elements."). Accordingly, the motif structure suggests the use of proportional variation while preserving the geometric characteristics of the rhombus elements. However, because the identification of geometric relationships was based on visual and interpretive analysis without formal geometric measurement, the observed size variations are interpreted as proportional scaling and similar geometric figures rather than as mathematically verified dilation.

3.4. Rotation: Movement and Continuity

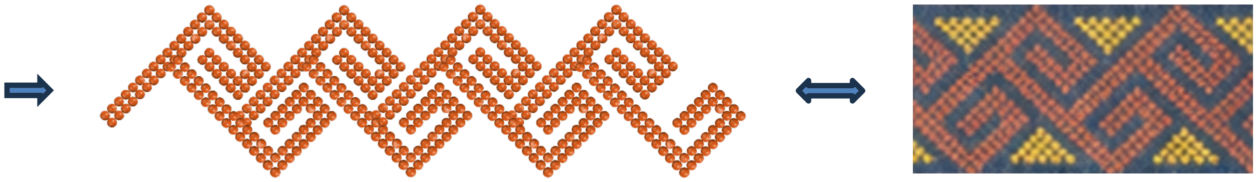
The Spiral or Wave Motif introduces a more dynamic visual structure compared to the rigid and symmetrical motifs found in other sections of the fabric. The motif is characterized by flowing curved lines that create an impression of movement and continuity throughout the woven design. From the perspective of transformation geometry, the motif demonstrates translation through the repeated arrangement of curved forms along a horizontal direction.

Closer observation also reveals rotational relationships among several adjacent curve motifs, which can be interpreted as repeated forms related through rotation about an approximate common center. However, because the available artifact does not permit precise geometric measurement, the exact center and rotation angle cannot be determined with certainty. As illustrated in Figure 12, the spatial arrangement of the motifs is more appropriately interpreted as a composition of geometric transformations, comprising reflection, rotation, and translation, rather than as a single transformation. This sequence represents the researchers' analytical reconstruction based on the observed motif configuration to explain the underlying geometric relationships embedded in the design. It should not be interpreted as evidence of the actual sequence of operations employed by the artisans during the weaving process.



(a) Basic Motif (b) Basic Motif Reflection (c) Second Reflected Motif

(d) Second Motif Rotation (e) Third Rotated Motif (f) Combined Basic and Third Motifs



(g) Translation Process (h) Spiral or Wave Motif

Figure 12. Rotation Process of Spiral or Wave Motif

Source: Panel (a) presents the original motif extracted from the photographic documentation of the *Paruki* woven fabric. Panels (b)–(h) were generated using ChatGPT Image (OpenAI) as an AI-assisted analytical visualization to illustrate the inferred composition of geometric transformations (reflection, rotation, and translation). The generated panels were prepared solely to support the interpretation of the observed geometric relationships and do not represent the actual weaving sequence or constitute primary analytical data. All transformation analyses and interpretations reported in this study were based on the original photographic documentation of the artifact.

The decomposition shown in Figure 12 represents an analytical reconstruction developed to visualize the inferred geometric relationships among the motif elements. It was generated using ChatGPT Image (OpenAI) solely for explanatory purposes and should not be interpreted as evidence of the actual sequence of weaving operations.

In Figure 12, the spiral or wave motif is developed from a single basic form that is gradually reoriented by rotating it around a central point. As each element turns at a specific angle, the pattern shows different positions without losing its original shape. This repetition produces a flowing and continuous design, giving the impression of movement and rhythm while clearly illustrating the idea of rotation. Based on Figure 12, the combination of translation, reflection, and rotation generated a rhythmic and continuous pattern symbolically representing movement, natural cycles, and continuity within Torajan cultural understanding.

Across the analyzed motifs, including the Buffalo Motif (*Tedong*), Butterfly Motif, Rhombus Chain Motif, Traditional House Motif (*Tongkonan*), Spiral or Wave Motif, Human Figure Motif, Traditional Weapon Motif (*Badi'*), and Zigzag Line Motif, the *Paruki* woven fabric demonstrates a variety of geometric transformations embedded within its visual structures. Translation is the most prominent transformation, occurring in the repeated arrangement of motifs throughout the fabric and, in several cases, in combination with reflection and rotation. Reflection is evident in symmetrical motifs such as the Buffalo, Butterfly, Human Figure, and *Tongkonan* motifs, while rotational relationships are observed in the Spiral or Wave Motif as part of a composition of geometric transformations. The Rhombus Chain Motif exhibits proportional variations in size that are interpreted as proportional scaling and similar geometric figures rather than conclusive evidence of geometric dilation. A thematic summary of the identified ethnomathematical transformations is presented in Table 1.

Table 1. Thematic Mapping of Ethnomathematical Transformations

Motif	Transformation Type	Mathematical Concept	Cultural Meaning
Buffalo heads (*Tedong*)	Reflection	Symmetry & repetition	Balance, status
Butterfly	Reflection, Translation	Mirror symmetry	Harmony
Rhombus Chain	Translation, Proportional Scaling	Scaling & pattern	Continuity
Human Figure	Reflection, Translation	Structural symmetry	Identity
Spiral/Wave	Rotation, Translation	Rotational motion	Life cycle
Tongkonan	Reflection, Translation	Proportional geometry	Social structure
Badi'	Translation	Linear repetition	Stability
Zigzag	Translation, Reflection	Linear repetition	Stability

Table 1 presents the thematic mapping of ethnomathematical transformations identified in the motifs of *Paruki* woven fabrics. The table demonstrates that each motif embodies specific types of geometric transformations that are closely related to mathematical concepts and cultural meanings within Torajan society. The Buffalo Motif (*Tedong*) reflects both reflection and translation transformations through its symmetrical head structure and repetitive arrangement across the fabric. Mathematically, the motif represents symmetry and repetition, while culturally it symbolizes balance and social status. Similarly, the Butterfly Motif demonstrates reflection and translation through its mirrored structure and repeated linear arrangement, representing the concept of mirror symmetry and symbolizing harmony.

The Rhombus Chain Motif illustrates translation and proportional scaling through the repetitive and scaled arrangement of diamond-shaped patterns, reflecting mathematical concepts of scaling and pattern continuity. The Human Figure Motif demonstrates reflection and translation through the balanced geometric structure of the human body and its repetitive placement, symbolizing identity within the cultural context. Meanwhile, the Spiral or Wave Motif reflects rotation and translation through its flowing curved forms, representing rotational motion and symbolizing the continuity of life cycles. The Traditional House Motif (*Tongkonan*) demonstrates reflection and translation through its symmetrical architectural structure and repeated arrangement across the fabric, representing proportional geometry and symbolizing social structure and harmony in Torajan culture. The Traditional Weapon Motif (*Badi'*) reflects repeated horizontal translation, forming a rhythmic visual structure that represents linear repetition and symbolizes stability. Lastly, the Zigzag Motif reflects translation and reflection through repetitive angular patterns that create rhythmic visual structures, representing linear repetition and symbolizing stability. Overall, the table indicates that geometric transformations in *Paruki* weaving are not only mathematical in nature but also deeply connected to cultural symbolism and traditional philosophical values.

These findings indicate that transformation geometry is not formally expressed within the weaving tradition but is implicitly embedded in the artisans' design practices. The arrangement of motifs reflects an intuitive understanding of geometric principles that are closely connected to aesthetic considerations and cultural symbolism. As a result, *Paruki* woven fabrics not only function as cultural artifacts but also represent meaningful visual manifestations of mathematical reasoning within traditional Torajan craftsmanship.

4. DISCUSSION

This study reveals that *Paruki* woven fabrics embody a structured system of geometric transformations, including translation, reflection, and rotation, embedded within culturally meaningful motifs, while the Rhombus Chain Motif exhibited proportional scaling and similar geometric relationships that may be associated with dilation, although a formal geometric verification of a fixed center and scale factor was beyond the scope of this study. These findings not only confirm the presence of mathematical structures in traditional Torajan weaving practices but also demonstrate that such structures are closely interconnected with the symbolic, aesthetic, and social dimensions of culture.

From a theoretical perspective, these results strongly align with D'Ambrosio's ethnomathematics paradigm, which conceptualizes mathematics as a cultural product emerging from human activity and interaction with the environment (D'Ambrosio, 1985). The repetitive and symmetrical patterns observed in *Paruki* motifs illustrate that mathematical reasoning is not exclusively formal or institutionalized but can develop organically within traditional craftsmanship. The artisans' intuitive application of transformation principles, despite the absence of formal mathematical notation, reinforces the argument that mathematics exists as a lived and practiced knowledge system. In contrast to formal mathematics, the transformations identified in *Paruki* woven fabrics are embedded in implicit, experiential, and practice-based processes, confirming that mathematical reasoning can develop beyond institutional frameworks.

4.1. Translation as Cultural Regularity and Cognitive Structuring

Among the four transformations identified, translation emerges as the most dominant structure across all motifs. This prevalence suggests that repetition is a fundamental design principle in *Paruki* weaving. From a cognitive standpoint, repetitive patterns may reflect an implicit understanding of spatial regularity and pattern generalization, which are essential components of mathematical thinking. The dominance of translation also indicates that repetition may function as a cognitive entry point for understanding geometry. Students exposed to repetitive cultural patterns such as those found in *Paruki* fabrics may more easily recognize spatial structures, identify geometric relationships, and develop spatial reasoning abilities. This interpretation aligns with studies emphasizing the importance of contextual learning in mathematics education (Rosa & Orey, 2021).

This finding is consistent with previous ethnomathematics studies in Indonesia, where translational patterns are frequently identified in cultural artifacts such as traditional foods and woven designs (Pathuddin et al., 2021; Utami et al., 2022). However, this study extends prior research by demonstrating that translation in *Paruki* fabrics is not merely decorative but structurally systematic, forming the foundational layer upon which other transformations are built.

4.2. Reflection as Symbolic Balance and Cultural Duality

Reflection symmetry, prominently observed in the head section of the Buffalo Motif (*Tedong*), Butterfly Motif, Human Figure Motif, and Traditional House Motif (*Tongkonan*), represents both a geometric operation and a cultural expression of balance and duality. In Torajan culture, symmetry often symbolizes harmony, equilibrium, and interconnectedness between opposing elements. The reflective arrangement of motifs along vertical axes demonstrates that geometric balance is intentionally preserved within the weaving composition.

This dual interpretation—mathematical and symbolic—supports the argument proposed by Rosa & Orey (2020) that mathematical concepts embedded in cultural artifacts carry layered meanings that extend beyond their formal definitions. Similar findings have been reported in studies of batik patterns, where symmetry is used not only for aesthetic purposes but also to convey philosophical and spiritual values (Mei et al., 2021). Reflection in *Paruki* weaving therefore represents not only mathematical regularity but also symbolic meanings associated with harmony, stability, and social order. In this context, geometric transformations should not be understood as purely mathematical constructs, but also as symbolic, cultural, and interpretative representations embedded in traditional knowledge systems.

4.3. Rotation and the Representation of Dynamic Systems

Although less dominant, rotational transformations identified in the Spiral or Wave Motif introduce a dynamic dimension to the fabric design. These patterns suggest movement, continuity, and cyclical processes, which may reflect natural phenomena or philosophical interpretations of life cycles within Torajan culture. This observation aligns with findings from ethnomathematical research on traditional artifacts that incorporate circular or curved forms to represent motion and continuity (Supiyati et al., 2019). The presence of rotation indicates that artisans not only engage with static symmetry but also conceptualize transformation in terms of movement and change.

In symbolic terms, rotational structures in *Paruki* weaving may represent continuity, cyclicality, and the interconnected flow of life within Torajan philosophical understanding. The combination of rotation and repetitive curved arrangements creates a visual impression of movement, reinforcing the idea that mathematical patterns in traditional weaving are deeply connected to cultural interpretations of nature and existence.

4.4. Scaling and Proportional Reasoning

Observed particularly in the Rhombus Chain Motif, reflects an intuitive understanding of proportional scaling. The ability to enlarge or reduce motifs while maintaining their structural integrity suggests that artisans possess an implicit grasp of geometric similarity. This finding resonates with studies highlighting proportional reasoning in cultural practices, particularly in architectural and textile designs (Hendriana et al., 2022; Hidayat et al., 2025). However, this study contributes a novel perspective by demonstrating how proportional scaling operates within a single textile artifact, rather than across separate cultural objects.

The integration of proportional scaling within *Paruki* motifs indicates that scaling is not only functional but also aesthetic, contributing to visual variation and hierarchical emphasis within the fabric. These findings suggest that proportional reasoning and geometric scaling are inherently embedded within the weaving process, despite not being formally conceptualized as mathematical operations by the artisans.

This study contributes to the ethnomathematics literature by reinforcing the idea that mathematical knowledge is culturally situated and contextually constructed. While previous research has largely focused on identifying mathematical elements in cultural artifacts, this study advances the field by systematically mapping these elements onto transformation geometry concepts and interpreting them within a coherent theoretical framework.

Furthermore, by examining an underexplored Torajan textile tradition, this research expands the cultural scope of ethnomathematics studies in Indonesia, which have traditionally centered on more widely studied artifacts such as batik and traditional foods. In doing so, the study provides new empirical evidence supporting the universality of mathematical thinking across diverse cultural contexts.

From an educational perspective, the findings highlight the significant potential of *Paruki* woven fabrics as culturally relevant learning resources for teaching transformation geometry. The integration of these cultural artifacts into classroom instruction enables students to connect abstract mathematical concepts with representations that are familiar within their sociocultural environment. Through this contextualization, students are more likely to develop a deeper conceptual understanding of geometric transformations because the learning process is grounded in meaningful visual experiences rather than purely symbolic explanations. In addition, the use of culturally meaningful motifs can increase students' engagement and participation during learning activities, as they perceive mathematics not as a distant and abstract discipline, but as knowledge closely related to their cultural identity and everyday experiences. The visual and tangible characteristics of *Paruki* motifs also support conceptual learning by providing concrete illustrations of translation, reflection, rotation, and dilation that students can directly observe and interpret. These educational implications are consistent with previous studies demonstrating that ethnomathematics-based instruction contributes positively to students' mathematical understanding, communication skills, and attitudes toward learning (Rosa & Orey, 2021; Sunzuma & Maharaj, 2019). Furthermore, within the context of contemporary multicultural education, such approaches contribute to more inclusive pedagogical practices by recognizing students' cultural backgrounds as valuable and legitimate sources of mathematical knowledge.

Although the types of geometric transformations identified in this study are generally consistent with findings reported in previous ethnomathematics research, this study offers several distinctive contributions that strengthen its academic significance. The novelty primarily lies in the focus on *Paruki* woven fabric, a Torajan textile tradition that has received very limited scholarly attention within ethnomathematics literature. In addition to introducing a relatively underexplored cultural artifact, this study provides a more systematic analytical approach by explicitly mapping traditional motifs onto transformation geometry concepts, including translation, reflection, rotation, and dilation.

Furthermore, this study plays an important role in supporting culturally based mathematics learning by demonstrating how local cultural elements can be meaningfully integrated into formal mathematical instruction. By positioning *Paruki* woven motifs as contextual learning resources, this research contributes to the development of ethnomathematics as an interdisciplinary field that bridges cultural practices with mathematical understanding. It also reinforces the theoretical relationship between ethnomathematics and geometry education by presenting cultural artifacts not merely as objects of observation, but as effective pedagogical tools that enhance students' conceptual comprehension.

In addition, this study contributes to the preservation of cultural heritage through education by highlighting the relevance of *Paruki* woven fabrics as culturally responsive learning media. Integrating these motifs into classroom practices can help sustain local wisdom while simultaneously making abstract mathematical concepts more accessible and meaningful to students. Therefore, this study does not merely reaffirm existing ethnomathematical perspectives, but also extends and deepens current understanding of how mathematical ideas are embedded, preserved, and communicated through cultural practices, while actively supporting education, cultural sustainability, and the advancement of ethnomathematics.

Notwithstanding these contributions, several limitations should be acknowledged. First, this study was based on a single *Paruki* woven fabric preserved in the La Galigo Museum, which may not fully represent the diversity of Torajan weaving traditions or motif variations found across different communities. Second, the cultural interpretations relied on interviews with museum professionals rather than traditional Torajan weavers. Consequently, the findings are grounded primarily in documented heritage knowledge and artifact-based analysis and should not be interpreted as direct evidence of contemporary weavers' practices or cognitive processes. Third, the identification of geometric transformations was based primarily on visual and interpretive analysis of the artifact without formal geometric measurements. Accordingly, the findings should be understood as qualitative interpretations of the observed geometric relationships rather than mathematically verified measurements. Finally, although this study discusses the pedagogical potential of *Paruki* woven fabrics for mathematics learning, these implications have not yet been empirically validated through classroom implementation. Future research is therefore encouraged to examine multiple *Paruki* weaving collections, involve traditional weavers through community-based ethnographic studies, incorporate quantitative geometric measurements where appropriate, and evaluate the effectiveness of ethnomathematics-based learning using *Paruki* motifs in classroom settings.

Future research should broaden the scope of artifact analysis by examining multiple *Paruki* woven fabrics from different Torajan communities to capture a wider range of motif variations and ethnomathematical characteristics. Studies involving traditional weavers through community-based ethnographic approaches and participant observation would provide deeper insights into the cultural meanings and weaving practices underlying the motifs. In addition, integrating quantitative geometric measurements and digital analysis tools could strengthen the mathematical rigor of transformation analysis. Finally, classroom-based intervention studies are needed to evaluate the effectiveness of *Paruki*-based ethnomathematics learning in improving students' understanding of transformation geometry, cultural awareness, and engagement with mathematics.

5. CONCLUSION

This study identified translation, reflection, rotation, and proportional scaling embedded in the motifs of *Paruki* woven fabrics preserved at the La Galigo Museum and discussed their pedagogical implications for teaching transformation geometry. By extending ethnomathematical analysis from Torajan architectural carvings to woven textiles, this study advances current knowledge through an artifact-based interpretation that connects cultural motifs with transformation geometry concepts and culturally responsive mathematics education. The findings provide a foundation for developing context-based mathematics learning while supporting the preservation and educational use of Torajan cultural heritage. Future research should validate these findings through studies involving traditional weavers, quantitative geometric measurements, and classroom implementation.

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