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ETHNOMATHEMATICAL EXPLORATION OF GEOMETRIC TRANSFORMATIONS IN BUGIS *LIPA' SABBE* MOTIFS OF SOUTH SULAWESI USING GEOGEBRA

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ABSTRACT

Lipa' sabbe, the hand-woven silk sarong of the Bugis people of South Sulawesi, Indonesia, carries a rich repertoire of geometric motifs, yet its use as a mathematically explicit resource for teaching geometric transformations remains limited, particularly with respect to coordinate-based modelling. This study aimed to identify and model the geometric transformations embedded in lipa' sabbe motifs and to distinguish transformations that are intrinsic to the woven designs from those that serve as pedagogical extensions. A qualitative ethnomathematical design with an artefact-analysis approach was employed. Four lipa' sabbe motifs representing the vertical-band (pucuk) and checkered (balo) design families were selected purposively, documented photographically, decomposed into fundamental units, and reconstructed in the Cartesian plane using GeoGebra; every translation, reflection, rotation, and dilation was verified algebraically through coordinate mapping. The results show that translation and reflection form the generative grammar of all four motifs: bilaterally symmetric units are completed by reflection and repeated across the cloth by translation. Rotation is intrinsic only as order-8 rotational symmetry in the eight-pointed star motifs, whereas quarter-turn rotation of the pucuk and ornament units and dilation of all units function as mathematical extensions rather than features of the cloth. A glide-reflection relation accompanied by colour change was also identified in one checkered motif. The study contributes a verified, coordinate-based set of culturally grounded tasks and a learning sequence that connect a living cultural artefact, dynamic geometry, and the formal algebra of transformations in mathematics education.

Keywords: Ethnomathematics; Geometric Transformation; *Lipa' Sabbe*; Bugis Culture; GeoGebra

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INTRODUCTION

Ethnomathematics has developed from a critique of the presumed cultural neutrality of mathematics into an established research programme that investigates how mathematical ideas are generated, organised, and transmitted within identifiable cultural groups (D'Ambrosio, 1985; Rosa et al., 2016). Early studies demonstrated that geometric thinking can be reconstructed from traditional crafts such as basketry and weaving, and that such reconstructions have genuine educational value when they help learners and teachers recognise the mathematics embedded in their own surroundings (Gerdes, 1988). Within this tradition, decorative patterns occupy a privileged position because their regularities are visible,

repeatable, and describable in the language of symmetry. Plane pattern analysis has shown that the structure of cultural designs can be characterised precisely by the isometries that map a pattern onto itself (Washburn & Crowe, 1988).

Geometric transformation is a curriculum topic in which this cultural potential is especially relevant. Research on students' understanding of transformations indicates that learners frequently interpret translation, reflection, and rotation as informal motions of a single figure rather than as functions that map every point of the plane, and that this view is only gradually refined into a defined, point-wise conception (Yanik & Flores, 2009). Dynamic geometry environments support this refinement because they allow students to manipulate pre-images, observe invariant properties, and connect visual change with symbolic rules (Hollebrands, 2003). More recent classroom studies report that GeoGebra helps students visualise reflection, rotation, translation, and dilation and encourages collaborative, discovery-oriented learning (Dahal et al., 2022). Technology alone, however, does not supply meaningful contexts: the figures manipulated in most transformation tasks are abstract polygons that bear little relation to students' cultural experience.

Indonesian scholarship has responded to this gap by exploring the mathematics embedded in local cultural artefacts. A review of ethnomathematics research in Indonesia published between 2010 and 2023 identified studies covering cultures from 34 provinces, with geometry among the most frequently explored domains (Kusuma et al., 2024), and a systematic review of ethnomathematics in geometry teaching found that Indonesia contributed the largest share of studies in the field (Kyeremeh et al., 2023). Batik patterns have been analysed as sources of geometric transformation and moral values (Prahmana & D'Ambrosio, 2020), Sundanese cultural practices as evidence of estimating, measuring, and pattern-making activities (Muhtadi et al., 2017), and woven textiles as contexts for reflection and translation, for example in the Sasak weaving of Sukarara (Sutarto et al., 2021). Analyses of Dayak Kenyah bead crafts and traditional clothing identified translation, reflection, and rotation, while noting that dilation was rare or absent (Abbas et al., 2024; Yahya et al., 2023). Internationally, Turkish kilim motifs have been used to teach transformational geometry to lower secondary students, with gains in interest and intuitive understanding, although rotation remained difficult for some learners (Dumlu & Alkaş Ulusoy, 2025).

Among the cultural artefacts of South Sulawesi, *lipa' sabbe* the hand-woven silk sarong of the Bugis, closely associated with the weaving centre of Sengkang in Wajo offers a particularly rich case. Ethnographic work has shown that Bugis weavers employ counting, designing, arranging, and measuring when creating motifs, and that the resulting designs can be described through reflection, translation, dilation, number patterns, and functions (Busrah et al., 2023). Subsequent studies have analysed the Lagosi motif as a context for translation and reflection (Pathuddin & Busrah, 2024), designed a reflection learning trajectory around the *bunga caramming* motif for eighth-grade students (Aras et al., 2023), and described symmetry, translation, and basic plane figures in Wajo silk sarongs with reference to the Cartesian coordinate system (Quraisy et al., 2025). Related research on the Bugis *walasuji* and on the Mandar variant of the silk sarong (*lipa' sa'be*) has likewise identified translation, reflection, rotation, and plane figures (Aras et al., 2025; Nakesya et al., 2024).

Despite this growing body of work, three limitations remain. First, most studies report the presence of transformations descriptively, by naming the transformation observed in a motif, without reconstructing the motif's fundamental unit in a coordinate system and verifying the mapping algebraically. Second, existing analyses rarely distinguish transformations that are intrinsic to the woven design from those that are imposed on a motif for instructional purposes.

This distinction matters, because presenting a pedagogical extension as a cultural fact misrepresents the artefact and weakens the epistemological claim of ethnomathematics. Third, although GeoGebra is widely used for teaching transformations, its use as an analytical instrument for modelling culturally situated motifs, rather than merely as a presentation tool, has received limited attention in the lipa' sabbe literature. Teachers also report that limited knowledge of how to translate cultural artefacts into geometry tasks is a major barrier to adopting ethnomathematical approaches (Sunzuma & Maharaj, 2019), which underscores the need for ready-to-use and mathematically verified materials.

Accordingly, this study aimed to (1) identify the fundamental units and symmetry structures of four lipa' sabbe motifs; (2) model translation, reflection, rotation, and dilation of these units in the Cartesian plane using GeoGebra and verify each mapping algebraically; and (3) classify each transformation as intrinsic to the cloth or as a pedagogical extension, and derive implications for the learning of geometric transformations. The study argues that lipa' sabbe motifs constitute a coherent and culturally authentic system of isometries dominated by translation and reflection, with rotation present as point symmetry in star motifs and that dynamic coordinate modelling can transform this cultural knowledge into rigorous and transparent learning resources.

METHOD

This section describes the research design, the cultural artefacts analysed, the procedures used to document and model the motifs, and the techniques employed to analyse and verify the findings.

Research Design

This study employed a qualitative design within the ethnomathematics research programme (Rosa et al., 2016), using an artefact-analysis approach. In ethnomathematical terms, the study adopted an etic orientation: the mathematical structure of the artefacts was examined and represented using the formal concepts of school geometry, while the cultural meaning of the motifs was drawn from existing ethnographic research on Bugis weaving (Busrah et al., 2023; Pathuddin & Busrah, 2024). The exploration focused on the four transformations that form the core of the lower-secondary geometry curriculum: translation, reflection, rotation, and dilation.

Research Objects

The objects of analysis were four lipa' sabbe motifs selected purposively to represent the two principal design families found in Bugis silk sarongs: the vertical-band family, in which pointed motifs (referred to in this study as *pucuk*, "shoots") alternate with gold stripes, and the checkered family (*balo*), in which coloured bands intersect to form squares that host small ornaments or stars. The selection criteria were that (a) the motif displays a clearly identifiable repeating unit; (b) the unit is sufficiently legible in photographic documentation to be digitised; and (c) the motifs collectively cover both linear (band) and planar (grid) repetition. The four motifs are summarised in Table 1 and shown in Figure 1.

Table 1. Characteristics of the Four *Lipa' Sabbe* Motifs Analysed

Motif	Design family	Dominant colours	Fundamental unit	Arrangement in the cloth
Lipa' Sabbe 1: pucuk and gold stripes	Vertical band	Maroon ground; gold	Half of a stepped pucuk (shoot)	Pucuk repeated horizontally between vertical gold stripes
Lipa' Sabbe 2: checks and gold ornaments	Checkered (balo)	Magenta, maroon, black; gold	Stepped double-headed ornament	Ornaments in alternating squares; larger pucuk along the border
Lipa' Sabbe 3: blue checks with stars	Checkered (balo)	Turquoise with multicoloured bands; pink and yellow stars	Elongated rhombic petal	Eight petals form a star; pink and yellow stars alternate diagonally
Lipa' Sabbe 4: red checks with white stars	Checkered (balo)	Red, dark brown, black, gold; white stars	Eight-pointed star	Stars placed in dark squares along a diagonal



Figure 1. The *Lipa' Sabbe* Motifs Analysed: Pucuk And Gold Stripes

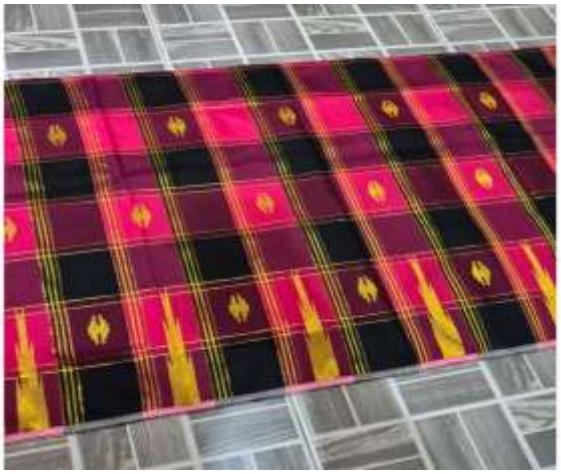

Figure 2. The *Lipa' Sabbe* Motifs Analysed: Checks And Gold Ornaments

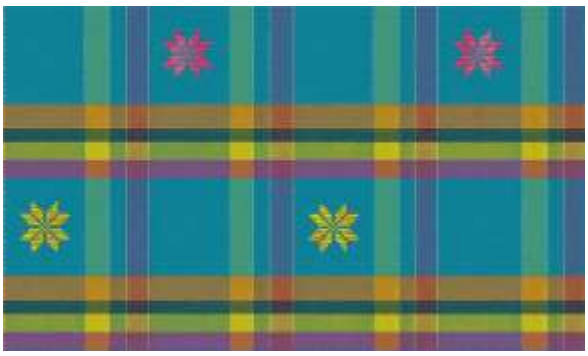

Figure 3. The *Lipa' Sabbe* Motifs Analysed: Blue Checks With Stars



Figure 4. The *Lipa' Sabbe* Motifs Analysed: Red Checks With White Stars

Data Collection

Data were collected through photographic documentation and structured visual observation of the four motifs, supported by a review of literature on Bugis weaving and ethnomathematics. For each motif, an observation protocol recorded the repeating unit, the arrangement of units across the cloth, the visible axes of symmetry, the presence of rotational symmetry, and any variation in unit size. The documented motifs were then digitised. The fundamental unit of each motif was traced as a polygon and placed in the Cartesian plane in

GeoGebra, with the unit's axis of symmetry aligned to the y-axis or its centre placed at the origin where appropriate. Each transformation was constructed using GeoGebra's transformation tools (Translate by Vector, Reflect about Line, Rotate around Point, and Dilate from Point), and a labelled reference point was tracked from pre-image to image.

Data Analysis Techniques

The analysis proceeded in three stages:

1. **Unit decomposition and symmetry description.** The fundamental unit of each motif and its point symmetry were identified (bilateral symmetry, the symmetry of a rectangle, or eightfold dihedral symmetry), following the principles of plane pattern analysis (Washburn & Crowe, 1988).
2. **Coordinate modelling and algebraic verification.** For each transformation, the image of the reference point was computed with the standard rules—translation by vector $u = (a, b)$: $(x, y) \to (x + a, y + b)$; reflection in the y-axis: $(x, y) \to (-x, y)$; rotation about the origin through angle θ: $(x, y) \to (x \cos \theta - y \sin \theta, x \sin \theta + y \cos \theta)$; and dilation centred at the origin with factor k: $(x, y) \to (kx, ky)$—and compared with the coordinates produced by GeoGebra.
3. **Cultural–mathematical classification.** Each transformation was classified as *intrinsic* (it maps the motif onto itself or generates the arrangement visible in the cloth), *partly intrinsic* (it approximates a feature of the cloth without describing it exactly), or a *pedagogical extension* (it is mathematically valid but does not describe how the motif appears in the cloth).

The analysis followed the iterative cycle of data condensation, data display, and conclusion drawing and verification (Miles et al., 2014). Credibility was strengthened by triangulating visual observation with the GeoGebra constructions and with independent algebraic computation, and by comparing the resulting classifications with findings reported in previous lipa' sabbe studies. Coordinates are reported to one decimal place, the precision displayed in the GeoGebra constructions.

RESULTS AND DISCUSSION

Results

The results are presented motif by motif. Figures 5-8 display the GeoGebra explorations, in which the darker figure represents the pre-image and the lighter figure the image. Table 2 summarises the algebraic verification of all mappings, and Table 3 synthesises the classification of the transformations.

Lipa' Sabbe 1: Pucuk and Gold Stripes

The first motif consists of tall, stepped pucuk woven in gold on a maroon ground and separated by vertical gold stripes (Figure 1). Observation showed that each pucuk is bilaterally symmetric about its vertical axis and that its outline narrows in stepped stages towards a single apex. The fundamental unit is therefore half of a pucuk; a complete pucuk is obtained by reflecting this half in the y-axis. In the GeoGebra model (Figure 5), the reflection maps Q(1.1, 3.4) to Q′(−1.1, 3.4), and the half-unit together with its image reproduces the complete shoot. Translation by $u = (4, 0)$ maps the apex P(0, 6) to P′(4, 6) and, when applied again, to P″(8, 6), generating the horizontal row of identical pucuk that characterises the band. Shape, size, and orientation are preserved, in agreement with the uniform spacing of the shoots along the cloth.

Rotation and dilation behave differently. Rotating the pucuk through 90° about the origin maps P(0, 6) to P′(−6, 0), and four successive quarter-turns produce a cross-shaped figure with

fourfold rotational symmetry. Dilation from the origin with k = 0.5 and k = 1.6 maps T(1.5, 6.5) to T′(0.8, 3.2) and T″(2.4, 10.4), producing similar shoots of different sizes. Neither the cross nor the scaled shoots appear in the cloth examined; both are mathematically valid constructions built from the cultural unit rather than features of the woven design.

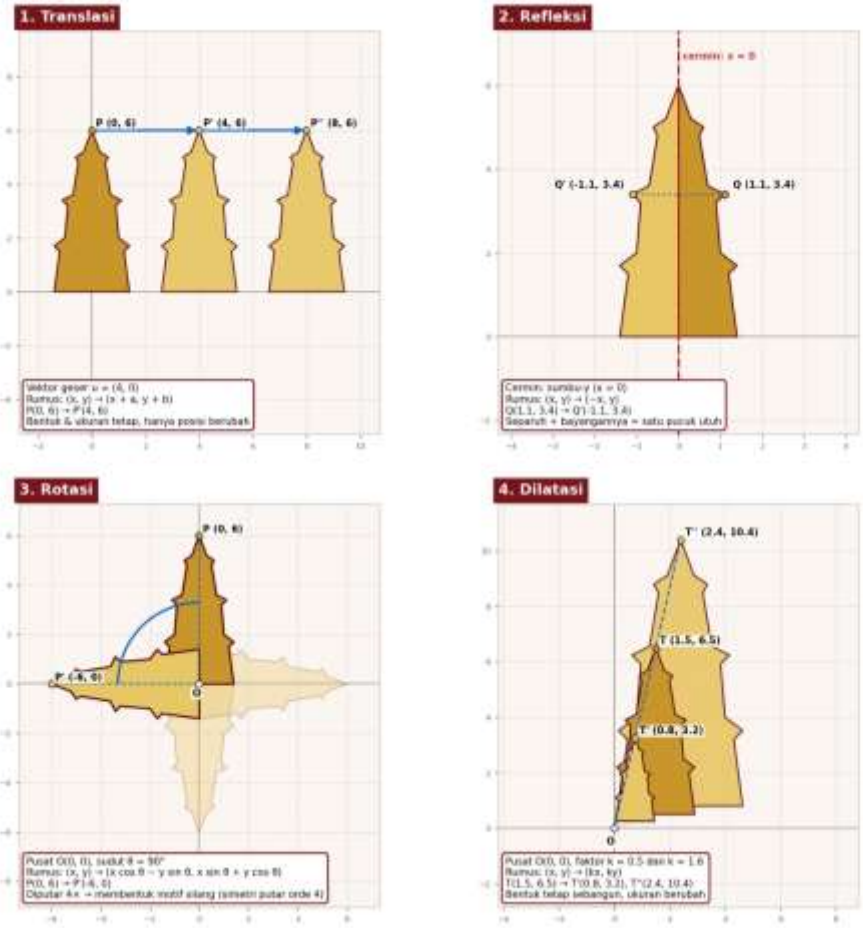

Figure 5. GeoGebra exploration of translation, reflection, rotation, and dilation in *Lipa' Sabbe'* 1

Lipa' Sabbe 2: Checks and Gold Ornaments

The second motif is a balo pattern in magenta, maroon, and black crossed by thin gold lines. Small gold ornaments are placed in alternating squares, and taller gold pucuk appear along the border (Figure 2). The ornament has a stepped, double-headed form that is symmetric about both its vertical and horizontal axes, giving it the point symmetry of a rectangle: two mirror lines and a half-turn. Reflection in the y-axis maps Q(0.8, 0.6) to Q′(−0.8, 0.6), confirming that one half of the ornament determines the whole (Figure 5). Translation by u = (3, 1.5) maps P(0, 2.4) to P′(3, 3.9) and P″(6, 5.4), modelling the diagonal displacement of the ornament from one square to the next in the checkered grid.

Rotation through 90° maps P(0, 5.6) to P′(−5.6, 0). Because the ornament does not possess fourfold symmetry, its rotated copies do not coincide with the original; four copies arranged about the origin instead generate a new four-petalled figure. Dilation with k = 0.5 and k = 1.7 maps T(2, 3.9) to T′(1, 2) and T″(3.4, 6.6). A size hierarchy is visible in the cloth, where the border pucuk are considerably larger than the ornaments in the squares. These are, however, different motifs rather than scaled copies of a single unit, so dilation is classified as only partly intrinsic for this motif.

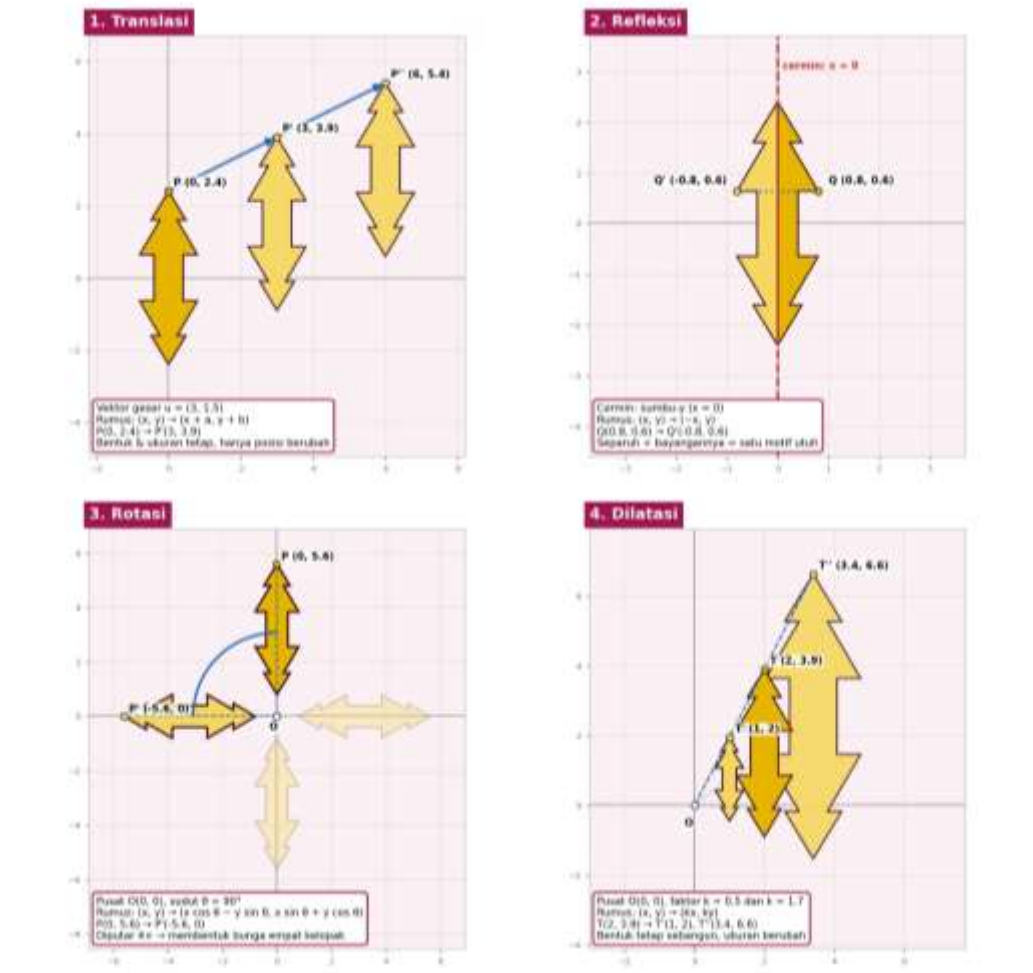

Figure 6. GeoGebra exploration of translation, reflection, rotation, and dilation in *Lipa' Sabbe'* 2

Lipa' Sabbe 3: Blue Checks with Stars

The third motif is a turquoise checkered pattern crossed by multicoloured bands, in which pink and yellow eight-pointed stars are placed in alternate squares (Figure 3). The fundamental unit is a single elongated rhombic petal. Rotating the petal about the origin through 45° maps P(2.5, 0) to P′(1.8, 1.8); repeating the rotation eight times produces a complete eight-pointed star (Figure 6). The star is therefore generated by rotation and possesses rotational symmetry of order 8; because each petal is also symmetric about its own axis, the star has eight lines of symmetry. Translation by u = (6, 5) maps P(2.5, 0) to P′(8.5, 5) and P″(14.5, 10), modelling the diagonal placement of stars in successive squares.

Reflection in the y-axis maps Q(6.5, 2) to Q′(−6.5, 2). Because the star is itself symmetric, its reflected image is congruent to the original. In the cloth, pink and yellow stars occupy squares on opposite sides of the vertical multicoloured band and are offset from each other by one row. Their relation is therefore described more precisely as a reflection followed by a vertical translation—a glide reflection—accompanied by a change of colour. Dilation with k = 0.5 and k = 1.6 maps T(5.3, 2.2) to T′(2.6, 1.1) and T″(8.5, 3.5); stars of different sizes were not observed in this cloth.

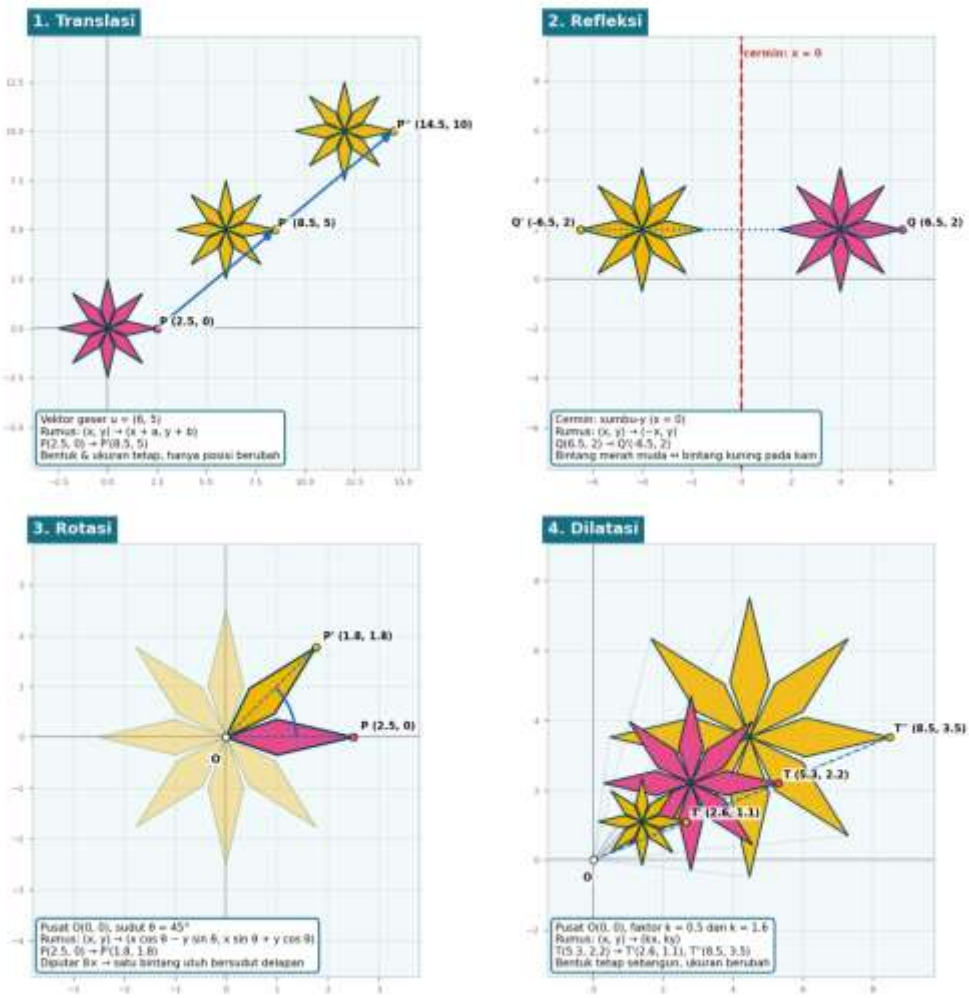

Figure 7. GeoGebra exploration of translation, reflection, rotation, and dilation in *Lipa' Sabbe'* 3

Lipa' Sabbe 4: Red Checks with White Stars

The fourth motif is a red and dark-brown checkered pattern crossed by black and gold lines, with small white eight-pointed stars placed in the dark squares (Figure 4). In contrast to Motif 3, the complete star is treated here as the fundamental unit, and the analysis focuses on its self-mapping properties (Figure 8). Rotation through 45° about the centre maps P(2.5, 0) to P′(1.8, 1.8), and the rotated star coincides exactly with the original, as shown by the dashed outline that overlaps the pre-image in the GeoGebra construction. The star is thus invariant under rotation by any multiple of 45°; that is, it has rotational symmetry of order 8.

Translation by u = (6, −5) maps P(2.5, 0) to P′(8.5, −5) and P″(14.5, −10), modelling the diagonal descent of stars from one dark square to the next. Reflection in the y-axis maps Q(6.5, 2) to Q′(−6.5, 2), corresponding to stars that appear on opposite sides of the vertical bands of the cloth. Dilation with k = 0.5 and k = 1.6 maps T(5.5, 2.2) to T′(2.8, 1.1) and T″(8.8, 3.5); as in Motif 3, variation in the size of the stars was not observed.

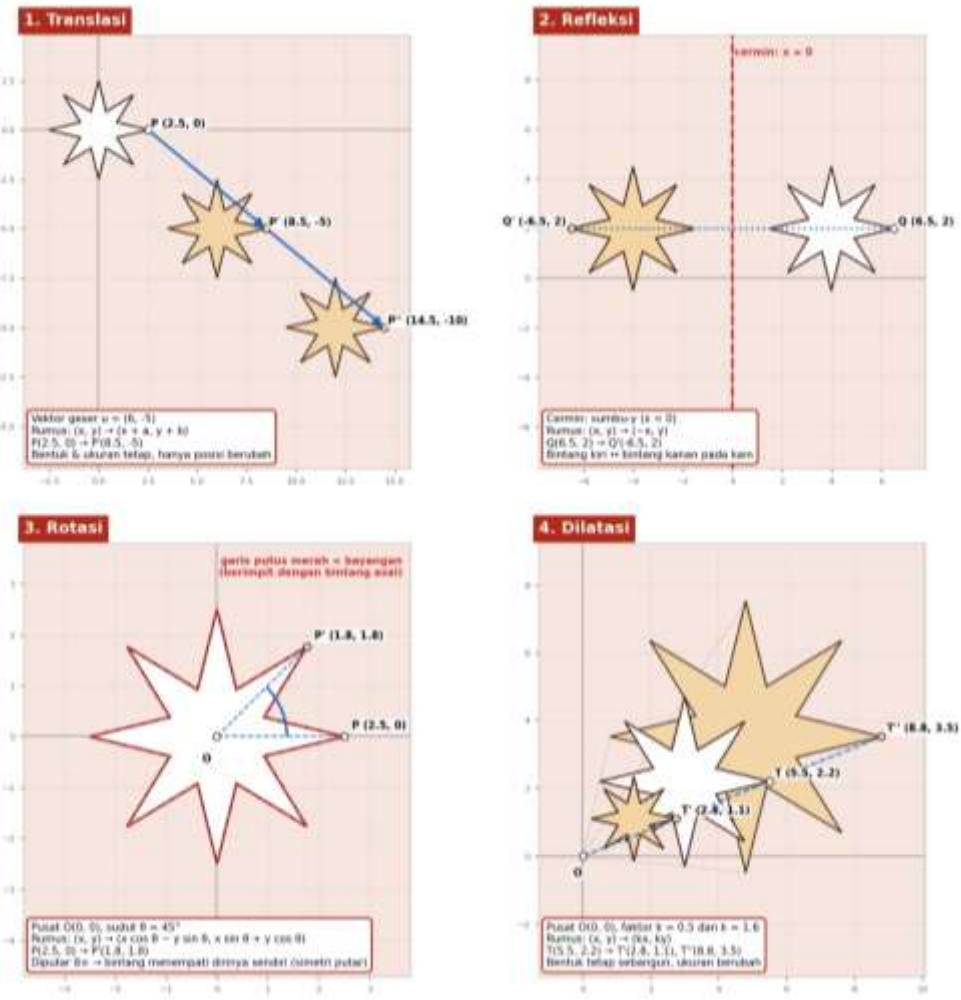

Figure 8. GeoGebra exploration of translation, reflection, rotation, and dilation in *Lipa' Sabbe'* 4

Table 2 compares the image coordinates obtained from the transformation rules with those displayed by GeoGebra. All sixteen mappings agreed; the only differences, such as 0.75 being displayed as 0.8, result from rounding to one decimal place.

Table 2. Algebraic Verification of the Transformations Modelled in GeoGebra

Motif	Translation	Reflection (x = 0)	Rotation about O	Dilation about O
1	u = (4, 0) P(0, 6) → P′(4, 6) → P″(8, 6)	Q(1.1, 3.4) → Q′(−1.1, 3.4)	θ = 90° P(0, 6) → P′(−6, 0)	k = 0.5; 1.6 T(1.5, 6.5) → (0.75, 3.25); (2.4, 10.4)
2	u = (3, 1.5) P(0, 2.4) → P′(3, 3.9) → P″(6, 5.4)	Q(0.8, 0.6) → Q′(−0.8, 0.6)	θ = 90° P(0, 5.6) → P′(−5.6, 0)	k = 0.5; 1.7 T(2, 3.9) → (1, 1.95); (3.4, 6.63)
3	u = (6, 5) P(2.5, 0) → P′(8.5, 5) → P″(14.5, 10)	Q(6.5, 2) → Q′(−6.5, 2)	θ = 45° P(2.5, 0) → P′(1.77, 1.77)	k = 0.5; 1.6 T(5.3, 2.2) → (2.65, 1.1); (8.48, 3.52)
4	u = (6, −5) P(2.5, 0) → P′(8.5, −5) → P″(14.5, −10)	Q(6.5, 2) → Q′(−6.5, 2)	θ = 45° P(2.5, 0) → P′(1.77, 1.77)	k = 0.5; 1.6 T(5.5, 2.2) → (2.75, 1.1); (8.8, 3.52)

Table 3 synthesises the classification. Translation and reflection are intrinsic to all four motifs. Rotation is intrinsic only in the two star motifs, where it either generates the star from a single petal (Motif 3) or maps the star onto itself (Motif 4); the quarter-turns applied to the

pucuk and the double-headed ornament are pedagogical extensions. Dilation is a pedagogical extension in three motifs and only partly intrinsic in Motif 2.

Table 3. Classification of geometric transformations in the four motifs

Transformation	Motif 1	Motif 2	Motif 3	Motif 4
Translation	Intrinsic: row of pucuk	Intrinsic: ornaments across the grid	Intrinsic: stars along a diagonal	Intrinsic: stars along a diagonal
Reflection	Intrinsic: bilateral pucuk	Intrinsic: two mirror axes	Intrinsic: eight mirror axes; glide reflection with colour change	Intrinsic: eight mirror axes; stars across bands
Rotation	Extension: 90° cross	Extension: 90° four-petalled figure	Intrinsic: 45° generates the star (order 8)	Intrinsic: 45° self-mapping (order 8)
Dilation	Extension	Partly intrinsic: border pucuk larger than field ornaments	Extension	Extension

Discussion

The findings show that translation and reflection constitute the generative grammar of lipa' sabbe. In every motif, a unit that is symmetric about at least one axis is completed by reflection and then repeated across the cloth by translation, either along a band (Motif 1) or across a lattice of squares (Motifs 2–4). This pattern is consistent with earlier reports that reflection and translation dominate Bugis weaving (Busrah et al., 2023; Pathuddin & Busrah, 2024) and other Indonesian textiles and crafts (Abbas et al., 2024; Sutarto et al., 2021). A plausible explanation lies in the craft itself: woven designs are produced on the orthogonal grid of warp and weft and are repeated along the length of the fabric, so that repetition by translation and mirror-symmetric thread arrangements are natural and economical. The weaver can, in effect, design half of a unit and obtain the whole by reflection a practice that corresponds to the mathematical decomposition of the motifs into half-units observed in this study.

Rotation appears in two pedagogically distinct forms. In Motif 3, rotation acts as a process that generates the star from a single petal; in Motif 4, it acts as an invariance under which the completed star coincides with itself. This distinction mirrors the developmental shift described by Yanik and Flores (2009), from viewing a transformation as the motion of one object to viewing it as a mapping of the whole plane in which some figures remain invariant. The presence of order-8 rotational symmetry is also mathematically notable: although weaving is constrained to an orthogonal grid, the stepped diagonals of the stars allow 45° directions to be represented, so that the eightfold symmetry is achieved within the constraints of the loom. Similar rotational structures have been reported in the Bugis walasuji and in Dayak Kenyah bead crafts (Aras et al., 2025; Yahya et al., 2023). Because rotation is the transformation students find most difficult when learning through cultural motifs (Dumlu & Alkaş Ulusoy, 2025), star motifs offer a valuable entry point in which the rotation is visible in the artefact itself rather than imposed on it.

The classification also clarifies the status of dilation and of quarter-turn rotations. Scaling the pucuk or the stars, and rotating the pucuk through 90°, produce valid and attractive figures, but they do not describe the cloth. This result agrees with the absence of dilation in Dayak Kenyah clothing (Abbas et al., 2024), whereas Busrah et al. (2023) reported dilation in Sengkang weaving; the difference may reflect the motifs selected or the interpretation of size hierarchies such as that between the border and field motifs of Motif 2. Making such distinctions explicit is important for ethnomathematics as a research programme, which seeks to recognise

the mathematical knowledge of cultural groups rather than to attribute to their artefacts properties they do not possess (Rosa et al., 2016). The glide-reflection relation with colour change identified in Motif 3 further shows that lipa' sabbe contains compositions of transformations that go beyond the four basic transformations of the school curriculum and could support enrichment tasks on composition and colour symmetry (Washburn & Crowe, 1988).

These findings have direct implications for teaching. The coordinate models enable a learning sequence in which students move from the cultural artefact to the formal rule rather than the reverse, as summarised in Table 4. Such a sequence combines the visual and exploratory affordances of dynamic geometry (Dahal et al., 2022; Hollebrands, 2003) with the cultural relevance demonstrated in learning trajectories built on lipa' sabbe and batik (Aras et al., 2023; Prahmana & D'Ambrosio, 2020). Because each mapping has been verified algebraically, the tasks can be adopted by teachers who lack experience in translating cultural artefacts into mathematics a barrier highlighted by Sunzuma and Maharaj (2019).

Table 4. Proposed learning sequence based on lipa' sabbe motifs

Phase	Focus	Student activity	Mathematical outcome
1	Observing the cloth	Identify the repeating unit and its axes of symmetry in a lipa' sabbe motif	Recognition of units, symmetry, and repetition
2	Reconstructing the unit	Trace the unit or half-unit as a polygon on the Cartesian plane in GeoGebra	Coordinate representation of a figure
3	Transforming and conjecturing	Apply translation, reflection, rotation, and dilation; track a reference point and record its coordinates	Conjectured rules for each transformation
4	Verifying and classifying	Verify rules algebraically and decide whether each transformation is intrinsic to the cloth or an extension	Formal rules; distinction between isometry and similarity
5	Designing	Create a new motif from a cultural unit using a chosen combination of transformations	Composition of transformations; creative application

This study has several limitations. It analysed four motifs, which do not exhaust the diversity of lipa' sabbe designs. The analysis was etic and based on photographic documentation; the names and cultural meanings of the motifs were drawn from the literature, so they require emic confirmation through interviews and observation with Bugis weavers. In addition, the proposed learning sequence has not yet been tested in classrooms. Future research should extend the analysis to the frieze and wallpaper symmetry groups of complete cloths, document the weavers' own design reasoning, and evaluate the learning sequence through design research or experimental studies.

CONCLUSION

This study explored geometric transformations in four Bugis lipa' sabbe motifs by reconstructing their fundamental units in the Cartesian plane with GeoGebra and verifying every mapping algebraically. Translation and reflection were found to be intrinsic to all four motifs and to form the generative grammar of the woven designs: bilaterally symmetric units are completed by reflection and repeated by translation along bands or across checkered grids. Rotation is intrinsic as order-8 rotational symmetry in the eight-pointed star motifs, whereas quarter-turn rotation of the pucuk and ornament units and dilation of all units serve as pedagogical extensions. A glide-reflection relation accompanied by colour change was also identified. Theoretically, the study contributes to ethnomathematics by proposing an explicit

distinction between transformations that are intrinsic to a cultural artefact and those introduced for instruction, thereby strengthening the authenticity of claims made about cultural mathematics. Practically, it provides a verified, coordinate-based set of culturally grounded tasks and a five-phase learning sequence that teachers can use to connect lipa' sabbe, dynamic geometry, and the formal algebra of transformations, while also supporting appreciation of Bugis cultural heritage. Future research should involve Bugis weavers to obtain emic accounts of motif design, extend the analysis to the frieze and wallpaper groups of complete cloths and to colour symmetry, and test the proposed learning sequence empirically to determine its effects on students' understanding of geometric transformations.

DECLARATIONS

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Author Contributions Statement

Suci Alisyia: Conceptualization, Methodology, Investigation, Formal Analysis, Visualization, Writing – Original Draft, and Writing – Review & Editing; Zaskia Arini: Data Collection, Data Curation, Formal Analysis, Validation, Visualization, and Writing – Review & Editing.

AI Usage Statement

The author takes full responsibility for the preparation, accuracy, and integrity of this manuscript. The manuscript has been carefully reviewed and edited to ensure clarity, coherence, and academic quality. All research data, analyses conducted using GeoGebra, and findings are based on the author's research process. All references have been verified against their original sources.

Conflict of Interest

The authors declare that they have no conflicts of interest related to the research, authorship, and/or publication of this article.

Data Availability

The photographic documentation and GeoGebra files supporting the findings of this study are available from the corresponding author upon reasonable request.

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Ethical Approval

Not applicable. This study analysed woven artefacts and their documentation and did not involve human participants or personal data.

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