E-ISSN: XXXX-XXXX
Ethnomathica
Journal of Ethnomathematics Studies
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VOLUME / ISSUE	PAGES	E-ISSN	DOI
Vol. 1, No. 1 (2026)	28–39	XXXX-XXXX	

Symmetry and Rigid Transformations in The Lontara Script: An Ethnomathematical Analysis of The Bugis–Makassar *Ina' Sure'* and Its Didactic Translation Into Coordinate Geometry

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Received: February 25, 2026 **Revised:** April 10, 2026 **Accepted:** Mei 27, 2026 **Published:** June 30, 2026

ABSTRACT

Ethnomathematical studies of Indonesian scripts have so far listed isolated geometric features, such as parallel lines or a rhombus, without analysing a script as a coherent geometric system or linking it to the formal treatment of transformations in school mathematics. This study examines the Bugis–Makassar Lontara script to (1) characterise the stroke geometry and symmetry of its 23 basic characters (*ina' sure'*), (2) identify the transformation relations that connect characters, and (3) translate these findings into coordinate-geometry tasks for lower-secondary students. A qualitative ethnomathematical design was used, combining document analysis of cultural and philological sources with a reproducible computational analysis of the standardised Unicode glyphs and a didactical-phenomenological analysis of an existing student worksheet. Diagonal strokes accounted for a mean of 91.4% of contour orientation (range 83.9–98.7%). Twelve characters had at least one isometric self-symmetry: sa and ha have two perpendicular mirror axes and a half-turn (D2), nine characters have a single vertical mirror axis (D1), and ka has only a half-turn (C2), produced by translating one stroke. Between characters, ma and da are exact half-turn images of ta and na, while ga, nra, mpa, ya and a are built by adding marks to a shared base. Because nearly all strokes have slope ±1, characters can be placed on the integer lattice so that translations, reflections and quarter-turns map lattice points to lattice points. The script therefore offers a culturally grounded and mathematically exact context for teaching the coordinate rules of transformations.

Keywords: Ethnomathematics; Lontara Script; Symmetry; Geometric Transformations; Coordinate Geometry.

How to Cite: Abdullah, A. F., & Lisdayanti. (2026). Symmetry and rigid transformations in the Lontara script: An ethnomathematical analysis of the Bugis–Makassar *Ina' Sure'* and its didactic translation into coordinate geometry. *Ethnomathica: Journal of Ethnomathematics Studies, 1(1), 28–39*

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INTRODUCTION

Mathematics education research has long recognised that mathematical ideas are produced and used within cultural practices, and that school mathematics becomes more meaningful when it connects with these practices. D'Ambrosio (1985) framed this view as *ethnomathematics*: the study of the ways in which cultural groups count, measure, locate, design and explain. Bishop (1988) identified designing and locating among the universal mathematical activities, and Gerdes (1988) showed that geometric thinking embedded in artefacts such as woven patterns can be "unfrozen" and turned into classroom mathematics. Later work has described ethnomathematics as a research programme with emic, etic and dialogic dimensions,

in which the insider's knowledge of a practice and the outsider's mathematical description are brought into conversation (Rosa & Orey, 2011, 2013; Rosa et al., 2016).

Indonesia, with its many cultures, has become one of the most active settings for this research. Studies have documented geometry in batik (Prahmana & D'Ambrosio, 2020), Sundanese estimating, measuring and patterning practices (Muhtadi et al., 2017), and the Javanese calendar system (Prahmana et al., 2021). A systematic review of ethnomathematics in geometry found that most of these studies are exploratory and descriptive, and that they rarely link their cultural findings to specific curricular content or to known difficulties in learning (Iskandar et al., 2022). Teachers who wish to use ethnomathematics in geometry also report that they lack ready mathematical analyses of local artefacts that they can turn into lessons (Sunzuma & Maharaj, 2019; Verner et al., 2019).

The Bugis–Makassar people of South Sulawesi have a writing system, the Lontara script (*aksara Lontara*, also called *urupu sulapa' eppa'*), whose characters are built from short straight strokes that meet at angles. Local tradition links the shapes of the characters to *sulapa' eppa'*, the four-sided (rhombus) figure that in Bugis cosmology represents the human being and the universe (Mattulada, 1985; Pelras, 1996). In a philological study of manuscript variation, Noorduyn (1993) noted that most characters can be built from four elementary graphs: a straight stroke, a V-shape, an inverted V and a dot. He treated this as a structural observation that "largely" agrees with the traditional *sulapa' eppa'* account, rather than as proof of the script's origin. Recent ethnomathematical work in the region has examined the *walasuji* motif, finding translation, reflection and rotation in its construction (Aras et al., 2025). The Lontara script itself has also been examined: Sudarmin et al. (2025) identified sets, number concepts, parallel lines (in *ka*), intersecting lines, right angles, triangles, a rhombus (in *sa*) and reflection (in *ha*).

These studies establish that the Lontara script contains geometric ideas, but they leave three gaps that this study addresses. First, features have been identified one character at a time, through observation and interviews, and no study has analysed the 23 basic characters (*ina' sure'*) systematically as one geometric system. Such an analysis would answer how prevalent a feature is, which symmetries occur, and how the characters relate to one another. Second, claims about symmetry have not been made reproducible: they rest on visual judgement and cannot be checked by other researchers. Third, the step from cultural observation to curriculum has stayed general. Previous work recommends the script as a learning source without showing how its geometry maps onto a specific curricular target. In the Indonesian *Kurikulum Merdeka*, that target is for Phase D (Grades 7–9) students to perform reflections, translations, rotations and dilations of points, lines and plane figures on the Cartesian plane (BSKAP, 2024).

This last gap matters because transformation geometry is a known area of difficulty. Students often treat transformations as motions of whole shapes rather than as functions that map every point of the plane. They also struggle to coordinate the visual image of a transformation with its coordinate rule (Edwards, 1991; Hollebrands, 2003; Yanik & Flores, 2009; Yanik, 2011; Gülkılık et al., 2015). Dynamic geometry environments such as GeoGebra can help students connect the geometric and algebraic views (Hohenwarter & Jones, 2007), and meta-analytic evidence shows a positive overall effect of GeoGebra-assisted instruction (Juandi et al., 2021; Zulnaidi et al., 2020). However, the figures transformed in such lessons are usually arbitrary triangles and polygons. A cultural artefact whose own structure is built from transformations could give students a reason to ask what stays the same and what changes.

This study therefore asks three questions. (1) What are the geometric characteristics, in stroke orientation and isometric self-symmetry, of the 23 *ina' sure'* of the Lontara script? (2)

Which transformation relations connect the characters with one another? (3) How can these findings be translated into the coordinate treatment of translation, reflection and rotation required in lower-secondary mathematics? We argue that the Lontara script is more than a decorative context for transformation geometry. Its characters form a small structured system in which reflection, half-turn and translation are present in the forms themselves, and the dominance of slope ±1 strokes makes the script well suited to exact work on the integer lattice.

METHOD

Research Design

The study used a qualitative ethnomathematical design with a descriptive–analytical orientation (Rosa & Orey, 2013). Following the dialogic approach to ethnomathematics, it combined an *emic* reading of the script, based on cultural and philological sources that describe how the Bugis–Makassar community understands the characters, with an *etic* mathematical description of the same forms. The two were then brought together in a didactic translation for school mathematics. This is not a research-and-development study: no product was designed, validated or tested for effectiveness. The student worksheet discussed below was an existing artefact, analysed as data for the third research question.

Data Sources

Three kinds of data were analysed. (1) *Cultural and philological documents*: ethnographic and historical accounts of the Bugis–Makassar people and the *sulapa' eppa'* concept (Mattulada, 1985; Pelras, 1996), the philological analysis of variation in the script (Noorduyn, 1993) and previous ethnomathematical studies of the script and related artefacts (Aras et al., 2025; Sudarmin et al., 2025). (2) *The script itself*: the 23 *ina' sure'* (ka, ga, nga, ngka, pa, ba, ma, mpa, ta, da, na, nra, ca, ja, nya, nca, ya, ra, la, wa, sa, a, ha), encoded in the Unicode Buginese block U+1A00–U+1A16 (Consortium, 2024) and rendered in the open-licence Noto Sans Buginese typeface (Project, 2017). A standardised digital typeface was chosen deliberately: it is the form students meet in present-day schoolbooks and signage, and it allows other researchers to reproduce the analysis exactly. (3) *A didactic artefact*: the student worksheet (*Lembar Kerja Peserta Didik*, LKPD) "Jejak Matematika Lontara", prepared by the authors for Grade IX. It comprises 16 student pages and 5 teacher pages and covers coordinates, translation, reflection and rotation with GeoGebra.

Data Collection

Cultural documents were collected through a literature search and analysed using document analysis (Bowen, 2009). Passages that describe the form, origin, construction or meaning of the characters were extracted. Each glyph was rendered at 400-point size into a 900 × 900 pixel greyscale image, binarised at the midpoint threshold and cropped to its bounding box. This produced 23 binary images, which formed the corpus for the computational analysis. The worksheet was read page by page, and each task was recorded with its mathematical content, the character or figure used, the coordinates given and the rule that students are expected to find.

Data Analysis Techniques

The analysis followed three stages, corresponding to the research questions.

1. **Stroke orientation.** For each glyph, image gradients were computed after Gaussian smoothing (σ = 2 px). The gradient magnitude was used to weight the edge direction, folded to the interval 0–180°, at each contour pixel (pixels above 20% of the maximum magnitude). Directions were assigned to four 45° wide bins centred on 0°, 45°, 90° and 135°. The *diagonal share* is the weighted proportion falling in the 45° and 135° bins.
2. **Isometric self-symmetry.** Each glyph was compared with its image under reflection in the vertical axis, reflection in the horizontal axis and a half-turn about the centre of its bounding box. Agreement was measured with a tolerance-based F-score. Precision P is the proportion of ink pixels of the transformed glyph lying within a distance τ of the original glyph's ink, recall R is the converse, and $F = 2PR/(P + R)$. We set τ to 3% of the glyph's larger dimension and treated $F \geq 0.90$ as evidence of symmetry. Each glyph was then assigned to the smallest symmetry group consistent with these results: C1 (none), C2 (half-turn only), D1 (one mirror axis) or D2 (two perpendicular mirror axes and a half-turn), following the classification conventions used in the analysis of cultural patterns (Washburn & Crowe, 1988; Weyl, 1952). Sensitivity was checked by repeating the classification for τ = 2%, 2.5%, 4% and 5%.
3. **Inter-glyph relations.** All glyphs were scaled to a 160 × 160 grid with their aspect ratios preserved. Small connected components (less than 25% of the area of the largest component), which correspond to the dots and short marks of the script, were then separated from the *base form*. For every ordered pair of base forms, the F-score (τ = 4 px) was computed for the identity and for the seven non-trivial symmetries of the square (reflections in the vertical, horizontal and two diagonal axes, and rotations of 90°, 180° and 270°). Pairs with $F \geq 0.90$ were recorded together with the transformation that achieved the highest score. A relation was classed as *isometric* when the full glyphs, marks included, matched under a non-identity transformation, and as *additive* when two glyphs shared a base form and differed only in their marks.

Image processing was done in Python with NumPy, SciPy and scikit-image (van der Walt et al., 2014). The script and the resulting per-glyph data are available from the authors (see Data Availability). For the third question, the worksheet tasks were analysed through didactical phenomenology (Freudenthal, 1983). For each task, we asked which cultural phenomenon it uses, which mathematical structure that phenomenon can organise, and what conjectured learning path it implies, in the sense of a hypothetical learning trajectory (Simon, 1995; Gravemeijer, 2004). The coordinate rules and answer keys in the worksheet were checked independently by computation. Credibility was supported by triangulating the computational results against the philological sources and by keeping the analysis reproducible (Lincoln & Guba, 1985; Miles et al., 2014).

RESULTS AND DISCUSSION

Results

Stroke orientation: a diagonal script. Diagonal directions dominated every character. Across the 23 *ina' sure'*, the mean diagonal share was 91.4%. The lowest values were for ga (83.9%), ya (86.9%) and pa (87.8%), where short rounded joins and dots add other directions, and the highest were for ka and nga (both 98.7%). The strokes of the script therefore run almost entirely at about ±45° to the line of writing, and horizontal or vertical segments are rare. This agrees with the traditional account that the characters are cut from the sides of the *sulapa' eppa'*

rhombus, whose sides are themselves diagonal when the figure stands on a vertex (Mattulada, 1985; Noorduyn, 1993). For mathematics, a stroke at 45° corresponds to a line of slope +1 or −1, so its endpoints can be placed on integer lattice points of the Cartesian plane without approximation.

Self-symmetry of the characters. Table 1 and Figure 1 summarise the symmetry classification. Twelve of the 23 characters (52%) showed at least one isometric self-symmetry. Two characters, sa (the rhombus) and ha, belong to D2: they are unchanged by reflection in both the vertical and horizontal axes and by a half-turn. Nine characters (ma, ta, da, na, nya, nca, ya, wa and a) have a single vertical mirror axis. One character, ka, has only a half-turn symmetry. It consists of two congruent parallel strokes, one of which is the image of the other under a translation (F = 1.00 for the matched strokes), so its half-turn symmetry arises from translation. The remaining eleven characters (ga, nga, ngka, pa, ba, mpa, nra, ca, ja, ra and la) are asymmetric (C1), although nga (F = 0.79, vertical) and ja (F = 0.79, horizontal) come close. No character had a horizontal mirror axis without also having a vertical one. The classification did not change for τ between 3% and 5%. At stricter tolerances (2–2.5%), da, na and, at 2%, ma, ta and a fell below the threshold because of the rounded apex and the off-axis placement of the dot in the typeface. The vertical-axis symmetry of these characters should therefore be read as a symmetry of the design rather than of every rendering.

Table 1. Symmetry classification of the 23 ina' sure' (F-scores for each test; τ = 3%)

Group	Characters	Vertical mirror F	Horizontal mirror F	Half-turn F
D2	sa, ha	0.99–1.00	0.99–1.00	1.00
D1 (vertical axis)	ma, ta, da, na, nya, nca, ya, wa, a	0.90–1.00	0.23–0.71	0.23–0.71
C2	ka	0.46	0.46	1.00
C1	ga, nga, ngka, pa, ba, mpa, nra, ca, ja, ra, la	0.26–0.79	0.32–0.79	0.21–0.65

Source: Authors' computation on Noto Sans Buginese glyphs (U+1A00–U+1A16)

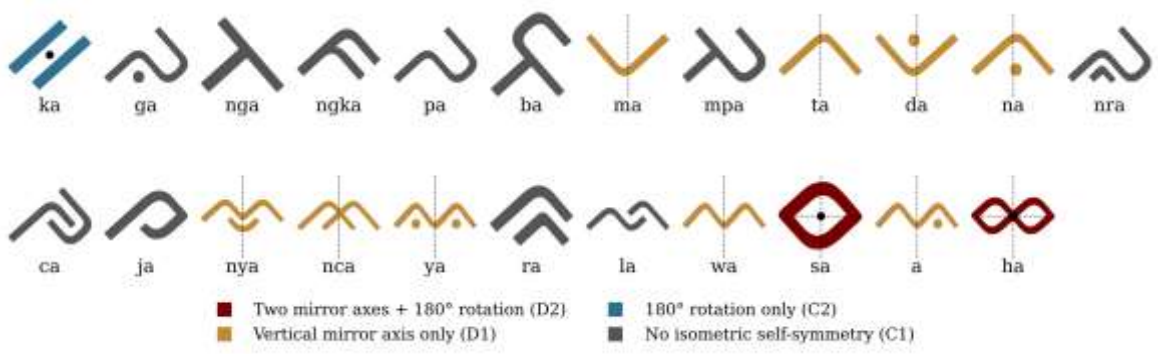

Figure 1. The 23 *Ina' Sure'* coloured by symmetry group; dotted lines mark mirror axes and black dots mark half-turn centres

Transformation relations between characters. The pairwise analysis revealed two kinds of structure (Table 2, Figure 2). The first is *isometric*. The characters ta (∧) and ma (∨) are exact half-turn images of each other (F = 1.00). Because ta is symmetric about the vertical axis, the same relation is also a reflection in the horizontal axis. The same holds for na and da, which are ta and ma with a dot below and above the stroke: the half-turn maps na onto da with its dot (F = 1.00). These four characters are the inverted-V and V graphs that Noorduyn (1993)

identified as building blocks of the script. They form a closed set under two operations: the half turn exchanges ta with ma and na with da, and adding a dot sends ta to na and ma to da.

The second kind of structure is *additive*. Several characters share a base form with another character and differ only in a dot or short stroke. ga and nra have exactly the base form of pa (F = 1.00), and mpa shares most of it (F = 0.92). Likewise, ya and a have the base form of wa (F = 1.00). Within wa itself, the two peaks are congruent and one is a translate of the other, which gives the character a frieze-like repetition. ka shows translation in its simplest form: one stroke and its translate. Thus the three rigid motions of the school curriculum (translation, reflection and rotation) each appear in at least one character or pair of characters, while the frequent additive derivations show that the script is organised economically around a few base forms.

Table 2. Transformation Relations Among the *Ina' Sure'* (F ≥ 0.90)

Relation	Characters	F-score	Mathematical description
Isometric (half-turn)	ta ↔ ma	1.00	R(O,180°); equivalently reflection in x-axis, since ta is symmetric about the y-axis
Isometric (half-turn)	na ↔ da	1.00	R(O,180°) of the base form and its dot
Translation within a character	ka	1.00	Second stroke = T(v) of the first stroke
Additive (shared base)	pa → ga, nra	1.00	Same base form + dot / short mark
Additive (shared base)	pa → mpa	0.92	Same base form + additional stroke
Additive (shared base)	ta → na; ma → da	1.00	Same base form + dot
Additive (shared base)	wa → ya, a	1.00	Same base form + one or two dots

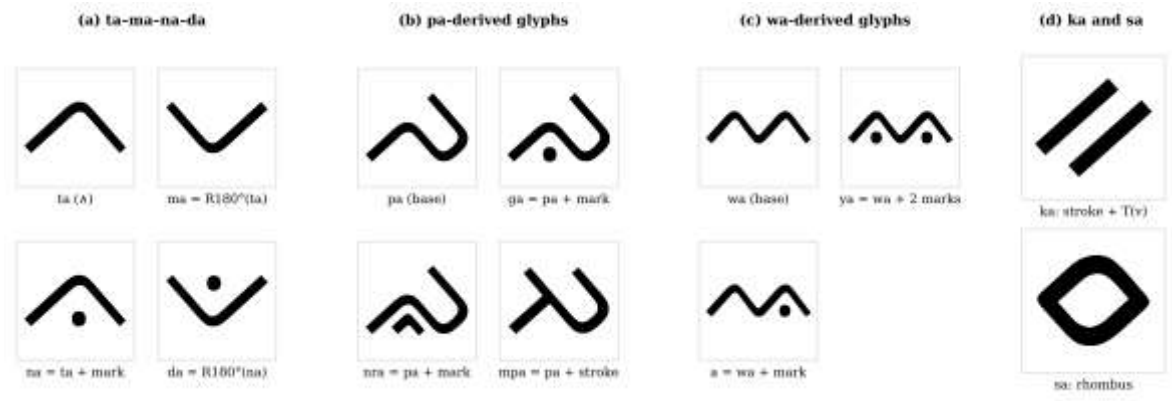

Figure 2. Structural relations among ina' sure': (a) the ta–ma–na–da set closed under a half-turn and the addition of a dot, (b–c) additive derivation from pa and wa, (d) translation in ka and the D2 rhombus sa

Didactic translation to coordinate geometry. The worksheet analysed for the third question follows a sequence in seven stages. Students (1) look at the 23 characters and the *sulapa' eppa'* story, (2) read off the coordinates of the vertices of the character nca, (3) map an octagonal figure based on *sulapa' eppa'* and connect its eight vertices, and (4) rebuild it in GeoGebra with the Polygon command. They then (5) translate, reflect and rotate the character pa, (6) identify which transformation produced each of three images, and (7) design their own motif with at least two transformations. Table 3 links each stage to the cultural phenomenon it uses and the mathematical structure it organises.

Table 3. Didactical-phenomenological mapping of the worksheet tasks

Worksheet stage	Cultural phenomenon	Mathematical structure	Conjectured learning step
Getting to know Lontara	23 ina' sure'; sulapa' eppa'	Shapes as sets of segments	A character can be described by its vertices
Observing (nca)	Character on a grid	Ordered pairs; quadrants	(x, y) as horizontal and vertical position
Tasks 1–3	Octagon based on sulapa' eppa'	Polygon as an ordered vertex list	Changing one point changes only adjacent sides
Task 4	pa shifted	Translation (x, y) → (x + a, y + b)	Every point moves by the same vector
Task 5	pa in a mirror	Reflections (x, −y), (−x, y)	One coordinate changes sign
Task 6	pa turned about O	Rotations (−y, x), (−x, −y), (y, −x)	Coordinates swap and/or change sign
Task 7 and mini project	Three images of pa; motifs	Identifying and composing transformations	Justify the type of transformation from coordinates

The character pa is modelled in the worksheet as the polyline A(−4, −2), B(−1, 1), C(2, −2), D(4, 0), E(1, 3). Every segment of this model has slope +1 or −1, which matches the diagonal dominance found in the first analysis. As a result, all images in the worksheet stay on the integer lattice. Translation by (4, 2) gives A′(0, 0), B′(3, 3), C′(6, 0), D′(8, 2), E′(5, 5). Reflection in the x-axis gives (−4, 2), (−1, −1), (2, 2), (4, 0), (1, −3), and reflection in the y-axis gives (4, −2), (1, 1), (−2, −2), (−4, 0), (−1, 3). Rotation by 90° about O gives (2, −4), (−1, −1), (2, 2), (0, 4), (−3, 1). The rotations by 180° and 270° behave in the same way (Figure 3). We recomputed all of these images and found them consistent with the worksheet's answer key. A quarter-turn sends a line of slope 1 to a line of slope −1 and vice versa, so the image of a diagonal character under any of the eight symmetries of the square is still a diagonal figure on the lattice. Thus the rotation rule (x, y) → (−y, x) can be checked by eye as well as by calculation. Most rotation tasks in textbooks do not have this property.

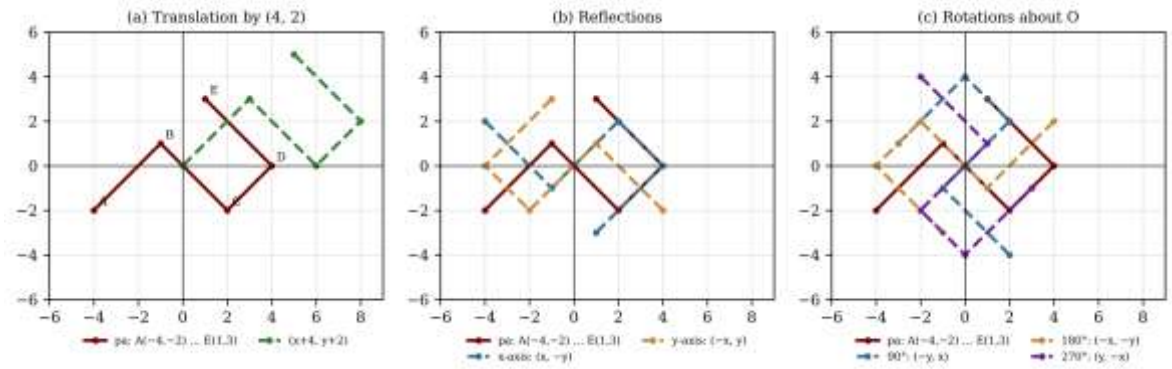

Figure 3. Coordinate model of pa from the worksheet with (a) translation by (4, 2), (b) reflections in the axes and (c) rotations about O; all images remain on the integer lattice

The analysis also showed structure that the worksheet does not yet use. The worksheet transforms a single asymmetric character (pa). It does not draw on the symmetric characters, the ta ↔ ma and na ↔ da relations, or the D2 symmetry of sa, even though these offer two further learning opportunities. First, the symmetric characters show students that a transformation can leave a figure unchanged: reflecting ta in the y-axis returns ta, while reflecting pa does not. This distinction underlies the idea of symmetry as invariance. Second, the

ta–ma pair embodies a result that students usually meet only as a formal statement. For a figure that is symmetric about the y-axis, a half-turn and a reflection in the x-axis give the same image, because R(O, 180°) = M(x-axis) ∘ M(y-axis). The worksheet's HOTS item already asks students to compose a translation with a reflection, so a task that composes two reflections of ta and compares the result with a half-turn would extend this naturally.

Discussion

The first finding, that about nine-tenths of the stroke orientation of the Lontara script is diagonal, gives quantitative support to a claim that has so far rested on tradition and visual impression: that the characters derive from the sides of the *sulapa' eppa'* rhombus (Mattulada, 1985; Pelras, 1996). It also agrees with Noorduyn's (1993) structural observation that the script is built from a stroke, a V, an inverted V and a dot. Our analysis adds that these elements are linked by transformations. The V and the inverted V are half-turn images of each other, and the doubled stroke of ka is a translation. In contrast to Sudarmin et al. (2025), who identified single concepts in single characters through observation and interviews, the present analysis treats the 23 characters as one system. It quantifies how often each property occurs and makes every judgement reproducible. Like the walasuji motif studied by Aras et al. (2025), the script contains translation, reflection and rotation, but here these transformations relate the elements of the writing system itself.

The symmetry profile of the script, in which about half the characters are symmetric and almost all symmetric ones have a vertical axis, is consistent with what pattern analysts have found in many cultural designs. In those designs, bilateral (vertical-axis) symmetry is the most frequent type, and symmetry choices are culturally meaningful rather than accidental (Washburn & Crowe, 1988). From an ethnomathematical perspective, this suggests a dialogic question for future fieldwork: do Bugis–Makassar readers and scribes regard symmetric pairs such as ta–ma as "the same shape turned over"? An emic answer would show whether the transformation structure we found is part of the community's own knowledge or only an outsider's description (Rosa & Orey, 2013; Barton, 1996).

For mathematics education, the most consequential finding is the combination of diagonal strokes and integer coordinates. Research on transformation geometry shows that students tend to see a transformation as a movement of one object rather than as a mapping of the whole plane. They also find rotations the hardest of the three rigid motions to coordinate with their algebraic rules (Edwards, 1991; Hollebrands, 2003; Yanik & Flores, 2009). The Lontara context addresses this in two ways. Because the characters lie exactly on the lattice and stay there under every transformation in the curriculum, students can verify a rule such as $(x, y) \to (-y, x)$ by counting squares, without rounding. Because the characters are themselves related by transformations, the question "which transformation maps this character onto that one?" is a real question about the script, not an exercise invented for school. This kind of question supports the shift from a motion view to a mapping view that Yanik (2011) and Gülkılık et al. (2015) describe. When combined with GeoGebra, where Translate, Reflect and Rotate act on every point of an object (Hohenwarter & Jones, 2007), the context links the visual, the algebraic and the cultural in a way that arbitrary polygons cannot.

The study also illustrates a methodological step for ethnomathematics. Much ethnomathematical research in Indonesia identifies mathematical concepts in artefacts through visual inspection (Iskandar et al., 2022). We have shown that simple, openly available image analysis can turn such observations into measured and reproducible claims, such as a proportion of strokes, a symmetry group or a transformation relation with a score. Other

researchers can check and extend these claims to other scripts or motifs. Such an analysis does not replace the emic voice of the community, but it strengthens the etic side of the dialogue and makes the step to the curriculum more precise (Rosa et al., 2016).

Several limitations should be noted. The analysis used a standardised digital typeface. Manuscripts and palm-leaf texts show considerable variation, including different forms of ka, ngka, ca, nca, sa and ha and different placements of the dot in a (Noorduyn, 1993). Our symmetry results therefore describe the modern standard form of the script, the form students meet today, and may not hold for every historical hand. The tolerance-based F-score depends on the tolerance chosen. We reported this sensitivity, and the characters affected at strict tolerances were those with rounded joins or off-axis dots. The emic component relied on published sources rather than on new interviews with cultural experts. Finally, the didactic translation describes a conjectured learning path and does not report evidence of student learning. Classroom studies, for example design experiments or comparative studies of student reasoning with Lontara characters and with conventional figures, are needed to test whether the context improves understanding of transformations.

CONCLUSION

This study analysed the Bugis–Makassar Lontara script as a geometric system and connected it to the school treatment of geometric transformations. The 23 *ina' sure'* are built almost entirely from diagonal strokes (mean diagonal share 91.4%), in agreement with the traditional account of their origin in the *sulapa' eppa'* rhombus. Twelve characters have isometric self-symmetry. The rhombus sa and the character ha have the D2 group, nine characters have a single vertical mirror axis, and ka has a half-turn produced by translating one stroke. Between characters, ta and ma, and na and da, are exact half-turn images, while ga, nra, mpa, ya and a are derived from a shared base by adding marks. Translation, reflection and rotation are therefore present in the structure of the script itself. Theoretically, the study moves Lontara ethnomathematics from listing isolated concepts to describing structure, and it shows how a reproducible computational analysis can strengthen the etic side of ethnomathematical research. Practically, it shows that characters with slope ±1 strokes stay on the integer lattice under all the transformations in the Phase D curriculum. This makes the script an exact and culturally meaningful context for learning the coordinate rules of translation, reflection and rotation, and for discussing symmetry as invariance and the composition of transformations. Future research should check the findings against manuscript variants and against the knowledge of Bugis–Makassar cultural experts. It should also investigate, in classrooms, how students reason with Lontara characters when moving between the motion and mapping views of transformations.

DECLARATIONS

Acknowledgments

The authors thank the Tadris Matematika Study Program, Faculty of Tarbiyah, IAIN Parepare, for academic support, and acknowledge the custodians of Bugis–Makassar cultural knowledge whose tradition of the Lontara script made this study possible.

Author Contributions Statement

Andi Fadia Abdullah: Conceptualization, Methodology, Formal analysis, Writing – Original Draft, and Visualization; Lisdayanti: Investigation, Validation, Writing – Review & Editing.

AI Usage Statement

During the preparation of this manuscript, the authors received assistance with manuscript drafting, language editing, and the development of the image-analysis script. The authors carefully reviewed and revised the manuscript, verified all computations and references, and take full responsibility for the accuracy and integrity of its content.

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 per-glyph measurements (diagonal share and symmetry F-scores) and the Python analysis script supporting the findings of this study are available from the corresponding author upon reasonable request. The Lontara glyphs analysed are in the public Unicode Buginese block (U+1A00–U+1A1F) and the open-licence Noto Sans Buginese typeface.

Funding

This research received no external funding.

Ethical Approval

This study analysed published documents, a publicly encoded script and a teaching artefact produced by the authors. It did not involve human participants, so ethical approval was not required.

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