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Mathematical Structures in The Movements and Formations of The Selendang Pemalang Dance: An Ethnomathematical Study

Shofa Hidayat[1], Naf'a Rohmaniyya[2], Utiya Nur Arimbi[3], Muthia Isna Arofah[4], Faridh Ricky Fahmy[5]

[1, 2, 3, 4, 5] Program studi Tadris Matematika, UIN K.H. Abdurrahman Wahid Pekalongan, Indonesia

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ABSTRACT (10 PT)

This study explores the mathematical structures embedded in the movements, floor patterns, body postures, rhythmic organization, and scarf use of the Selendang Pemalang Dance. A qualitative descriptive design with an ethnographic orientation was employed. Data were obtained from an in-depth interview with a dance practitioner on 3 November 2025, visual observation of three performance videos, and relevant literature. The data were reduced, displayed in a movement-mathematics matrix, and interpreted through the ethnomathematical framework; credibility was strengthened through method and visual-source triangulation. The findings reveal horizontal, parallel, and curved lines; rectangles, parallelograms, trapezoids, scalene and right triangles, rhombi, and semicircles; vertical reflection; and acute, right, obtuse, and straight angles. These forms are not isolated geometric objects but emerge through coordinated spacing, bodily direction, and scarf trajectories. The study's novelty lies in integrating movement, formation, rhythm, and the scarf as one cultural-mathematical system and translating the findings into concrete classroom tasks involving coordinate geometry, polygon classification, transformation, and angle measurement. Selendang Pemalang Dance therefore offers a culturally meaningful resource for contextual mathematics learning and local heritage appreciation.

Corresponding Author:

Naf'a Rohmaniyya
e-mail: nafa.rohmaniyya24021@mhs.uingusdur.ac.id

INTRODUCTION

Mathematics education is expected to develop logical, analytical, critical, and creative thinking, yet many students still encounter mathematical ideas as detached symbols rather than as structures that organize real experience. Contextualization is therefore not merely an instructional decoration; it is a way of helping learners recognize that mathematical relations are produced, interpreted, and used within human activity. Recent reviews show that Indonesian ethnomathematics research has expanded rapidly because cultural practices provide accessible contexts for number, geometry, measurement, pattern, and spatial reasoning (Hidayati & Prahmana, 2022; Iffah et al., 2025). Internationally, ethnomathematics is also increasingly viewed as a bridge between school mathematics and culturally situated ways of knowing (Batiibwe, 2024).

D'Ambrosio (1985, 2006) conceptualized ethnomathematics as the mathematical ideas and practices developed by identifiable cultural groups, while Bishop (1988) emphasized universal mathematical activities such as counting, locating, measuring, designing, playing, and explaining. From this perspective, cultural objects should not be treated only as decorative examples of pre-existing school concepts. They need to be interpreted as systems in which spatial organization, bodily action, values, and social meanings work together. Such an interpretation is especially relevant for dance, because choreography organizes bodies through space, time, repetition, direction, balance, and relation.

Traditional dance offers an embodied form of mathematical reasoning. Dancer positions can be represented as points, pathways as lines or curves, group arrangements as polygons, mirrored movements as reflections, and changes in body direction as angles or rotations. Recent studies have identified these structures in Balinese dance (Dewi et al., 2022), Lahbako Dance (Wardah et al., 2023), Jaipong Dance (Lestari et al., 2024), Gandrung Lombok Dance (Hidayati et al., 2024), Lenggang Nyai Dance (Mardiyati et al., 2025), Kupang Renteng Dance (Sa'adah et al., 2025), Jogi Dance (Fauziah et al., 2025), and Sigeh Penguten Dance (Desmawati et al., 2025). A recent systematic review further indicates that floor patterns, body postures, rhythm, and dance accessories repeatedly serve as carriers of mathematical ideas in Indonesian traditional dance (Endilina et al., 2025).

The Selendang Pemalang Dance is a regional dance from Pemalang Regency, Central Java. It was created by Kustoro in 1985 as an artistic identity for the region and was later recognized as a regional identity dance in 2012. Its movement vocabulary combines influences associated with Surakarta, Yogyakarta, Banyumas, Sunda, coastal dynamism, and inland refinement. The dance narrates the transition of a girl toward maturity, while the scarf functions as its dominant visual property. Curved swings, turns, extended poses, changing pathways, and coordinated group formations produce a rich spatial structure. In Javanese performance aesthetics, the scarf also contributes to impressions of refinement, continuity, and controlled expression (Hadi, 2007).

Previous dance-based ethnomathematics studies have generally followed two patterns. Some identify geometric shapes from still images or floor patterns, whereas others discuss cultural meaning but provide limited mathematical elaboration. In addition, many studies examine only one representational layer, such as dancer formation or body posture. Consequently, the relationship among movement trajectories, group formations, rhythmic sequences, body angles, the scarf as an extended moving object, and the cultural meanings of the choreography has not always been analyzed within a single framework. This limitation is important because a polygon drawn by connecting dancer positions is not equivalent to the dance itself; the mathematical interpretation becomes more meaningful when it is related to how and why dancers move into that configuration.

The novelty of this study is therefore an integrated ethnomathematical reading of Selendang Pemalang Dance that combines four analytical layers: (1) the geometry of dancer positions and pathways, (2) the geometry of body and scarf configurations, (3) cultural interpretations of balance, refinement, and collective coordination, and (4) direct translation into classroom learning activities. Unlike studies that end with geometric identification, this research develops a movement-mathematics-learning matrix to show how each cultural observation can become a teachable mathematical problem. The study aims to identify and analyze the mathematical structures embedded in Selendang Pemalang Dance and to formulate their potential use in contextual mathematics learning.

METHOD

This research used a qualitative descriptive design with an ethnographic orientation. The design was selected because the study did not seek to test a learning treatment or quantify dance movements; instead, it sought to interpret mathematical ideas within a specific cultural practice. The cultural unit of analysis was the Selendang Pemalang Dance, particularly its movement vocabulary, dancer formations, floor patterns, rhythmic organization, and use of the scarf.

The primary source was an in-depth interview conducted on 3 November 2025 with Bayu Kusuma Listianto, S.Sn., a practitioner and inheritor of the dance tradition at Sanggar Seni Kaloka, Pelutan, Pemalang Regency. The interview addressed the history of the dance, the philosophy of the scarf, names and sequences of movements, formation changes, and the meanings attached to selected gestures. The secondary visual corpus consisted of three publicly available performance videos listed in the References and accessed on 22 November 2025. The videos were observed repeatedly to identify stable positions, transition pathways, coordinated spacing, body angles, scarf trajectories, and recurring formation patterns. Literature on ethnomathematics, geometry learning, and traditional dance was used to support interpretation and comparison.

Table 1. Data sources and analytical functions

Data source	Time / corpus	Information obtained	Analytical function
Key-informant interview	3 November 2025; one in-depth session	History, movement names, scarf philosophy, choreographic organization, and cultural interpretation	Establishes the emic or practitioner perspective
Video observation	Three performance videos; accessed 22 November 2025	Dancer positions, floor patterns, transitions, body postures, scarf paths, and visual symmetry	Provides repeatable visual evidence for geometric coding
Scholarly literature	Foundational and recent studies on ethnomathematics and dance	Conceptual framework, comparison with previous findings, and pedagogical implications	Supports interpretation and positions the study's novelty

Data analysis followed the interactive logic of Miles, Huberman, and Saldana (2014). During data reduction, the interview notes and video observations were segmented into units consisting of a named movement, a stable formation, a transition, or a scarf configuration. Each unit was coded for (a) spatial relation, (b) geometric representation, (c) cultural interpretation, and (d) possible learning use. During data display, the codes were organized in matrices that linked visual evidence with lines, plane figures, reflections, angles, and rhythmic patterns. During conclusion drawing, interpretations were compared across the interview, the three videos, and previous research. A mathematical label was retained only when the relevant spatial relation was visually consistent and could be explained without forcing the cultural form into an inaccurate ideal shape.

Credibility was strengthened through triangulation of methods and visual sources. Interview explanations were compared with repeated video observation, while similar formations were checked across more than one performance whenever possible. The three videos also reduced dependence on a single camera angle or performance occasion. The analysis distinguished between an exact geometric property and a visual approximation: for example, a dancer formation was described as 'parallelogram-like' when camera perspective or bodily movement prevented exact measurement. This distinction was necessary to avoid presenting interpretive diagrams as if they were instrument-based geometric measurements.

RESULTS AND DISCUSSION (HEADING 1) (BOLD, 10 PT)

The analysis identified five interconnected categories: line and curve structures, plane figures, reflection, angle structures, and rhythmic-spatial organization. Table 2 summarizes the relationship among the dance evidence, mathematical ideas, cultural interpretation, and classroom application. The findings show that mathematical meaning does not reside only in the final pose. It is produced by the relation among positions, transitions, bodily orientation, scarf movement, and coordinated timing.

Table 2. Ethnomathematical findings and classroom translation

Dance evidence	Mathematical structure	Cultural reading	Potential classroom task
Horizontal and parallel group rows; scarf trajectories	Horizontal and parallel lines; arcs and other curves	Order, coordinated spacing, continuity, and controlled flow	Plot dancer positions on a coordinate plane; compare slopes; model the scarf path as an arc
Rectangular, parallelogram-like, trapezoidal, triangular, rhombus-like, and semicircular configurations	Plane figures and their properties	Collective balance emerges from relative positions rather than isolated bodies	Connect position points, classify polygons, calculate side relations, perimeter, or area from a scale drawing

Dance evidence	Mathematical structure	Cultural reading	Potential classroom task
Left-right pairing around a central vertical line	Reflection and bilateral symmetry	Visual equilibrium and reciprocal movement between dancer groups	Determine image coordinates after reflection; identify the axis and equal perpendicular distances
Arm and leg postures in named movements	Acute, right, obtuse, and straight angles	Direction, emphasis, softness, and firmness are shaped by bodily orientation	Estimate and measure joint angles from still images; verify using a protractor or dynamic geometry software
Repeated counts and coordinated transitions	Sequence, periodicity, and spatial-temporal pattern	Shared timing enables the group to maintain form while moving	Represent movement order as a sequence; relate count changes to formation transformations

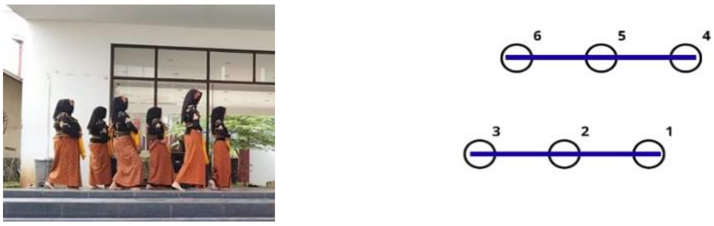
Line and Curve Structures in Movement Pathways

The first category appears in the placement and movement paths of dancers. In the Egot Banyumasan sequence, the six dancers are arranged in two groups whose positions can be connected as horizontal line segments. In Lembehan Tataban, the dancers form two rows that remain approximately parallel. These relations are more informative than a simple statement that 'a line is present.' The horizontal arrangement stabilizes the visual field and provides a common directional reference, while parallel spacing allows two groups to move without collapsing into one another. The formation is therefore simultaneously geometric and choreographic.

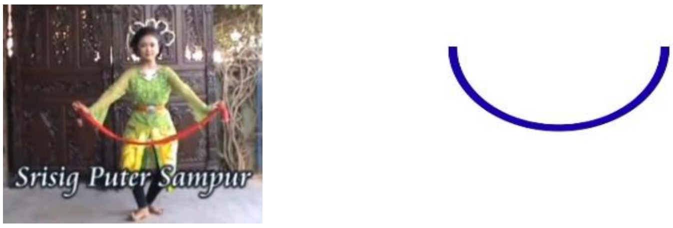
The scarf extends the geometry beyond the dancer's body. During Srisig Puter Sampur, the two ends of the scarf are controlled by the hands while the middle section hangs and moves continuously. At selected moments, the scarf resembles a semicircular arc; during transitions, it may produce more complex curves. The practitioner associated this movement with 'kelembutan perempuan Jawa' or the gentle quality associated with Javanese women (interview, 3 November 2025). This statement shows why the curve should not be interpreted only as a visual shape. Its smoothness, continuity, and controlled change of direction participate in the cultural expression of refinement.

Similar relationships between trajectories and cultural organization have been reported in Jogi, Jaipong, and Balinese dance studies (Dewi et al., 2022; Fauziah et al., 2025; Lestari et al., 2024). The Selendang Pemalang case adds the scarf as a flexible geometric extension of the body. In classroom learning, a teacher may pause the video at selected frames, assign approximate coordinate points to dancer positions, and ask students to compare the gradients of the two rows. The scarf can then be modeled using an arc through three selected points, enabling students to discuss the difference between an exact mathematical curve and an observed cultural form.

(a) Egot Banyumasan: horizontal alignment of two dancer group



(b) Lembehan Tataban: two parallel rows of dancers



(c) Srisig Puter Sampur: the scraf traces a curved path

Figure 1. Line and curve representations in selected Selendang Pemalang Dance movements.
Source: Dance stills adapted from Fauzi (2022), JalanJalanKeJateng (2018), and The Pait (2025); geometric overlays prepared by the authors.

Plane Figures in Formations, Body Postures, and the Scarf

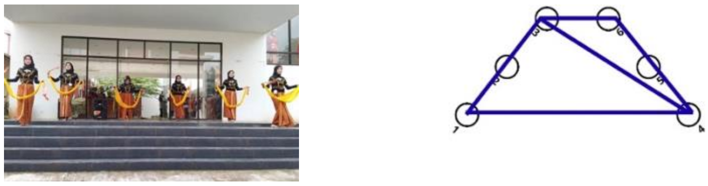
Plane figures emerge when dancer positions are treated as vertices and their spatial relations are connected. Six positions produce a rectangle in one formation, while diagonal displacement produces a parallelogram-like arrangement. Another formation generates a trapezoid with one pair of approximately parallel sides, and a wider group configuration can be decomposed into scalene triangles. These diagrams do not imply that dancers consciously calculate polygon properties during performance. Rather, they reveal how choreographic design uses relative distance and direction to create stable and varied spatial organizations.

The rectangle and parallelogram-like formations are particularly useful for discussing invariance and change. When a row shifts diagonally but maintains its internal spacing, the visual structure changes from a rectangle toward a parallelogram. Students can model this transition by applying a translation to selected vertices, then compare which properties remain invariant. This transforms a static cultural photograph into a problem about congruence, parallelism, and transformation. The approach aligns with recent dance studies that connect floor patterns with triangles, quadrilaterals, circles, and transformations (Desmawati et al., 2025; Mardiyati et al., 2025; Sa'adah et al., 2025).

(a) A Rectangular formation produced by six dancer position

(b) A parallelogram like formation during a diagonal transition

(c) A trapezoidal formation with one pair of parallel sides



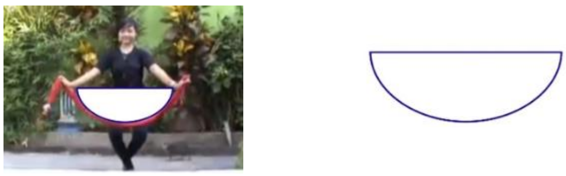
(d) A scalene triangle configuration formed by linked position

Figure 2. Polygonal structures interpreted from dancer formations.

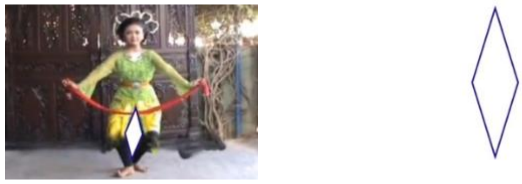
Source: Dance stills adapted from Fauzi (2022) and JalanJalanKeJateng (2018); geometric overlays prepared by the authors.

Geometric representations also arise from the body and scarf. A hanging scarf forms a semicircular region when its ends are held at approximately the same height. Crossed, bent legs in Srisig Puter Sampur create a rhombus-like visual configuration, while the bent and extended arms in Lembehan Step can be represented as a right triangle. These forms are local and momentary: they are produced by a particular camera frame within a continuous movement. For this reason, the analysis uses terms such as 'rhombus-like' rather than claiming exact equality of all sides.

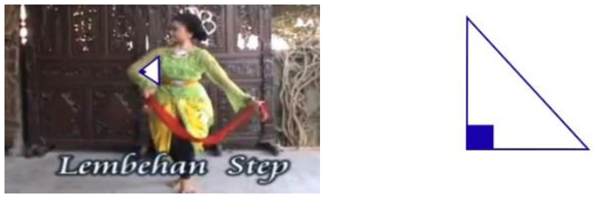
This distinction between ideal geometry and embodied approximation has pedagogical value. Students can first classify the apparent form and then test the classification by estimating lengths and angles from a scaled image. The discrepancy between appearance and measurement becomes an opportunity to discuss mathematical assumptions, measurement error, perspective, and the criteria that define a shape. In this way, the dance does not merely provide answers; it generates questions about how mathematical models are constructed from real phenomena.



(a) A semicircular curve created by the hanging scraf



(b) A rhombus-like visual pattern formed by the crossed legs



(c) A right triangle representation in arm posture

Figure 3. Plane figures represented through the scarf and body postures.

Source: Dance stills adapted from The Pait (2025); geometric overlays prepared by the authors.

Reflection, Symmetry, and Collective Balance

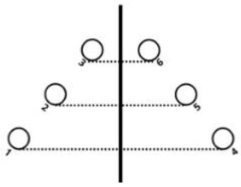
Reflection is visible in several formations organized around an imaginary vertical axis. In Balangan Jala, dancers on the left and right occupy corresponding positions. The direction of the scarf and the orientation of the upper body also create paired visual relations. In a second formation, three dancers on each side are placed at approximately equal distances from the center. A third formation layers these pairs at different distances, producing bilateral symmetry across the group.

The important mathematical relation is not simply that the two sides 'look the same.' For a reflection, each position and its image should have equal perpendicular distances from the axis, and the connecting segment should be perpendicular to that axis. The diagrams make these conditions explicit and allow the formation to be discussed in terms of coordinate transformation. At the cultural level, the symmetry can be interpreted as organized reciprocity: each dancer's position is meaningful because it responds to another position across the center. Visual balance is therefore generated collectively.

Albanese and Herrera-Janques (2024) argue that symmetry in dance becomes more informative when displacement and relational links are considered, not only the final pattern. The same principle applies here. A classroom activity can provide coordinates for the left group and ask students to determine the reflected coordinates for the right group. Students may then compare their mathematical construction with the actual dance frame and explain any deviation caused by perspective, movement, or choreographic emphasis.

(a) Reflection across a vertical axis in Balangan Jala

(b) Paired dancers Positioned at equal distances from the axis



(c) Layared bilateral symmetry in the final group formation

Figure 4. Reflection across a vertical axis in three group formations.

Source: Dance stills adapted from Fauzi (2022) and JalanJalanKeJateng (2018); reflection diagrams prepared by the authors.

Angles as Embodied Direction and Expression

Four angle categories were identified in arm and leg postures. Lembehan Tataban displays an approximately right angle between an extended forearm and the bent arm segment. Balangan Jala creates an acute angle near the face, while the bent-leg posture in the same movement produces an obtuse angle. Kipat Balangan Sampur extends the arms in opposite directions and can be represented by a straight angle. The angle is not an independent object placed on the body; it describes a change in direction between body segments.

Angle size also contributes to visual expression. Acute configurations concentrate the movement and direct attention toward a focal area. Right angles produce a clearer and firmer directional break. Obtuse angles open the posture and broaden the visual field, while straight configurations emphasize extension. These interpretations should be treated as analytical readings rather than universal rules, because the expressive quality also depends on tempo, force, level, and the dancer's control.

For classroom use, students can overlay rays on still images, estimate angle categories, and then verify the estimates with a transparent protractor or dynamic geometry application. A more advanced task can ask students to compare angle changes across consecutive video frames and represent the movement as a function of time. This approach extends findings in previous dance research, which commonly identifies angles but less frequently develops a sequence of measurement and verification activities (Mardiyati et al., 2025; Nasution & Lubis, 2025; Wardah et al., 2023).

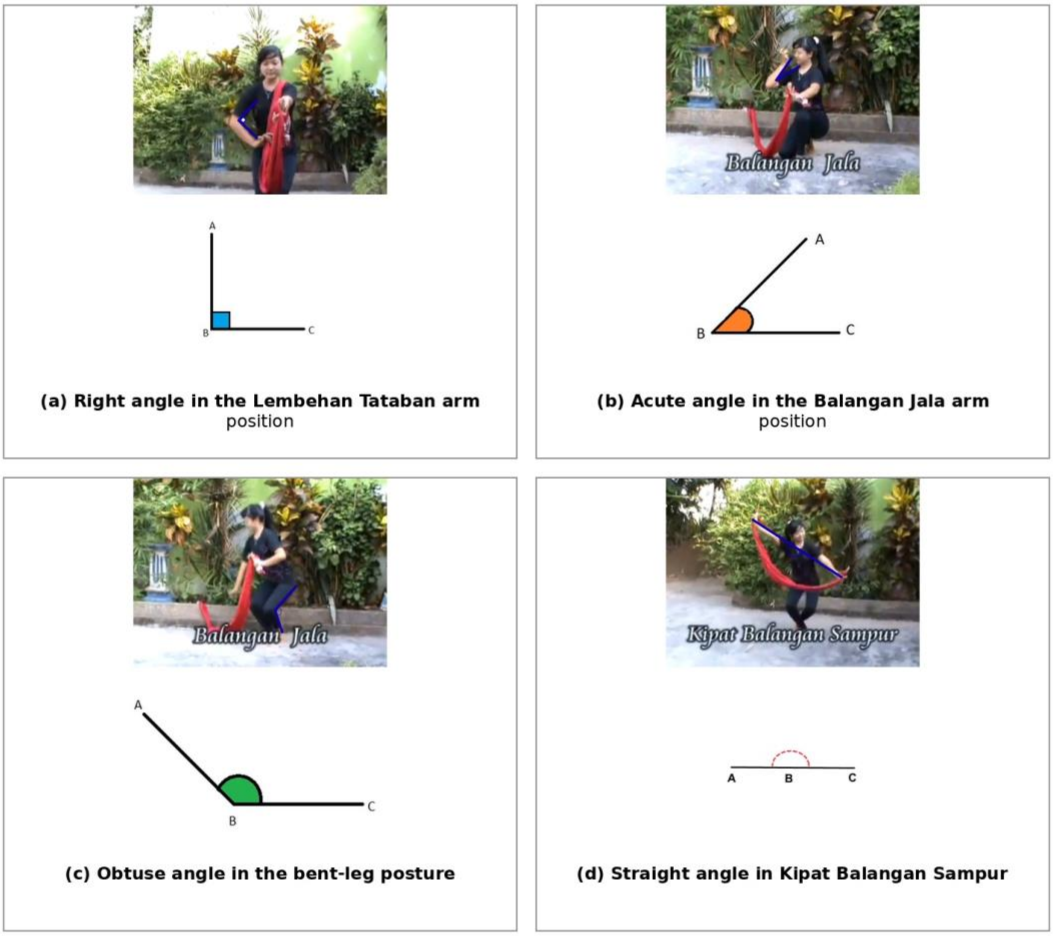


Figure 5. Acute, right, obtuse, and straight angles represented in body postures.
Source: Dance stills adapted from The Pait (2025); angle diagrams prepared by the authors.

Pedagogical Implications, Contribution, and Limitations

The results support a sequence of culturally contextualized geometry learning rather than a single illustrative example. At the introductory level, students observe a video and name visible relations using everyday language such as straight, slanted, balanced, opposite, or curved. At the modeling level, they represent dancer positions as points and connect them to form lines or polygons. At the formalization level, they test definitions, calculate measures, and apply coordinate rules. At the interpretation level, they return to the dance and explain what the mathematical model clarifies and what it omits. This sequence preserves the cultural phenomenon as more than a background picture.

The movement-mathematics-learning matrix can be developed into student worksheets, a digital module, or GeoGebra-assisted tasks. For example, one worksheet may ask students to reconstruct a trapezoidal formation from given coordinates and calculate the effect of moving one dancer. Another may ask them to reflect a formation across the y-axis and compare it with Figure 4. A third may use successive scarf positions to introduce loci or curve approximation. Research on ethnomathematics teaching materials suggests that cultural contexts can improve motivation and conceptual accessibility when the mathematical tasks remain explicit and purposeful (Wulandari et al., 2024).

The principal contribution of this study is an integrated analysis of the dance as a spatial-temporal cultural system. The findings show that the same movement can be read at several levels: as a bodily action, a geometric relation, an aesthetic organization, a cultural sign, and a potential learning task. This integrated reading differentiates the study from purely descriptive shape inventories. It also responds to recent reviews calling for ethnomathematics research to move from identification toward systematic instructional translation (Batiibwe, 2024; Endilina et al., 2025; Iffah et al., 2025).

The study nevertheless has limitations. It relies on one key informant and indirect observation of existing video recordings, so it does not capture all variations that may occur across dancers, stages, or teaching lineages. Camera perspective also limits exact geometric measurement. In addition, the proposed classroom applications have not yet been tested with students; therefore, no claim is made regarding their effectiveness in improving achievement. Future research should involve additional practitioners, record movements from calibrated camera positions, develop validated learning materials, and examine their classroom feasibility and learning outcomes.

CONCLUSION

Selendang Pemalang Dance contains an interconnected system of mathematical structures expressed through dancer positions, movement pathways, body postures, rhythmic coordination, and scarf trajectories. The identified concepts include horizontal and parallel lines; curved paths and semicircular arcs; rectangles, parallelogram-like forms, trapezoids, scalene triangles, right triangles, rhombus-like forms, and semicircles; reflection across a vertical axis; and acute, right, obtuse, and straight angles. These structures arise through collective spacing and controlled movement rather than as isolated geometric objects. The study contributes an integrated ethnomathematical interpretation that connects visual evidence, cultural meaning, and concrete learning activities involving coordinate geometry, polygon classification, transformation, and angle measurement. Selendang Pemalang Dance can therefore serve as a contextual source for mathematics learning while strengthening learners' engagement with local cultural heritage. Further studies should develop and validate worksheets or digital modules based on the dance, involve more cultural practitioners, and test the proposed activities in mathematics classrooms.

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