Journal of Mathematics Instruction, Social Research and Opinion
Vol. 4, No. 3, September 2025, pp. 799 – 816, https://doi.org/10.58421/misro.v4i3.674
ISSN 2962-7842

Exploration of Mathematical Values on Traditional Umbrellas in the Alas Indigenous Community in Southeast Aceh

Dinda[1], Machrani Adi Putri Siregar[2]
[1,2]Universitas Islam Negeri Sumatera Utara, Indonesia

Article Info

Article history:

Received 2025-07-11
Revised 2025-08-17
Accepted 2025-08-20

Keywords:

Alas Culture
Contextual Learning
Ethnomathematics
GeoGebra
Geometry
Payung Mesikhat

ABSTRACT

This study explores ethnomathematics embedded in the forms and motifs of the *Payung Mesikhat*, a cultural symbol of the Alas Indigenous community in Darul Amin Village, Southeast Aceh Regency. A qualitative approach with an ethnographic method was employed to uncover the mathematical meanings inherent in the geometric elements of this traditional umbrella. Data were collected through observation, in-depth interviews with cultural figures and artisans, and visual documentation. To analyze the geometric shapes identified, GeoGebra was used as a tool for visualization and mathematical representation. The findings reveal that the *Payung Mesikhat* embodies various mathematical concepts, such as reflection symmetry, rotation, geometric transformations, patterns, and repetitions, each carrying philosophical significance in the Alas culture. With the aid of GeoGebra, these concepts can be represented visually and interactively, thereby supporting contextual mathematics learning based on local culture. This study is expected to enrich locally grounded mathematics teaching materials and strengthen cultural preservation through educational approaches.

Corresponding Author:

Dinda
Universitas Islam Negeri Sumatera Utara, Indonesia
Email: dinda0305213109@uinsu.ac.id

1. INTRODUCTION

Indonesia is rich in cultural heritage with philosophical, aesthetic, and educational values. This wealth is not limited to the aspects of art and rituals, but also holds potential to be studied from the perspective of science, including mathematics through an ethnomathematics approach [1]. One of the fascinating cultural heritages to study is in Aceh Tenggara Regency, namely the Mesikhat Umbrella owned by the Alas indigenous community. This umbrella protects from heat and rain and is symbolic in that it reflects the community's social status, spiritual values, and life philosophies [2].

As stated by D'Ambrosio, ethnomathematics highlights how mathematical practices and concepts are rooted in local culture through crafts, architecture, and traditional symbols [3]. Previous research by Apriliani shows that cultural artifacts such as batik or traditional houses contain mathematical principles in symmetry, patterns, and transformations [4]. However, the research focus is still directed mainly at popular cultures at the national level, while local cultures such as the Alas community are relatively rarely explored.

On the other hand, mathematics learning in schools is still often seen as abstract, rigid, and lacking context, making it difficult for students to understand geometric concepts concretely [5]. On the other hand, mathematics learning in schools is still often seen as abstract, rigid, and lacking context, making it difficult for students to understand geometric concepts concretely [6].

Along with the development of educational technology, interactive applications like GeoGebra offer opportunities to visualize the geometric forms of cultural artifacts more concretely and engagingly. GeoGebra has proven effective in supporting spatial visualization-based geometry exploration [7]. Nevertheless, studies linking Payung Mesikhat with digital technology are still minimal. This creates an important research gap: (1) the lack of exploration of ethnomathematics in the local Alas culture, particularly Payung Mesikhat, and (2) the absence of the utilization of GeoGebra to analyze and visualize the mathematical concepts contained within it [8].

Previous research by Richardo shows that cultural artifacts such as batik, weaving, and traditional houses contain mathematical principles in symmetry patterns, geometry, fractals, and transformations [9]. However, research tends to focus on more nationally recognized cultures, while local traditions such as the Alas community culture are still rarely studied. The study conducted by Rahman also emphasizes that cultural elements can be effectively utilized in mathematics education to connect abstract concepts with students' social realities [10]. The ethnomathematics approach in learning has been proven to increase students' interest in studying, strengthen their cultural identity, and facilitate a more concrete and meaningful understanding of concepts.

Based on the description, this research aims to identify and analyze the mathematical elements in the structure and ornamentation of the Mesikhat umbrella of the Alas community in Darul Amin Village. It utilizes the GeoGebra application as a visualization medium to reveal the geometric aspects of the umbrella. This will develop a foundation for culturally-based, contextual, innovative, and relevant mathematics learning for students, while also contributing to preserving local culture.

2. METHOD

Based on the description, this research aims to identify and analyze the mathematical elements in the structure and ornamentation of the Mesikhat umbrella of the Alas community in Darul Amin Village. It utilizes the GeoGebra application as a visualization medium to reveal the geometric aspects of the umbrella. This will develop a foundation for culturally-based, contextual, innovative, and relevant mathematics learning for students, while also contributing to the preservation of local culture [11].

The research location is set in Darul Amin Village, Aceh Tenggara Regency, which is known as one of the centers of the Alas indigenous community. The research subjects include customary leaders, craftsmen of the Mesikhat Umbrella, local educators, and community members directly involved in customary activities. The presence of researchers in the field plays a crucial role as the main instrument, collecting data and participating interactively in making the Mesikhat Umbrella and customary activities, allowing for a complete capture of the meaning and cultural values [12].

Data were collected through participatory observation, semi-structured interviews, and visual documentation. Observations were conducted by directly engaging in making and using the Payung Mesikhat. At the same time, interviews were directed towards community leaders, artisans, teachers, and the community to explore the symbolic understanding and mathematical value of the motifs and structure of the umbrella. Documentation in photos and videos was used to capture the details of the ornaments and geometric patterns. Subsequently, the researcher used GeoGebra software to reconstruct the geometric motifs so that they could be analyzed within the framework of the concepts of symmetry, geometric transformations, plane figures, and the mathematical regularities that emerge in the design of the Payung Mesikhat [13].

Data analysis was conducted using thematic analysis techniques developed by Braun and V. Clarke [14]. The initial stage begins with repeatedly reading the interview results, observations, and documentation data, then conducting initial coding on data segments that represent mathematical concepts and cultural values. These codes are then grouped into themes such as symmetry and aesthetics, transformation and order, and the philosophical values in the motifs. The formed themes are then reviewed to remain consistent with the field data and validated through confirmation with key informants (member checking). This process ensures that the interpretations produced do not deviate from the meanings held by the local community.

Several strategies were implemented to ensure the research's reliability and validity. Source triangulation was conducted by comparing observations, interviews, and visual documentation data. Member checking was carried out by discussing the analysis results with local leaders and craftsmen to align with the local perspective. In addition, the researcher conducted peer debriefing with fellow researchers to minimize subjective bias. Research notes were also systematically stored (audit trail) so that the process could be traced and re-verified [15].

The ethical aspects of the research receive special attention. Researchers first obtain voluntary consent from each informant. The identities of the informants are kept confidential through the use of anonymous codes. Sensitive cultural information is stored carefully and used only for academic purposes. As a form of respect for the rights of indigenous communities, researchers are committed to returning the research results in the form of a concise report that can be accessed and utilized by the local community.

3. RESULTS AND DISCUSSION

3.1. Results

3.1.1. History of the Development of Mesikhat Umbrella Craft in Southeast Aceh

Field observations indicate that the Mesikhat Umbrella has a strong historical root in the traditions of the Alas community in Southeast Aceh. Initially, this umbrella was made, predominantly featuring black and gold colors, and symbolized social status and protection in customary ceremonies. Over time, its function evolved to suit the nobility's interests and customary activities, such as weddings and welcoming honored guests. Observations also found a transformation in its shape and motifs. What used to be simple motifs with basic geometric patterns has now developed into more complex designs with additional floral ornaments and philosophical symbols that represent the values of the Alas community. From a technical perspective, several stages have utilized modern tools, although the process of drawing motifs is still maintained traditionally.

Furthermore, field observations indicate challenges in artisan regeneration. Only a small portion of the younger generation is involved in the making of Payung Mesikhat, while others show less interest, raising concerns about the sustainability of this craft as a cultural heritage of the Alas community. The findings from the above observations are also consistent with the results from interviews, as shown in the following interview results.

Customary Leader (Mr. A, 65 years old)

In an interview, a customary leader of the Alas community stated that the Mesikhat umbrella was originally only used by noble families or customary leaders in official ceremonies. According to him, this umbrella has become a symbol of authority, respect, and protection for its owner.

“In the past, not everyone could use the Mesikhat Umbrella. Only certain circles were entitled to use it, even with strict customary rules.”

However, over time, its use began to expand. The Mesikhat Umbrella is used in traditional events such as weddings, circumcisions, and welcoming honored guests.

Local Craftsman (Mrs. B, 48 years old)

A traditional craftsman still actively making Mesikhat umbrellas explained that there have been changes in techniques and materials used in the making. According to him, past generations used bamboo and traditional woven fabric as the main materials, while now some craftsmen have started to utilize more modern materials to strengthen the frame and enhance the appearance. However, crafting the motifs is still done by hand to preserve the artistic value and cultural authenticity.

"If the motif was once simple with geometric shapes, now there are many additional motifs of flowers and symbols of life."

Local Educator (Ms. C, 40 years old)

A high school teacher in the Darul Hasanah District stated that the development of Payung Mesikhat is facing challenges in terms of regeneration. He assesses that the younger generation's interest in learning and preserving this craft is very low.

"Children nowadays are more interested in modern technology, rarely wanting to learn how to make a Mesikhat umbrella."

He emphasizes the importance of integrating cultural values into formal education, for example, through local content in schools, so that this cultural heritage remains preserved and known by future generations.

Based on the observations and interviews, it can be concluded that the Mesikhat Umbrella has a strong historical root as a symbol of social status, authority, and protection in the traditions of the Alas people. Initially, its use was limited to nobility and customary leaders, but over time, its function expanded to become an important part of various traditional ceremonies. In terms of shape and motif, there has been a transformation from simple geometric patterns to a variety of more complex ornaments with symbols of life. In manufacturing techniques, there is a combination of using modern materials for the frame while maintaining manual processes in motif work, thus preserving the artistic value and cultural authenticity. Nevertheless, a significant challenge arises in the aspect of regeneration due to the low interest of the younger generation in continuing this tradition. This raises concerns about the sustainability of Payung Mesikhat as a cultural heritage, making it imperative to undertake preservation efforts through education and strengthening cultural awareness among the community.

3.1.2. GeoGebra as a Medium for Learning Mathematics

Observations conducted in the classroom indicate that using GeoGebra as a medium for mathematics learning brings a new dynamic to the teaching and learning process. The teacher utilizes this application to explain abstract concepts, such as geometry, algebra, and calculus, with more interactive visualizations. For instance, in geometry material, students can directly observe changes in the shapes of flat figures or function graphs when parameters are manipulated, making previously difficult-to-comprehend concepts more concrete. Furthermore, using GeoGebra seems to enhance student engagement in the learning process. Students are more active in asking questions, trying out the application's features, and discussing with their peers to discover mathematical patterns or relationships. This is in contrast to conventional learning, which tends to be passive, where students only receive explanations from the teacher without deep interaction.

However, the observation also found several obstacles. Not all students have adequate devices or technology skills, so some still face difficulties operating the application. In addition, time limitations during lesson hours prevent teachers from being able to optimize all features of GeoGebra fully. Nevertheless, using GeoGebra has proven to help clarify concepts, foster learning motivation, and encourage students to think more critically and exploratively in understanding mathematics. The observation results also align with the interview findings; the researcher has presented the interview results below.

Mathematics Teacher (Mr. A, 45 years old)

In the interview, the math teacher stated that using GeoGebra is constructive in explaining abstract concepts, especially geometry and functions. According to him, interactive visualization allows students to understand the relationships between variables more quickly than conventional methods.

"With a blackboard, students often have difficulty imagining shapes or graphs. Nevertheless, they can see the changes directly with GeoGebra, making it easier to understand."

Eleventh Grade Student (Siti, 16 years old)

A student mentioned that learning with GeoGebra makes her more interested in studying mathematics. She feels more active because she can try the application's features to discover mathematical patterns or relationships.

"Learning with GeoGebra is fun because we can directly drag the graphs or shapes. So it feels like playing a game, but at the same time, we understand the subject."

School Principal (Mrs. C, 50 years old)

The principal acknowledged that the use of GeoGebra positively impacts the quality of mathematics learning, but he also highlighted the technical constraints faced. He says not all students have adequate devices and sufficient digital skills.

"This program is very good, but equipment and classroom learning time are still limited. Therefore, there needs to be additional support facilities so that its use can be more optimal."

Based on the observations and interviews, it can be concluded that the use of GeoGebra as a medium for mathematics learning positively impacts the quality of the teaching and learning process. The interactive visualization helps facilitate understanding abstract concepts, fosters learning motivation, and encourages students to be more active and critical. Teachers find it beneficial for explaining material, students feel more interested and engaged, while the school considers this innovation effective, even though it is still faced with limitations in equipment, technology skills, and learning time. Thus, GeoGebra can be viewed as a potential learning medium to be integrated into the curriculum, as long as adequate facilities and training support it.

3.1.3. Mathematical Concepts in the Ethnomathematical Object of *Payung Mesikhat* in Southeast Aceh

This study found that *Payung Mesikhat*, a cultural object and traditional symbol of the Alas community, contains mathematical concepts that can be identified, modeled, and applied in contextual, culture-based mathematics learning (ethnomathematics). The analysis used a qualitative-ethnographic approach and visual exploration with GeoGebra to identify the mathematical structures within the umbrella's ornaments and form.

The findings show that several dominant mathematical concepts are integrated into the physical structure and ornaments of *Payung Mesikhat*, including Plane and solid geometry, Geometric transformations (rotation, translation, reflection), Reflectional and rotational symmetry, Patterns and regularities, Angle and length measurement, Fractal, and recurrence concepts in border motifs These concepts are embedded in ornamental motifs such as flowers, curved lines, triangles, and stars, as well as in the umbrella's structural form, such as the central circle, frame segments, and fabric petals shaped as circular sectors and segments.

Table 1. Mathematical Concepts in the Mesikhat Umbrella

No.	Cultural Element (Object/Ornament)	Mathematical Concept	Description
1	Umbrella frame structure (main framework)	Solid geometry: circle, sector, segment	The frame forms a circle with sectors as the umbrella's covering panels.
2	Central ornament of the umbrella (star or symmetrical flower)	Rotational symmetry and reflection symmetry	The central motif has regular rotation and multiple lines of reflection symmetry.
3	Circular embroidery (repetitive curved lines)	Patterns, simple fractals, geometric transformation	The repeating pattern resembles a simple fractal motif.
4	Radial lines from the center to the edge of the umbrella	Concepts of angles, lines, and segments	Shows the division of the central angle into several equal parts.
5	Umbrella petals and edges shaped like triangles	Isosceles/right triangles, measurement of length and angles	A repetitive pattern forms petal-like shapes around the umbrella's edge.
6	Combination of colors and motifs	Arithmetic patterns and visual regularity	Repeating patterns with specific color combinations create visual harmony.
7	Repetition of motifs on the umbrella's fabric cover	Transformations (translation, reflection)	Several motifs are repeated using reflection and translation forms.

These findings indicate that *Payung Mesikhat* is a cultural object rich in implicit mathematical values. These concepts can be explicitly revealed and utilized as contextual media in school mathematics learning through an ethnomathematical approach and the use of GeoGebra. This provides a more meaningful learning experience, closely connected to local culture, while also promoting the preservation of cultural values through education.

Table 2. Classification of Mathematical Concepts in the Payung Mesikhat

Diameter of Canopy/Cover	Handle Height	Number of Upper Spokes (Usuk)	Length of Upper Spokes	Number of Lower Spokes (Sanggah)	Length of Lower Spokes	Number of Upper Decorative Balls	Size of Upper Decorative Balls	Size of Lower Decorative Balls	Size of Finial (Kuncung)
84 cm	50 cm	20 and 22 pieces	42 cm	20 and 22 pieces	12–15 cm	6 pieces	6 cm	5 cm	4 cm
66 cm	45 cm	20 pieces	33 cm	20 pieces	12–15 cm	5 pieces	5 cm	5 cm	4 cm
50 cm	40 cm	18 pieces	25 cm	18 pieces	12 cm	5 pieces	5 cm	5 cm	4 cm

The *Payung Mesikhat* is a traditional symbol of the Alas community, characterized by its distinctive physical structure and rich symbolic meaning. Documentation shows that this umbrella appears in three main size types: 84 cm, 66 cm, and 50 cm, which reflect the level of sacredness of the ceremony and the social status of its user. These size differences are reflected in the number and length of ribs (*usuk* and *sanggah*), as well as the size of the decorative spheres (*bola-bola*) and the finial (*kuncung*). Mathematically, the structure of the *Payung Mesikhat* demonstrates the concepts of measurement, symmetry, and proportional ratios in an orderly and systematic way. Therefore, the *Payung Mesikhat* can serve as a source for contextual learning based on local culture, particularly in introducing ethnomathematics concepts such as geometry, symmetry, and measurement in mathematics education.

These forms are not merely mechanical structures but also imply mathematical regularities such as axes of symmetry, rotational symmetry, volume, surface area, and geometric projections. For example, in mathematics learning, the umbrella canopy can be used as a medium to calculate the area of a sector or the surface area of a cone, the volume of a small pyramid (the *kuncung*), or even apply geometric transformation concepts through rotation and reflection on the umbrella's fabric ornament patterns. Using GeoGebra in this study enhances the ability to visually and analytically reconstruct these forms. Digital models facilitate measurement, comparison, and the visualization of geometric concepts in a tangible way within a local cultural context. This aligns with the ethnomathematics approach, which is understanding mathematical concepts derived from a community's cultural practices.

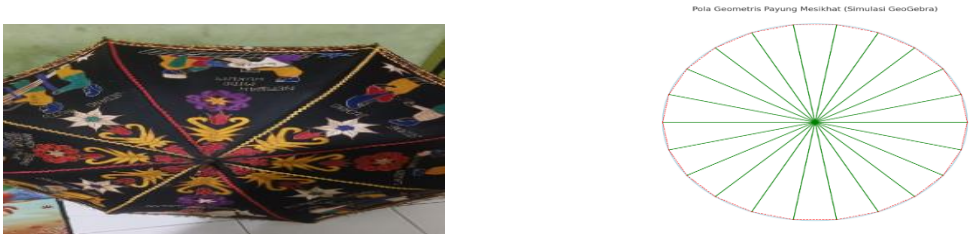

Figure 1. Documentation and Top-View Illustration of the Mesikhat Umbrella of Southeast Aceh

The top view of the *Payung Mesikhat* from Aceh Tenggara represents a blend of aesthetic value and strong geometric structure. Mathematically, this pattern forms a symmetrical circle with evenly divided sectors and segments. In digital construction using GeoGebra, this pattern is visualized as a circle centered at point (0,0) with a radius of approximately 42 cm. Dividing the circle into 20–22 ribs produces equal central angles, creating a consistent rotational symmetry pattern. This structure demonstrates the application of circle geometry concepts within local culture and reinforces the value of ethnomathematics as a meaningful medium for contextual learning.

In GeoGebra, the pattern is visualized by creating a circle as the base, then placing points evenly using their polar coordinates, which are subsequently connected to display the sector and segment patterns. This approach reveals the beauty of the umbrella's geometric design even in digital form and facilitates understanding of concepts such as circle division,

central angles, and symmetry within the local cultural context (Muhtadi, 2021). Through the top-view construction of the umbrella in GeoGebra, mathematics learning becomes more contextual and meaningful, linking abstract mathematical concepts with tangible forms of traditional culture. This approach aligns with the principles of ethnomathematics, which integrate culture and mathematics to enrich students' learning experiences (Prihastari, 2021).

Table 3. Construction of the Mesikhat Umbrella Image of Southeast Aceh

No	Center Point (O)	Description	Value / Notation
1	Circle Radius (r)	The center point of the circle in the umbrella's top-view diagram, located at the coordinate origin (0,0)	O = (0,0)
2	Number of Ribs (n)	The distance from the center point to the circumference represents the size of the umbrella's top view	r = 42 cm
3	Angle Between Ribs	The number of ribs (*usuk*) that evenly divide the circle	n = 20 – 22
4	Rib End Points	The central angle formed between two adjacent ribs	θ = 360° / n (for example,360°/20=18°)
5	Circle Segments	Points on the circumference resulting from the division of the central angle	Ck=(rcos(kθ),rsin(kθ))C_k = (r \cos(kθ), r \sin(kθ)) with k=0,1,...,n-1
6	Circular Sectors	The straight line connecting the center point to the rib end point	Segmen O–C_k
7	Symmetry Pattern	The region bounded by two ribs and the arc between them	The area of a sector is calculated from the angle θ and the radius r
8	Center Point (O)	The repeating pattern of ribs and sectors that creates the symmetrical shape of the umbrella's top view	Rotation repeats every θ

Figure 2. Documentation and Illustration of the Mesikhat Umbrella of Southeast Aceh

Payung Mesikhat is a cultural symbol rich in meaning within the Alas Indigenous community in Southeast Aceh. As part of cultural heritage, this umbrella functions in traditional ceremonies such as weddings and welcoming honored guests. It also carries mathematical values, particularly in aspects of transformation geometry. The motifs on the Mesikhat Umbrella are often arranged in a circular pattern around the umbrella's center, reflecting the rotation concept. Patterns like stars or flowers exhibit rotational symmetry at specific angles, such as 45° or 60°, creating visual and aesthetic balance. This aligns with findings in ethnomathematics research that show traditional communities often apply the concept of rotation in their cultural designs without consciously recognizing it as a formal mathematical concept.

The design of this umbrella also shows the presence of mirror symmetry or reflection. Identical motifs on an axis's left and right sides indicate that the principle of reflection creates harmony and balance in the design. This concept is also found in other cultural elements, such as batik motifs and traditional carvings, reflecting the community's intuitive understanding of symmetry and balance. At the edges of the Mesikhat Umbrella, small motifs like lines or simple geometric shapes are arranged repetitively at constant distances and directions, reflecting the concept of translation. This repetition shows a rhythmic order in the design, which is also found in various other traditional motifs, such as woven fabrics and house carvings.

The Mesikhat umbrella is a cultural symbol that is not only rich in aesthetic and philosophical values but also contains concepts of transformation geometry, such as dilation, rotation, symmetry, reflection, and translation. The variation in motif sizes on this umbrella reflects the application of the dilation concept, with a prominent motif in the center and smaller motifs on the edges to create a visual hierarchy. Through an ethnomathematics approach and the support of GeoGebra applications, the structure and ornaments of the Mesikhat umbrella have been successfully modeled digitally, allowing for precise and interactive mathematical analysis. This visualization reveals rotation symmetry patterns of order 8, the repetition of isosceles triangles, and kite and trapezoid shapes that are reflected. This research shows that the Mesikhat Umbrella can be used as a source of contextual mathematics learning that integrates local cultural wisdom with the concept of transformation geometry, making learning more meaningful, relevant, and close to the students' lives.

The construction steps in GeoGebra are as follows: determining the Center Point (O): This point serves as the center of rotation for all ornaments. All radial lines start from this point. Forming the Radius of the Framework: The radius length is input according to field data (for example, 40 cm), and is divided into eight equal parts (45° per sector). Drawing the Main Ornament: Ornaments such as isosceles triangles, kites, and trapezoids are drawn in one sector, then replicated with rotational transformations seven times (a total of 8 sectors). Adding Symmetry and Reflection: For reflective motifs, reflection is performed along the central axis of each sector to form a symmetric pattern. Using Translation for Edge Motifs: The edge motifs are drawn as a single unit and then translated horizontally along the circumference of the umbrella. Application of Color and Aesthetics: Typical colors such as red, yellow, and black are incorporated to reflect the cultural values of Alas in the digital design.

From the results of the GeoGebra construction, it is evident that the structure of the Mesikhat Umbrella ornament consistently employs the concepts of 8-fold rotation, reflection, and translation. The motifs used are not merely aesthetic but contain philosophical meanings rooted in the local wisdom of the Alas community, such as harmony, protection, and unity. Digital visualization with GeoGebra allows these traditional motifs to be precisely modeled as flat shapes and mathematical transformation patterns. This opens up opportunities for integration in contextual mathematics learning, where students can learn geometry while understanding their local culture. The construction of the top ornaments of the Mesikhat Umbrella using GeoGebra successfully demonstrates that culture and

mathematics intersect harmoniously. GeoGebra is a visual aid and a bridge between cultural heritage and science, especially in ethnomathematics-based mathematics education.

Figure 3. Illustration of the Umbrella Handle of Mesikhat, Southeast Aceh

The Mesikhat umbrella is a symbol of honor and a spiritual emblem for the indigenous Alas community in Southeast Aceh. In addition to the richly ornamented and culturally symbolic top, one important component that often goes unnoticed is the umbrella's handle. This handle serves structurally as the main support and embodies aesthetic, philosophical, and particular mathematical principles, especially in the context of three-dimensional geometry and symmetry. The handle of the Mesikhat umbrella is generally made from selected wood, such as surian or meranti wood, which is known for being strong yet lightweight. Visually, this handle has an elongated cylindrical shape with a length of about 100–120 cm and a 2–3 cm diameter. The handle's surface is often decorated with carvings of traditional Alas motifs or covered with red or yellow fabric that symbolizes strength and honor. At the top of the handle, there is a connector (socket) to the umbrella frame shaped like a small cone head or a curved profile cylinder, while at the bottom, it is sometimes paired with a round, flat wooden or brass pad as a balance. Mathematically, the umbrella handle can be analyzed through several methods.

Table 4. Mathematically, the Handle of the Umbrella Mesikhat in GeoGebra

Geometric Aspect	Description
Solid Shape	The handle is shaped like a cylinder, allowing for volume and surface area analysis.
Rotational Symmetry	Circular carvings or evenly engraved patterns along the handle reflect infinite-order rotational symmetry (due to symmetry along the vertical axis).
Patterns and Repetition	The ornaments on the handle often follow repetitive patterns such as spirals, stars, or floral motifs, which can be analyzed as linear translational patterns.
Proportion and Scale	The proportion of length to diameter demonstrates the principles of ratio and scale, which are important for comfortable handling.

The Umbrella Handle of Mesikhat supports the physical structure and upholds symbolic meaning. It symbolizes moral strength, the firmness of the customary leader, and the continuity of tradition. When used in customary ceremonies, the handle is held upright as a symbol of upholding truth and customary justice. The colors adorn the handle (red, yellow, or black) also carry philosophy: Red symbolizes bravery and the spirit of struggle. Yellow represents honor and glory. Black, steadfastness, and protection. The illustration of the Mesikhat umbrella handle reveals that this part not only serves as a functional element

but also contains geometric and symbolic values that enrich the overall meaning of the umbrella as a cultural artifact. Through an ethnomathematics approach, this handle can be analyzed in the context of three-dimensional shapes, geometric transformations, and mathematical patterns, while also becoming a relevant entry point to connect local culture with contextual and meaningful mathematics learning.

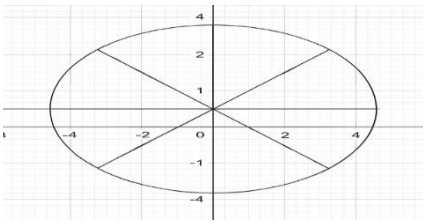

Figure 4. Upper Ribs (Struts) of the Mesikhat Umbrella from Southeast Aceh

The upper or inner part of the ribs, locally known as 'usuk,' on the Mesikhat Umbrella serves as the main support for the covering fabric and the top ornament. This component has a structural function and embodies cultural meanings and geometric values that reflect the local wisdom of the Alas people in Southeast Aceh. Constructing the usuk in this research context uses GeoGebra software to reveal this traditional form's mathematical regularities and visual representations.

The ribs usually consist of 8 to 12 thin wooden sticks arranged radially from the center of the umbrella frame. This arrangement demonstrates the concept of radial symmetry and rotational symmetry, where each rib forms the same angle to the central point (the center of rotation). Philosophically, the number of ribs is often associated with the principles of unity and order in life within traditions and pointing to the directions and social roles in Alas society, such as the eight cardinal directions or the eight layers of traditional leadership.

The following are the steps in constructing the illustration of the radial arms using GeoGebra: Determine the Center Point (O) as the center of rotation and the starting point of the spokes. Draw a radius line of 40 cm from point O. Determine the Number of Spokes, assumed to be eight spokes; thus, each angle between the spokes = 360° / 8 = 45°. Using Rotation Transformation, the first radius line is replicated 7 times using rotations of 45° to form a symmetrical radial arrangement. Add decorative elements to each spoke, which can be depicted as patterns of triangles or small kites as ornaments, reflecting the repetitive and reflective patterns typical of Alas culture.

Table 5. Results of Constructing the Ribs of the Mesikhat Umbrella

No	Element	Geometric Shape	Size / Value	GeoGebra Transformation	Function / Meaning
1	Center Point (O)	Point	–	Reference point of rotation	Center of life/spirituality
2	Radius Line	Radial line	Length 40 cm	Rotation 45∘×745^\circ \times 7 sectors	Support of customary values
3	Angle between Spokes	Angle	45∘45^\circ	Even circular distribution	Balance of directions
4	Ornaments between Spokes	Small triangle/kite	Base 6 cm, height 8 cm	Translation and reflection	Motif of protection and nobility

The visualization in GeoGebra shows that the upper ribs of the Mesikhat Umbrella have rotational symmetry of order 8, reflecting harmony and order. Consistent repetition of patterns among the ribs. The potential to be used as teaching materials in the context of rotational geometry, symmetry, plane shapes, and geometric transformations. The construction of illustrations of the upper ribs of the Mesikhat Umbrella using GeoGebra demonstrates structural precision and reveals the close relationship between culture and mathematics. As functional elements, the ribs also contain deep mathematical concepts that can be utilized in ethnomathematics learning. This process strengthens the position of the Mesikhat Umbrella as a contextual and meaningful learning resource in culture-based mathematics education.

Figure 5. Lower Ribs (Support) of the Mesikhat Aceh Tenggara Umbrella

In the structure of the Mesikhat Umbrella, in addition to the top part (usuk), there are other important elements, namely the lower spokes, or in local terms known as "sangga." Sangga functions as a secondary support that upholds the stability of the framework and gives a curved shape to the lower part of the umbrella. Besides its mechanical function, sangga has aesthetic and symbolic value that reflects the strength and order in the social and cultural structure of the Alas Indigenous community. To document and analyze this part mathematically, a reconstruction process of the sangga illustration was carried out using GeoGebra, as part of a digital visual-based ethnomathematics approach.

The support in the form of arc-shaped rods that spread circularly is placed between the ends of the upper beams and the lower part of the handle. The number equals the beams, usually 8 or 12 rods, forming a neat and balanced geometric arrangement. The shape of the support resembles a circular arch and is connected with fabric and edge ornaments that form the visual circumference of the umbrella. Symbolically, the support reflects support for the order of community life, both physically and socially. The support ensures that the values of tradition remain strong in the community's life.

The steps for constructing the strut illustration in GeoGebra are carried out using the following procedures: Determining the Center Point (O) as a reference to form a radial arrangement, drawing the Base Circle, a circle with a diameter of 80 cm (adjusted to the size of the field). The circle is divided into 8 Points (P1–P8), with an angle of 45° between each point. Connecting Adjacent Points, an arc is formed between each pair of adjacent points (for example, P1–P2, P2–P3, etc.). Using the Arc or Circular Segment feature to create the strut illustration as a consistent curved arc. Adding edge ornaments and triangular or wave patterns can be added to the bottom side of the arc to represent cultural aesthetics.

Table 6. Results of Lower Radius Construction (Support)

No	Element	Geometric Shape	Size / Value	GeoGebra Transformation	Cultural Function / Meaning
1	Base Circle	Circle	Diameter 80 cm	Symmetrical rotation 360°	Foundation of the cycle of life
2	Supporting Radius Points	Points on the circumference	Distance between points 45°	Circular division	Support for customary values
3	Curved Supports	Circular arc	Length between points 15 cm	Arc connecting adjacent points	Balance and stability
4	Edge Ornaments	Small isosceles triangles	Base 5 cm, height 4 cm	Translation along the circumference	Ornament of protection and aesthetics

From the visualization results in GeoGebra, it was found that the lower radius has a high level of regularity: Rotational symmetry of order 8 (or, according to the number of struts). Applying the concepts of arc and circumference of a circle can be used in learning flat and curved geometry. Decorative elements can be analyzed with translation and symmetry patterns. Regarding cultural values, the struts reinforce the meaning that customs must be supported by strength from all directions, symbolizing mutual support in preserving tradition.

The illustration of the support on the Mesikhat Umbrella shows a harmonious relationship between mechanical structure and philosophical meaning, while also presenting concepts of transformation geometry that can be utilized in contextual education. The construction through GeoGebra not only simplifies the understanding of shapes but also opens up opportunities for preserving and learning culture through a modern mathematical approach.

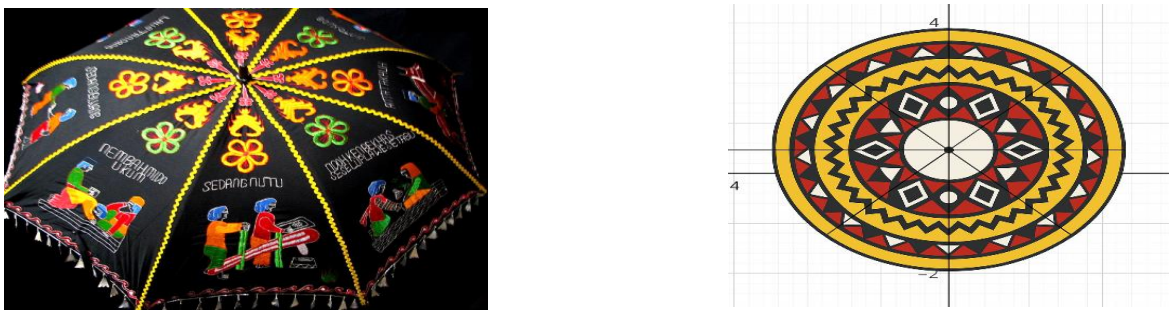

Figure 6. Motif (Nyabeulah) of the Mesikhat Umbrella from Southeast Aceh

The motif known as "nyabeulah" is a distinctive ornamental part that adorns the surface of the Mesikhat umbrella, especially on the fabric stretched between the ribs (usuk) and the support. This motif serves as a decorative element and contains cultural symbolism and philosophical values that represent the beauty, social order, and identity of the Indigenous Alas community in Southeast Aceh. The nyabeulah motif typically consists of repetitive geometric patterns, such as triangles, diamonds, zig-zag lines, and small circles, arranged symmetrically and neatly. This motif is constructed using GeoGebra to mathematically represent and express the relationship between visual forms and local values.

The nyabeulah motif features a combination of patterned shapes, including isosceles triangles or right triangles arranged reflectively. A diamond shape that forms an interlaced pattern. Zig-zag lines symbolize firmness and dynamism. Small circles or dots as markers of unity and continuity. This motif is arranged along a circular or ribbon-like path along the edges of the umbrella fabric, reflecting a pattern of fold symmetry and translation. The steps for digitally constructing the nyabeulah motif are as follows:

1. Determine the Baseline (Path).
   a. Drawing a curved or ribbon-like path as a place to place the motif.
   b. The path length is adjusted to the number of sectors on the umbrella (usually 8–12 sectors).
2. Creating Basic Motifs
   a. Form a basic pattern unit: one isosceles triangle with a base of 4 cm and a height of 3 cm, and one rhombus with 4 cm and 2.5 cm diagonals.
   b. Add a small circle as a dot inside or between the motifs.
3. Organizing Pattern Repetition
   a. Using the translation feature to duplicate pattern units horizontally or along the perimeter of the path.
   b. Adding horizontal and vertical reflections to enhance symmetry.
4. Coloring and Aesthetics
   a. Setting red, yellow, black, and white as the characteristic colors of Payung Mesikhat.
   b. Ensuring visual regularity to create a symmetrical and harmonious effect.

Table 7. Results of the Construction of the Motif (Nyabeulah)

No	Motif Component	Geometric Shape	Size / Proportion	GeoGebra Transformation	Symbolic Function
1	Decorative Triangle	Isosceles triangle	Base 4 cm, height 3 cm	Translation and reflection	Firmness and balance
2	Rhombus	Rhombus	Diagonals 4 cm and 2.5 cm	Translation and 45° rotation	Social bonds and kinship
3	Zig-Zag Line	Connected polygonal line	Each segment is 2 cm long	Translation and line symmetry	Dynamics and struggles of life
4	Decorative Dots	Small circle	Diameter 1 cm	Periodic distribution	Unity and continuity
5	Motif Path	Ribbon / circular arc	Radius 35–40 cm	Circular clockwise arrangement	Aesthetic boundary and harmony

The nyabeulah motif showcases the connection between visual aesthetics and geometric principles, particularly regarding folded and rotational symmetry. Transformation through translation and reflection in pattern repetition. Periodic distribution that depicts the

rhythm and patterns of the Alas community's life. Through GeoGebra, this visualization reinforces the understanding that traditional ornaments are not merely decorations but contain complex and systematic mathematical structures, making them a contextual and engaging source of mathematical learning. The illustration of the nyabeulah motif on the Mesikhat umbrella represents a form of cultural expression rich in symbolic value and full of geometric order. Using GeoGebra, this motif can be represented precisely, providing an understanding of how mathematics is present in local culture and how ethnomathematics can be integrated into modern education. Digital visualization also becomes part of the preservation of the visual culture of the Alas community through technology.

3.2. DISCUSSION

3.2.1. Ethnomathematics in Umbrella Mathematics Learning in Southeast Aceh

The results of this research show that the Mesikhat Umbrella of East Aceh is not just a cultural artifact but rich in historical, philosophical, artistic, and mathematical values. This finding is in line with Sembiring's research, which states that traditional cultural artifacts often contain symbols of social status and spiritual functions and play a role in strengthening community identity [16]. Initially, the Mesikhat umbrella was only used by the nobility as a symbol of authority, but it has now evolved into an integral part of various traditional ceremonies of the Alas people. This transformation of function reflects the process of enculturation and cultural adaptation, as emphasized by Hutapea, that every cultural product undergoes dynamics following the social changes of society [17].

From the perspective of cultural preservation, the interview results show serious challenges in the regeneration of Payung Mesikhat craftsmen. This phenomenon aligns with the findings of Putri & Arifin, which state that the younger generation's interest in traditional crafts is declining due to the dominance of digital culture [18]. Therefore, it is necessary to have a cultural integration strategy in education, as emphasized by Hidayat, that incorporates local wisdom into the local content curriculum, which can effectively preserve cultural heritage amidst modernization [19].

In the context of mathematics education, this research reveals that the Mesikhat Umbrella contains mathematical concepts such as symmetry, rotation, reflection, dilation, translation, and concepts of measuring angles, lengths, and patterns. This reinforces D'Ambrosio's findings on ethnomathematics, which is how the cultural practices of traditional societies represent mathematical concepts unconsciously [3]. A similar study was also conducted by Rosa & Orey, emphasizing the importance of connecting cultural objects with contextual mathematics learning, so that students can understand mathematics in situations close to their lives [20].

The use of GeoGebra as a visual analysis medium in this research also shows positive results. These findings follow the study by Hohenwarter & Preiner, which proves that GeoGebra can enhance understanding of abstract concepts through interactive visualization [21]. Furthermore, Marpaung's research emphasizes that integrating GeoGebra in ethnomathematics-based learning can bridge students' understanding of geometry while still appreciating local culture [22]. This is also in line with Afgani's findings, which show that

the GeoGebra application helps students to be more critical and exploratory in understanding the concepts of symmetry and geometric transformations [23].

In addition, the results of the digital construction of the Payung Mesikhat motif using GeoGebra reveal the presence of rotation patterns of order 8, reflection, translation, and geometric repetition, which mathematically demonstrate a high degree of regularity. This phenomenon aligns with Prihastari's research, which states that traditional architectural forms of the archipelago, such as batik, weaving, and carvings of traditional houses, contain patterns of mathematical transformations that can be analyzed using modern software [24]. Thus, this approach not only facilitates contextual learning but also encourages the preservation of cultural heritage.

Philosophically, the ornament of the Payung Mesikhat also embodies the values of the Alas community, such as harmony, protection, and unity. These values align with Sardjono's findings that traditional motifs of the archipelago not only serve an aesthetic function but also represent the cosmology, ethics, and social values of a community [25]. Through mathematical analysis, the philosophical meaning can be transmitted to students within the framework of culturally based education.

Thus, the results of this research strengthen the view that ethnomathematics is not only about 'teaching mathematics through culture,' but also 'preserving culture through mathematics.' This approach aligns with Bishop's argument that mathematics is a part of human culture that is always manifested in everyday practices [26]. Therefore, by making the Mesikhat Umbrella the object of learning, teachers can create meaningful and interactive learning experiences while supporting the preservation of local culture.

4. CONCLUSION

This research emphasizes that the Mesikhat Umbrella of Southeast Aceh is a cultural artifact, a historical and spiritual symbol, and an educational tool that harbors mathematical values. Historically, this umbrella was born as a symbol of social status and has continued to endure in various traditional rituals of the Alas community. An ethnomathematics analysis shows that its motifs and structure contain concepts of geometry, symmetry, and transformations that can be integrated into mathematics learning. With the help of GeoGebra, this cultural heritage can be bridged with modern technology, making it easier for the younger generation to understand. This finding has important implications: cultural preservation can go hand in hand with contextual education; mathematics learning can be more meaningful through a cultural approach; and digital technology becomes an effective means to revive traditions. However, this research is still limited to descriptive analysis and has not fully explored the aspects of regeneration and the comprehensive utilization of technology. Therefore, future research is suggested to develop teaching modules based on Payung Mesikhat, utilizing 3D or AR/VR technology, and formulating creative strategies to engage the younger generation actively in cultural preservation. In this way, Payung Mesikhat is remembered as an ancestral heritage and as a source of educational inspiration and cultural identity that is relevant in the modern era.

REFERENCES

[1] R. Aflah and L. Andhany, Etnomatematika: Integrasi budaya lokal dalam pembelajaran matematika, Yogyakarta: Deepublish, 2022.

[2] A. Kadir, "Filosofi dan simbolisme Payung Mesikhat masyarakat Alas," *Jurnal Antropologi Indonesia*, vol. 48, no. 2, p. 178–190, 2023.

[3] U. D'Ambrosio, "Ethnomathematics and its place in the history and pedagogy of mathematics," *For the Learning of Mathematics*, vol. 5, no. 1, p. 44–48, 1985.

[4] S. Apriliani, "Mathematical principles in Indonesian traditional houses: An ethnomathematics perspective," *Journal of Mathematics and Culture*, vol. 9, no. 1, p. 45–58, 2024.

[5] M. Abdullah, Contextualizing mathematics learning through local culture: A case study in secondary schools, Jakarta: Pustaka Edukasi, 2022.

[6] H. Muchlian, "Integrating local artifacts into mathematics education: A preliminary study," *International Journal of Mathematics Education*, vol. 6, no. 2, p. 101–112, 2022.

[7] N. Presmeg, "Visualization in mathematics learning: The role of dynamic technology," *Journal of Mathematical Thinking*, vol. 12, no. 3, p. 233–247, 2025.

[8] N. Prasetyawati, "Cultural-based learning in mathematics classrooms: Opportunities and challenges," *Jurnal Pendidikan Matematika*, vol. 17, no. 1, p. 55–70, 2023.

[9] R. Richardo, "Symmetry and transformation in batik motifs: An ethnomathematics study," *Indonesian Journal of Mathematics Education*, vol. 11, no. 4, p. 321–335, 2022.

[10] F. Rahman, "Ethnomathematics as a bridge between abstract concepts and cultural reality," *International Journal of Ethnomathematics*, vol. 3, no. 1, p. 77–89, 2025.

[11] J. Creswell, Desain Penelitian: Pendekatan Metode Kualitatif, Kuantitatif, dan Campuran (edisi ke-4), Thousand Oaks: CA: Publikasi Sage, 2020.

[12] Sugiyono, Metode Penelitian Kuantitatif, Kualitatif, Dan R&D, Bandung: CV. Alfabeta, 2022.

[13] L. J. Moleong, Metode Penelitian Kualitaif, Bandung: PT. Remaja Rosdakarya, 2000.

[14] V. Braun and V. Clarke, "Using thematic analysis in psychology," *Qualitative Research in Psychology*, vol. 32, no. 1, p. 77–101, 2022.

[15] H. Miles and Saldaña, Qualitative Data Analysis: A Methods Sourcebook, New York: SAGE Publications, 2024.

[16] H. Sembiring, "Traditional artifacts as cultural identity and social symbols," *International Journal of Cultural Studies*, vol. 9, no. 1, p. 55–70, 2020.

[17] R. Hutapea, "Transformation of traditional artifacts in the modern Alas community," *Cultural Studies Journal*, vol. 12, no. 4, p. 355–370, 2021.

[18] A. Putri and M. Arifin, "Regeneration challenges of traditional crafts in the digital era," *Indonesian Cultural Heritage Studies*, vol. 14, no. 2, p. 201–214, 2022.

[19] T. Hidayat, "Integrating local wisdom in school curriculum: A strategy for cultural preservation," *Indonesian Journal of Education*, vol. 8, no. 1, p. 212–220, 2024.

[20] M. Rosa and D. Orey, Ethnomathematics and its diverse approaches for mathematics education, New York: Springer, 2016.

[21] M. Hohenwarter and J. Preiner, "Dynamic mathematics with GeoGebra," *Journal of Online Mathematics and its Applications*, vol. 7, no. 1, p. 1–6, 2022.

[22] Y. Marpaung, "The role of GeoGebra in ethnomathematics learning: Case of Bataknese gorga," *Jurnal Didaktik Matematika*, vol. 7, no. 2, p. 150–163, 2024.

[23] J. Afgani, "GeoGebra as a tool in teaching geometry transformation," *Journal of Mathematics Education Research*, vol. 10, no. 2, p. 145–156, 2024.

[24] N. Prihastari, "Mathematical transformations in Indonesian traditional ornaments," *Journal of Ethnomathematics*, vol. 5, no. 1, p. 87–101, 2021.

[25] A. Sardjono, "Filosofi dan estetika motif tradisional Nusantara," *Jurnal Seni dan Budaya*, vol. 11, no. 2, p. 133–148, 2020.

[26] A. J. Bishop, Mathematical Enculturation: A Cultural Perspective on Mathematics Education, Dordrecht: Kluwer Academic, 1991.