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Ethnomathematics Exploration of the Toraja Tribe Tongkonan House's Traditional Carving

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Abstract

This study investigates the mathematical ideas that are carved on the traditional tongkonan house of the Toraja tribe in Indonesia. This research is ethnographic and uses an ethnomathematical research model. Observational methods and in-depth interviews were employed throughout the data collection process, while ethnographic, domain, and taxonomic approaches were utilized during the data analysis process. The findings of this research indicate that the carving patterns found in this traditional house contain mathematical objects and concepts that are appropriate for use as a medium for learning mathematics in educational settings such as schools. The following mathematical ideas can be found embedded within these motifs: parallel lines, perpendicular lines, curved lines, rhombuses, conceptual congruence, symmetry, horizontal translation, arcs, areas of segments, squares, rectangles, and triangles. Measurement, estimation, and approximation have been identified as mathematical practices that were utilized in the process of making these engravings. Estimation and approximation are performed through the use of guesses that are still approximative and do not make use of standard mathematical principles, whereas measurement activities are carried out with standardized measuring equipment such as a ruler.

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1. Introduction

Learning mathematics at school is often considered a boring subject because the material is difficult for students to understand. This is due to the fact that learning mathematics in schools is often too theoretical, unattractive, and teacher-centered. Such learning will cause students' reasoning powers to be too weak to understand abstract mathematical concepts properly. Many students find mathematics lessons difficult and scary. This causes some students to experience dizziness, as evidenced by their complaints and stress when facing mathematical problems. As a result, student mathematics learning outcomes are always low and bad. This is in line with the statement from Hans [1], who views most classroom mathematics as the "fossilized remains" of reasoning processes from decades ago. Even though they are empty, the facts and methods of school mathematics may look as terrible as the petrified remains of a tyrannosaurus rex.

Mathematics learning must provide opportunities for students to learn in ways that are meaningful and relevant to them. The mathematics subject matter must be related to real experiences and the context of students' lives. Mathematics teachers should design learning that is interesting, effective, creative, innovative, and student-centered. Learning mathematics should use a contextual learning approach and use student-centered learning methods, such as group discussions, simulations, case studies, project-based learning, problem-based learning, etc.

In efforts to relate the teaching of mathematics to real everyday life, it is necessary that the concept of mathematics be developed as a result of the activities or cultural habits of a particular society. This is supported by the concept of learning mathematics using ethnomathematics, Reference [2]. Ethnomathematics introduces how mathematical concepts are processed and used through cultural results and interactions in daily activities. Ethnomathematics can help improve mathematics learning by making it more meaningful for everyone.

Now a days, many researchers have been working in the field of ethnomathematics. Reference [2] states that to create new knowledge, including mathematics, we must look at society as a whole and its cultural dimensions, taking into account the traditions and needs of the community members. This opinion emphasizes that the development of mathematical learning is inseparable from the influence of the social environment and human culture. It can be understood that people develop mathematical concepts from the results of activities and social interactions in everyday life in accordance with the development of their lives.

Inspired by the opinions above, many researchers are engaged in ethnomathematics research and try to explore the mathematical concepts contained in the cultural works of certain societies. Reference [3] have researched ethnomathematics on sero sets found in the Kokas Fakfak community of West Papua. Reference [4] have examined the concept of transformation geometry found in the carvings of the tongkonan traditional house. Reference [5] have studied geometry learning by using geometry objects found in Yogyakarta batik patterns. Furthermore, Reference [6] have explored the ethnomathematics principles found in bark paintings originating from the Asei people in Sentani Papua. Furthermore, Reference [7] have researched ethnomathematics to explore three-dimensional geometric ideas contained in the design of the traditional Dani house building, Wamena Papua. Then Martinus and his colleagues [8] studied ethnomathematics related to the concept of geometry in the paintings and carvings of the Teluk Ampimoi Kepulauan Yapen as a source for learning school mathematics.

Cultural products in the form of paintings and carvings and even traditional house buildings from various tribes in Indonesia are rich in mathematical concepts. In particular, the paintings and carvings of the Toraja people are very rich from an ethnomathematics perspective. Some of the results of research related to ethnomathematics are as follows: Reference [9] has examined the mathematical concepts in typical Tana Toraja carvings. Furthermore, Reference [10] has researched the mathematical exploration of designs in typical Toraja carvings such as Pa'tedong, Pa'barre Allo, Pa'manuk Londong, and Pa' Sussu'. Reference [11] researched the concept of transformation geometry in Toraja painting. Reference [12] have researched the ethnomathematics exploration of Toraja carvings. Reference [13] researched the ethnomathematics exploration of geometric patterns in tongkonan traditional houses in Toraja. They explore the concept of geometry contained in the traditional tongkonan house structure.

Based on the previous research results, there are many interesting studies on ethnomathematics based on the culture of the Toraja people. Tongkonan houses have various carvings. These patterns usually represent mathematical objects. The study in this research relates to the ethnomathematics of the Toraja tribe's tongkonan house carvings. The aim is to explore objects and mathematical concepts found in the carving patterns of the tongkonan traditional house of the Toraja tribe, especially the *pa'manik-manik* motif. This study's findings should help math teachers create teaching materials, such as textbooks, and also use local culture to teach math.

2. Research Methods

This research is qualitative, using ethnographic models and ethnomathematical approaches. This was done because this research focuses on studies related to mathematical knowledge and culture [14, 15, 16, 17]. The researcher acts as a participant observer while the research subject is set in a natural situation without any intervention or treatment. Furthermore, data were collected directly and indirectly through field studies, observations, documentation studies, and interviews with key informants. Key informants were selected purposively following the modified criteria of Umbara, Reference [18] and Martinus and his colleagues [8] as follows: (1) the informant is from the Toraja tribe; (2) the informant is a traditional Toraja tribal figure; (3) the informant is knowledgeable about the culture, customs, and traditional carvings of the Toraja people.; (4) the informant has sufficient time to be interviewed; and (5) the informant can provide complete information.

The researchers conducted a literature study, direct participant observation in natural situations, and interviews to investigate mathematical ideas and concepts and the meaning contained in the Toraja tribe's tongkonan house's traditional carving. To explore each finding, research data were processed utilizing content analysis and triangulation. Content analysis provides specific information about the Toraja tribe's tongkonan houses' traditional carving, and observation techniques are carried out to identify and analyze in depth the mathematical concepts in the drawing and carving designs of the tongkonan houses.

Furthermore, ethnographic, domain, and taxonomic analyses were carried out. The ethnographic analysis aims to study and analyze the culture of the Toraja tribe from an insider's point of view (people who come from the Toraja tribe). Participatory observations were made to observe aspects of the Toraja cultural context. Domain analysis aims to identify activities or ideas in the process of making Toraja ethnic carvings that are related to mathematical objects or concepts. The taxonomic analysis aims to identify and classify objects or carving patterns of the Toraja people that contain mathematical objects and concepts.

3. Results and Discussion

This research was carried out in the Toraja region. To see Toraja culture's beautiful carvings, several tongkonans were visited. Using photographs, researchers can later examine the data to determine whether sculptures depict mathematical concepts. Located at Jalan Poros Palopo-Toraja, Lembang Tondon Nanggala, North Toraja, is the Tongkonan traditional house, which serves as an excellent example of a typical Toraja house, see Figure 1.

Figure 1: Tongkonan traditional house with carved walls.

Furthermore, the carving process is carried out traditionally using simple tools as shown in figure 2.

Figure 2: A carving process at a tongkonan traditional house.

Various pieces of information obtained from the results of observations are as follows: 1. Carving activities in Toraja traditional houses still exist today. 2. The values of carving according to the customs of the Toraja people. 3. Carving media and tools is usually done by engravers. 4. The process of carrying out the carving 5. The forms of the carving and the meaning contained in the carving.

a. Ethnographic Analysis

The findings of an analysis of data gathered in the field through observation, documentation study, and interviews provide the following overview of community activities in the Toraja tribal community.

1. Several motifs of carvings made by the Toraja indigenous people found in tongkonan traditional houses are as follows: *pa'manik-manik, pa'dadu, pa'barre allo, pa'tangkiq pattung I, pa'tangkiq pattung II, pa'barre allo, pa'bulu londong, pa'sekong anak, pa'sekong bungai, pa'sekong kandaure, pa'ne'limbongan, pa'bombo uai I, pa'bombo uai II, pa'kapuq baka, pa'tanduk reqpe, pa'ulu karua, pa'sulan sangbua, pa'polloq gayang, pa'sekong kandaure, pa'tedong.*
2. Toraja culture and customs are robust, especially their philosophical and life-filled traditional houses. Tongkonan houses are beautiful and unique. Toraja people use the tongkonan traditional house as a residence, powerhouse, and place for socio-cultural development. The Toraja tribe's tongkonan house has wood carvings. These carvings represent Toraja's religious beliefs, artistic values, and cultural values, such as cooperation, unity, and brotherhood.
3. Toraja carvings have a characteristic that is often used to decorate objects in the lives of the Toraja people, such as the tongkonan traditional house; the lembang, which are traditional containers for the Toraja people used to store rice, sugar, or other food ingredients; wooden or stone statues are often carved with typical Toraja motifs; the alang, which is the roof of a traditional Toraja house; the door of a traditional Toraja house; and the frame of traditional Toraja houses made of bamboo.
4. The tools used to make Toraja carvings are various types of wood chisels, sharp knives, wood saws, hammers, and rulers. Meanwhile, the media or materials used to make Toraja carvings are wood and bamboo.
5. Toraja carvers are referred to as "*ma'batu*" and their work is renowned across the world. They are persons who have specific expertise in woodcarving and are responsible for conserving the cultural values of the Toraja people. Because the *ma'batu* typically has talents that have been passed down from generation to generation, they have a deep respect for the Toraja cultural values of tradition and continuity.

b. Domain Analysis

The findings of domain analysis were obtained from the results of data analysis collected through observation, documentation studies, and interviews. The findings include the process of making tongkonan traditional house carvings; the activities of carvers related to mathematics are presented in the following table.

Table 1: Domain Analysis.

Domain	**Linkages**	**Ethnomathematics activity in the engraving process**
Counting activity	To answer how many	This appears when calculating the number of carving motifs in the Toraja traditional tongkonan house.
Measure activity	To answer what size (length, width), use certain measuring tools.	This appears when measuring the length and width of the wall when making a carved pattern for the Toraja traditional tongkonan house.
Designing activity	To answer how to make shapes, patterns, or cultural motives	This appears when deciding on or choosing the motif to be carved as well as the drawing technique to be used.
Location-determining activity	To answer where a particular carved motif is placed and the carved object is placed	This occurs when applying carving rules to painting layouts.
Activity explained	To respond to cultural values such as shapes, patterns, and carving motifs	This appears in the four activities above. The form of explanation is divided into two, namely, explanations based on practical objectives and explanations based on cultural values.

c. Taxonomy analysis and exploration of ethnomathematics

Taxonomy analysis of Toraja traditional tongkonan house carvings was done using data from observation, interviews, and documentation. The taxonomy analysis is used to figure out what objects or mathematical steps are used in engraving, as well as what the engraving looks like when it's done. In addition, the results of this identification are used to explore the ethnomathematical ideas contained within them and connect them with models, definitions, and the fundamental characteristics of related mathematical ideas.

The following is an explanation of the ethnomathematical principles that can be found in the sculptures of Toraja traditional tongkonan house.

- Parallel lines

In the traditional carving, there are parallel line objects as shown in figure 1.

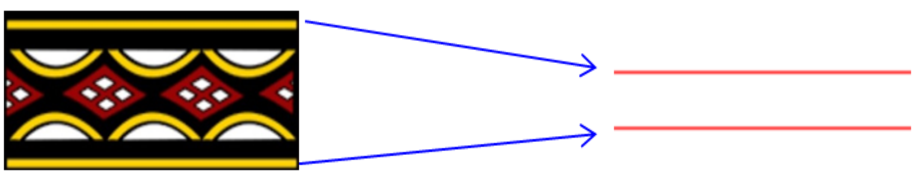

Figure 1: Parallel lines in the carving motifs.

Two parallel lines have the same slope, so they don't intersect. The following is a list of properties that parallel lines have:

Two lines that are parallel have the same slope or gradient. As parallel lines never meet, there is no point at which they may be said to intersect with one another. The distance between the two parallel lines is always the same. The angles created when one parallel line crosses another parallel line are equal to one another.

Two lines with the equations $l_1 = mx + c$ and $l_2 = nx + d$. The two lines are parallel (l_1 // l_2) if and only if $m = n$.

- Perpendicular lines

In the traditional carving, there are parallel line objects as shown in figure 2.

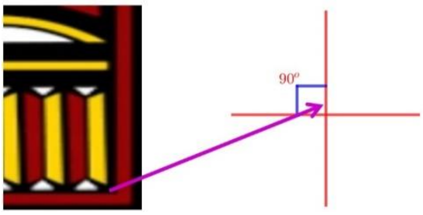

Figure 2: Perpendicular lines in the carving motifs.

Two lines are perpendicular if they form a 90-degree angle (the right angle). Two straight lines, with the equations $l_1 = mx + c$ and $l_2 = nx + d$. The two lines are perpendicular if and only if $m \, x \, n = -1$.

- Curved lines

In the traditional carving, there are curved line objects as shown in figure 3.

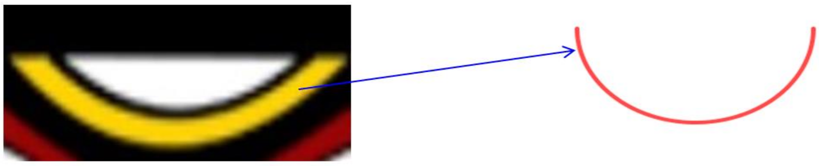

Figure 3: Curved lines in the carving motifs.

A curved line or curve is a shape that has curvature and does not consist of straight line segments. Mathematically, a curved line is a set of points on a plane or in space that meet certain mathematical conditions. Curved lines are either closed or open. The initial and terminal endpoints of a closed curved line meet. Ellipses and circles are examples of closed curved lines. An open curved line is a line that does not form a closed curve, so its beginning and termination do not meet. The exponential curve, hyperbola, and parabola are open curved lines.

- Rhombus

Toraja traditional carvings contain several forms that are flat and have the form of rhombuses as shown in figure 4.

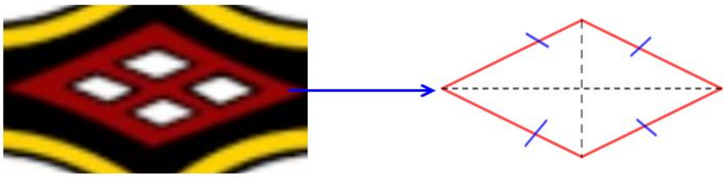

Figure 4: Rhombuses in the carving motifs.

Mathematically, a rhombus is a four-sided shape with certain properties: (1) All four sides are the same length. (2) It has two opposite pairs of equal angles. (3) The diagonals intersect perpendicularly and divide the rhombus to form four equal triangles. (4) The diagonals meet perpendicularly at their midpoints. (5) Rhombus has two axes of symmetry.

- Conceptual Congruence

Congruence is the mathematical idea of two or more geometric objects being similar in shape and size. Geometric objects can be triangles, circles, or other shapes. The symbol "≅" means "congruent with". Two geometric objects are congruent if their shape and size are the same and they can exchange places. The concept of congruence in the carvings as shown in figure 5.

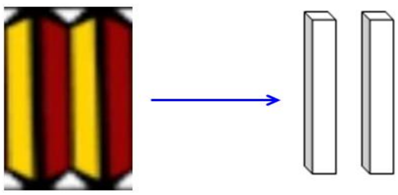

Figure 5: Congruence Objects in the carving motifs.

- Symmetry

In the field of mathematics, symmetry refers to the property that two similar shapes retain their identity even after being translated, rotated, or mirrored.

– Reflective symmetry

Reflective symmetry matches an object or image with its mirrored version, so that it has the same shape before and after being flipped. The line of symmetry divides the object into two equal parts.

There is a carving motif that has a second degree of reflective symmetry, as shown in figure 6.

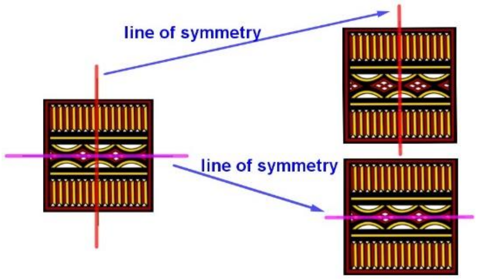

Figure 6: Reflective symmetry in the carving motifs.

- Horizontal translation

There is a carving motif that has a horizontal translation, as shown in figure 7.

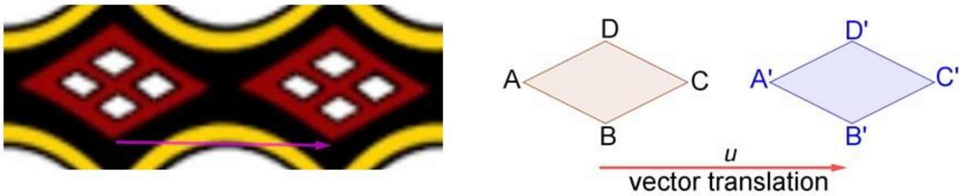

Figure 7: Horizontal translation in the carving motifs.

The process of moving something along the horizontal axis is also known as horizontal translation. To represent a horizontal translation in Cartesian coordinates, the *x* value of a coordinat is modified.

- Arc and area of segment

There are arcs and areas of segmentation of the circle on the carving motifs as shown in figure 8.

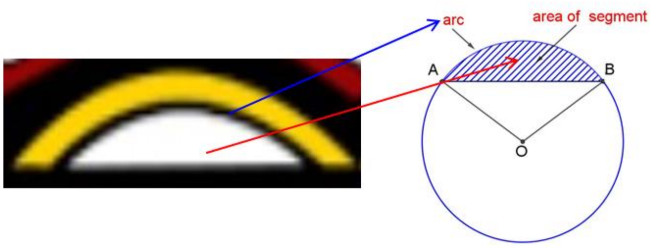

Figure 8: Arc and area of segmentation of the circle in the carving motifs.

An arc of a circle is the part of a curved line on a circle that is between two points on that circle. The region of a circle that the circular arc and chord surround is known as its segment.

- Square

There are squares on the carving motifs as shown in figure 9.

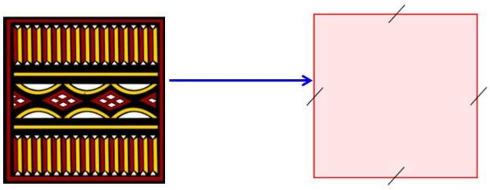

Figure 9: Square in the carving motifs.

A square has four equal sides and four 90-degree angles. The square has equal-length sides. There are many characteristics that are associated with square, including the following: (1) there is no variation in length between any of the four sides. This indicates that the length of the square's four sides is all the same; (2) all four angles are equal and every angle on a square is exactly 90 degrees; (3) square consists of two diagonals that are equivalent in length to one another and they cross in the middle of the square; (4) the square is a geometric shape that has four-fold symmetry.

- Rectangle

There are rectangles on the carving motifs as shown in figure 10.

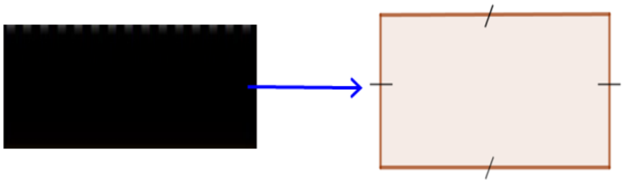

Figure 10: Rectangle in the carving motifs.

A rectangle is a two-dimensional plane shape that has two pairs of parallel sides that are the same length and four right angles (90 degrees). A rectangle has two sides that are longer than the other two. A rectangle is a geometric shape that has the following properties: (1) all four angles are right angles (90 degrees), (2) has two pairs of parallel sides and the same length, (3) has two pairs of diagonals that are the same length and intersect in the middle of the rectangle, (4) a geometric shape that has fold symmetry parallel to one of its diagonals

- Triangle

There are triangles on the carving motifs as shown in figure 11.

Figure 11: Triangles in the carving motifs.

A triangle is a type of geometric shape that has three sides and is made up of three points that are joined by three straight lines. The triangle is one of the most fundamental and significant geometric forms, and it has a variety of fascinating qualities and characteristics in addition to being one of the shapes. The following is a list of some of the properties that triangles have: (1) The combined degrees of the three angles that make up a triangle always add up to exactly 180. (2) Based on the lengths of their three sides, triangles can be put into three different groups: equilateral triangles, isosceles triangles, and scalene triangles. (3) Triangles can be categorized according to the size of their internal angles; acute triangles, obtuse triangles, and right triangles. (4) The line that connects the midpoints of the triangle's sides will always cross at one point, and that point is the center of the triangle.

4. Discussion

The tongkonan house of the Toraja tribe is carved with a number of designs that are related to mathematical objects. The carving pattern in this traditional house is carved on the wooden walls. In the art of carving, *pa'manik-manik* motifs are those that have a significant relationship to certain mathematical objects and concepts. According to the findings of the study, the Toraja tongkonan house's traditional carvings feature the following mathematical concepts: parallel lines, perpendicular lines, curved lines, rhombus, conceptual congruence, symmetry, horizontal translation, arc, area of segment, square, rectangle, and triangle. There are still a great number of items and mathematical concepts hidden within other carving designs that have not been properly identified. In most cases, the mathematical objects that were discovered are connected to the discipline of geometry in some way.

Apart from these mathematical objects and concepts, the researcher also found mathematical practices in the process of making these carvings. The engravers apply mathematical concepts related to measurement, estimation, and approximation. Measuring, approximation, and approximation activities are found through observation and interviews with the engravers while they are doing the carving. Measurements are carried out with standard measuring instruments, but estimates and approximations still use rough estimates, but the results are very good. So it can be seen that the engravers have very good skills that are obtained from life experience and cultural heritage passed down from their ancestors.

From the results of observation and analysis, it was found that the carved motifs on the *pa'manik-manik* motif are non-abstract and easily observable motifs. Therefore, this motif is very suitable to be used as a medium for learning mathematics in schools. This will foster students' interest in learning mathematics because the inculcation of concepts is associated with the results of community culture. In addition, the integration of cultural practices into educational settings can help students develop personalities that are more appreciative of their indigenous traditions and more nationalistic in perspective [8, 19].

Integration of ethnomathematics with models and learning that is materially suitable would increase teachers' capacity to explore the effects of cultural products of a given community, which can then be used as instructional resources or media in schools. This will allow teachers to better understand how cultural products may be used to teach students. In addition to that, it has the potential to enhance students' mathematical literacy, critical thinking skills, and ability to communicate with other students. The students will be able to overcome the obstacles in mathematics that they face in their studies, Sirate [20].

5. Limitation

It should be noted that this research is mainly concentrated on *pa'manik-manik* motifs of the Toraja tribe's traditional carving, which is the study's primary limitation. While there are still other carving motifs on the traditional house, of course, they have a relationship with mathematical ideas. These carvings have not been clearly defined. Accordingly, there is a requirement for further investigation.

6. Conclusion

Mathematical objects and concepts found from the results of an ethnomathematics analysis of the tongkonan house of the Toraja tribe are generally related to the field of geometry. The motifs are carved into the wooden walls and neatly arranged. The mathematical ideas contained in these motifs are parallel lines, perpendicular lines, curved lines, rhombuses, conceptual congruence, symmetry, horizontal translation, arcs, areas of segments, squares, rectangles, and triangles.

In addition to these artifacts, researchers discovered mathematical procedures that were used in the process of constructing these engravings. The engravers make use of mathematical ideas such as measuring, estimation, and approximation in their work. Although measurements are taken with standardized measuring equipment like a ruler, estimation and approximation are accomplished with guesses that are still approximative and do not make use of standard mathematical principles.

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