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Ethnomathematics in Papuan Indigenous Patterns

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Abstrak

Studi etnomatematika suku Malind telah mengidentifikasi berbagai materi matematika yang tertanam dalam budaya mereka. Penelitian ini bertujuan untuk mengetahui konsep-konsep matematika yang ada pada motif khas Papua yang terdapat pada alat musik Kandala. Penelitian ini merupakan penelitian kualitatif dengan pendekatan etnografi. Penelitian ini dilakukan di kampung Wasur Kabupaten Merauke Propinsi Papua Selatan. Teknik pengumpulan data pada penelitian ini yaitu pengamatan, wawancara dan dokumentasi. Analisis data menggunakan analisis data kualitatif model interaktif yaitu kondesasi data, tampilan data dan kesimpulan. Hasil penelitian menunjukkan bahwa terdapat konsep-konsep matematika pada motif-motif yang terdapat pada bagian luar alat musik. Konsep matematika yang muncul pada motif-motif yang ada pada alat musik Kandala yaitu konsep bangun datar yaitu segitiga, persegi, persegi panjang, belahketupat dan lingkaran selain itu terdapat juga konsep transformasi geometri yaitu translasi, refleksi dan dilatasi.
Kata Kunci: Dilatasi; Etnomatematika; Geometri; Motif Khas Papua; Refleksi; Translasi.

Abstract

Ethnomathematics studies of the Malind tribe have identified various mathematical materials embedded in their culture. This research aims to identify the mathematical concepts embedded in Papuan cultural patterns found on the Kandala musical instrument. This is a qualitative research using an ethnographic approach. The research was conducted in Wasur Village, Merauke District, South Papua Province. Data collection techniques in this study include observation, interviews, and documentation. Data analysis uses an interactive qualitative data analysis model, namely data condensation, data display, and conclusion. The results show that there are mathematical concepts in the m-otifs found on the outer part of the musical instrument. The mathematical concepts that appear in the patterns on the Kandala musical instrument are the concepts of plane figures such as triangles, squares, rectangles, rhombus, and circles. In addition, there are also concepts of geometric transformations such as translation, reflection, and dilation.
Keywords: Dilation; Ethnomathematics; Geometry; Papuan Indigenous Patterns; Reflection; Translation.

I. INTRODUCTION

Previously known as Irian Jaya or Dutch New Guinea, Papua was officially renamed in accordance with Law No. 21 of 2001 on Special Autonomy for Papua. The indigenous population of Papua Province belongs to the Melanesian ethnic group, a part of the diverse ethnic groups in Indonesia, each with its own unique culture, history, customs, and language. There are approximately 254 tribes in Papua, scattered across various customary territories (Rumansara, 2015). One of the newest provinces, carved out in 2022, is South Papua Province.

Merauke is a regency located in South Papua Province. The indigenous people inhabiting Merauke are the Malind tribe, also known as Malind-Anim, meaning 'true humans'. The Malind people's lives remain deeply intertwined with nature. The traditional customs and culture of the Malind tribe are still well-preserved to this day. This is evident in the continued practice of traditional ceremonies such as the Cabut Misar ritual. This ritual is a long series of events that involve singing and dancing accompanied by the traditional musical instrument, the Kandala.

In this context, the researchers have endeavored to delve into the indigenous mathematical knowledge embedded within the Kandala musical instrument, particularly focusing on the distinctive Papuan motifs found on the Kandala's exterior. This exploration has been conducted through the application of diverse theoretical lenses. The Malind tribe possesses a unique perspective on understanding and utilizing mathematics. They practice distinct mathematical concepts in their daily lives, constituting a component of informal mathematical knowledge.

Ethnomathematics is a mathematical concept that is embedded and practiced within the culture of a specific group of people (Susanto, Setiawan, & Daniaty, 2023; Musliana et al., 2024). The term ethnomathematics has been coined with varying perspectives. According to Rosa and Orey (2010), ethnomathematics is seen as ideas and concepts embedded within diverse cultural contexts. For Ascher and Ascher (1997), ethnomathematics is the study of the mathematical ideas of non-literate people. On the other hand, D'Ambrosio (2006) defines ethnomathematics as "the mathematics practiced by the cultural groups, such as urban and rural communities, groups of workers, professional classes, children in a given age group, indigenous societies and so many other groups that are identified by the objectives and traditions common to these groups.

In Indonesia, particularly in Papua, ethnomathematics is a relatively new research field that is linked to the domain of mathematics education and describes mathematical ideas and activities embedded in cultural contexts (Riadi, Turmudi, & Juandi, 2024). Mathematics is a cultural product developed as a result of various activities including counting, locating, measuring, designing, playing, and explaining (Bishop, 1991). Daily life is imbued with the knowledge and practices of a culture, and cultural activities created by various societies always utilize some kind of mathematical knowledge and concepts.

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Mathematical concepts can be embedded within both the practices and artifacts of a culture. Cultural artifacts, as defined by D'Ambrosio (1993), are objects created by a cultural group that provide insights into the group's knowledge and beliefs. In this study, Kandala artifacts, which serve as walls, ceilings, baskets, and other utilitarian and ceremonial objects, are examined for their embedded mathematical concepts.

Some studies on the ethnomathematics of the Malind tribe include, Malind-Papua Ethnomathematics: Kandara as a Learning Media for Geometry Concepts in Elementary School, the results of the study state that ethnomathematics is found in parts of the kandara, kandara musical instruments can be used as a learning medium to explain geometry concepts in elementary school (Fredy, Halimah, & Hidayah, 2020). Ethnomathematics studies of the Malind tribe have identified various mathematical materials embedded in their culture, as revealed in Purwanty & Fredy's research (2020). The purpose of this study is to explore ethnomathematics activities and find mathematical concepts that exist in typical Papuan motifs, namely the concept of flat buildings and geometric transformations.

II. METHOD

This study is qualitative research with an ethnographic approach. Ethnography is field study research that emphasizes providing a very detailed description of different cultures from the point of view of people in those cultures to facilitate understanding of them (Neuman, 2008). This research was conducted in the Malind Marori Men-gey indigenous community in Wasur village, Merauke Regency, South Papua Province. Data regarding mathematical ideas residing in cultural artifacts were collected through observations and interviews with two traditional elders and one expert in making Kandala through observing their activities, listening and asking appropriate questions for the duration of the study from August 2022 to December 2023. This was done with the help of interview guidelines and documentation studies.

Research data analysis was validated by triangulating data sources and triangulating techniques to test credibility by checking data that has been obtained from various data sources including observation, interviews, and other documents. Data analysis uses an interactive model of qualitative data analysis, namely data condensation, data display and conclusions (Miles, Huberman, & Saldana, 2014). These three activities of data condensation, data display, and conclusion drawing and verification were interwoven before, during, and after data collection forming an interactive and cyclical process. The three activities are shown in Figure 1.

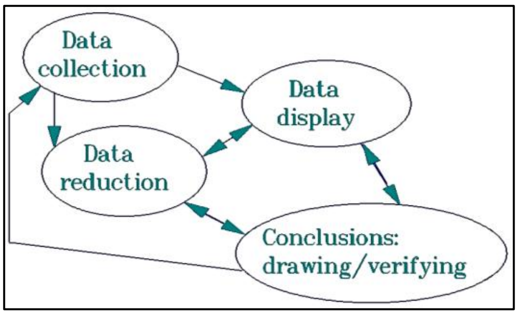

Figure 1. Components of Data Analysis.

III. RESULT AND DISCUSSION

A. Cultural attributes of the Malind Marori Men-gey ethnic group

1. Language System

Language functions as a fundamental medium of communication within the global human community. The vast majority of nations utilize language as a marker of national or cultural identity. The Indigenous Malind people are no exception. Papua is home to approximately 254 distinct ethnic groups distributed across various customary territories (Rumansara, 2015), among which are the Malind. The Malind language is comprised of several dialects, including Imbuti, Marori, Engkalembu, and Bian Marind dek (Retnaningtyas, 2021). The Yelmek and Maklew languages are also part of the Malind linguistic landscape.

The Marori language remains in use, albeit with a declining number of speakers. Indonesian has become the primary language among the younger and adult generations. Informants suggest that compiling a Marori language dictionary is a viable strategy for language preservation. Mathematics constitutes a language that represents a sequence of meanings conveyed through symbolic expressions. Mathematical symbols are 'artificial' entities that derive their meaning from assigned interpretations. Absent such interpretations, mathematics would be reduced to a sterile collection of formulas. According to Mr. Tobias Gebze, a resident of Wasur, the local community has been exposed to numerical concepts from a young age through their social environment. Table 1 presents the Malind Marori Men-gey people's counting system.

Table 1.
System of Counting among the Malind Marori Men-gey people

Numbers	Marori Men-gey Numbers	English Numbers
1	Sokodu	One
2	Yenadu	Two
3	Penar	Three
4	Anda Yenadu	Four
5	Bya Baren Korou	Five
6	Mbaren Korou Sonouw Sokodu	Six
7	Mbaren Korou Sonouw Yenadu	Seven
8	Mbaren Korou Sonouw Penar	Eight
9	Mbaren Korou Sonouw Anda Yenadu	Nine
10	Korou Sonouu	Ten

2. Knowledge System

In navigating life, humans require tools to support their existence. The Malind people have demonstrated their capabilities through the availability of tools such as bamboo bows, reed arrows, wooden spears and clubs, stone axes, boats, as well as cutting and stabbing tools made from bone or seashells. They cook using bamboo tubes or by utilizing heated stones (Bakar batu). The presence of these traditional tools is evidence that the Malind people have possessed scientific knowledge for a long time.

3. Social System

Malind marriages follow a patrilineal system, meaning descent is traced through the father's line. Kinship is classified under the Iroquois type, which categorizes parallel cousins with the same terms as siblings. Additionally, the same term is used for both the father and paternal or maternal uncles (Mansoben, 2006). When establishing a village, the Malind people typically place different clans in proximity. Usually, two main clans, each with two subclans, are positioned opposite each other. In coastal areas, the Kelapa and Kasuari clans face inland areas (Sagu and Buaya clans) or, in other words, the mainland faces the swamps. Members of the same named group across different villages often assist one another, and all Malind people perceive themselves as a unified entity.

4. Technological System

Traditional societies employ a variety of tools and physical cultural elements. These are utilized by people living in small, nomadic communities. Examples include weapons (bows and arrows), shelters and dwellings, production tools, clothing, and adornments. The Malind people currently inhabit very simple houses, while their traditional attire is renowned for its attractiveness and vibrancy.

5. Religious System

In the past, the Malind people believed that Samb-Anem was a loving god, akin to a father figure (Sobari, 2015). Samb-Anem was not worshipped with prostration, trembling, or awe, but was invoked through religious cult communications of Mayo, Imo, Sosom, and Esam-Usum. Today, the majority of the Malind people have converted to Catholicism and Protestantism. However, beliefs in the supernatural, spirits, demons, and black magic persist to this day.

6. Subsistence System

The primary subsistence strategy of indigenous peoples is foraging. According to Boelaars (1986), Malind culture can be classified as a "foraging" culture, meaning that a Malind individual can directly benefit from their natural surroundings and their fellow human beings. They can almost always fulfill their needs immediately. They simply gather, hunt, and fish. There is always a "harvest" available to them.

7. Art System

Art is an imitation of nature in various beautiful and pleasing forms (Rumansara, 2003). Furthermore, it is expressed that art is a person's creativity in creating a work that is eventually recognized by the entire community. The Malind people possess an art form that has been passed down through generations, inseparable from its role in every traditional ceremony accompanied by artistic activities such as dance, music/instruments, vocals, literature, and others. The Gadzi dance, accompanied by the beating of the kandala drum and songs, is still performed at every event to this day.

B. Exploring the intersection of culture and cognition: A study of mathematical concepts embedded in Papuan (Malind) Indigenous Pattern

The intricate patterns found in Papuan art, including batik, body painting, and carvings, serve as a visual language that encapsulates the worldview and cultural identity of indigenous communities.

Wulandari (2022) identifies seven significant batik patterns: Cenderawasih, Asmat, Sentani, Tifani Honai, Kamoro, Prada, and Asymmetrical. These patterns are not merely decorative elements but carry deep cultural significance, often embodying both literal and symbolic meanings.

Based on research data on Papuan patterns found on the kandala musical instrument, it was discovered that these motifs possess ethnomathematical aspects related to the material of two-dimensional geometry and geometric transformations. The geometric materials obtained from this research include: triangles, squares, rectangles, rhombus and circles.

Figure 2. An Inventory of Patterns Present on the Kandala.

1. Concept of Plane Figures

Referring to Figure 2, the exterior of the traditional Kandala musical instrument of the Malind Marori Men-gey people is adorned with carvings that depict the owner. This practice indirectly illustrates how the indigenous Malind Marori Men-gey people maintain their identity by creating lan-specific patterns on the exterior of the Kandala.

Generally, the motifs found on the exterior of the Kandala are in the form of triangles, squares, rectangles, rhombus and circles. Various linear patterns and angles are also observed. These distinctive Papuan motifs can serve as cultural artifacts to teach geometric concepts as well as other concepts such as measurement. In the classroom, these Papuan motifs can be demonstrated to resemble triangles, squares, rectangles, rhombus and circles, thereby enabling us to derive formulas for calculating area and circumference.

a. Triangle

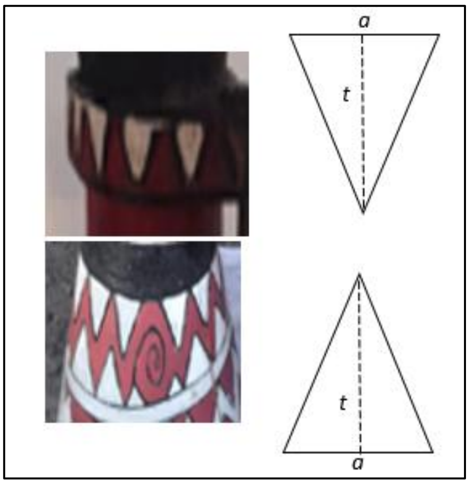

Figure 3. Triangle.

Determining the Area and circumference of a Triangel:

Area of a Triangel $= \frac{1}{2}at$

Circumference of a Triangel$= s \times s \times s$

b. Squares and Rectangles

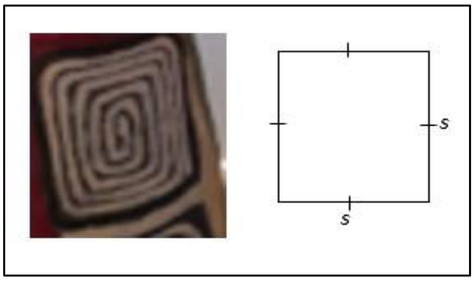

Figure 4. Squares.

Determining the Area and circumference of a Squares:

Area of a Squares $= s \times s$

Circumference of Squares $= 4s$

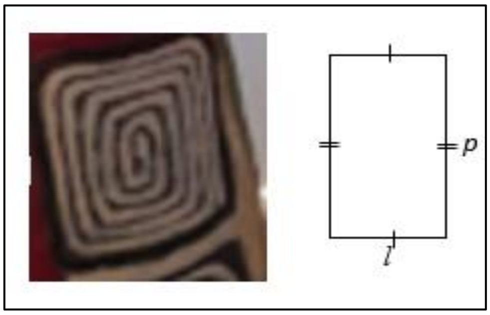

Figure 5. Rectangles.

Determining the Area and circumference of a Rectangles:
Area of a Rectangles $= p \times l$
Circumference of Rectangles $= 2(p + l)$

c. Rhombus

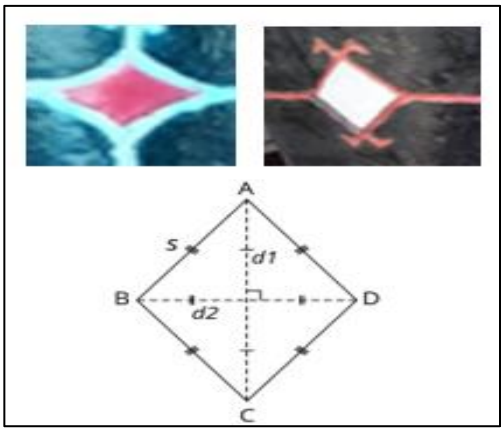

Figure 6. Rhombus.

Determining the Area and circumference of a Rhombus:
Area of a Rhombus =1/2 d_1 d_2
Circumference of a Rhombus=4s

d. Circle

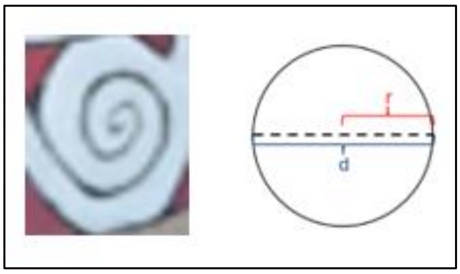

Figure 7. Circles.

Determining the Area and circumference of a Circle:
Area of a Circle =πr^2
Circumference of a Circle=2πr or πd

2. Concept of Geometric Transformations

Transformation geometry refers to the alteration of an object's position from its initial to a final location. There are four primary types of transformations: translation, reflection, dilation, and rotation. The following presents the results of an exploration of ethnomathematical aspects of the motifs found on the Kandala.

a. Translation

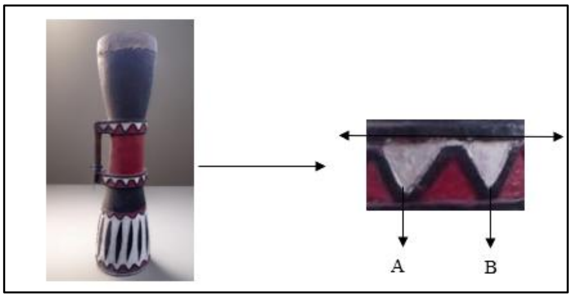

Figure 8. Patterns on the Segos.

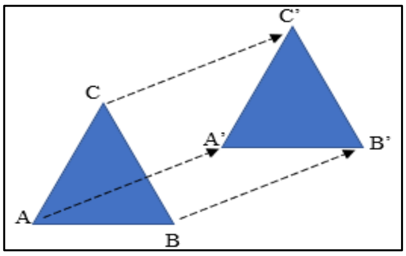

Figure 9. Translation.

Observe Figure 8. The motifs on the Segos or divider between the head and belly of the Kandala, as well as between the belly and tail, exhibit a translation process. Translation refers to the shifting of an object along a straight line in a specific direction and distance.

A translation is a transformation that shifts every point in a plane by a fixed distance and direction.

Given a translation $T = \binom{a}{b}$, the image of point $P = (x, y)$ under this transformation is denoted by $P'(x', y')$.

$$P(x,y) \xrightarrow{T = \binom{a}{b}} P'(x+a, y+b)$$

The matrix representation of a translation is given by:

$$\binom{x'}{y'} = \binom{x}{y} + \binom{a}{b}$$

b. Reflection

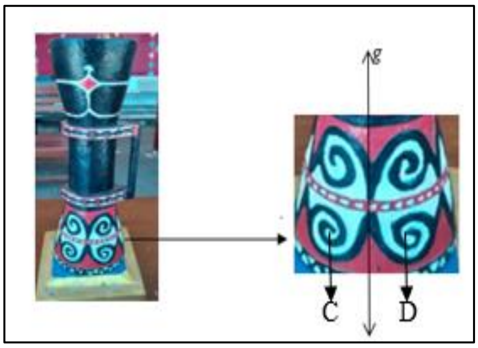

Figure 10a. The Boar Tusk Motif, Referred to as Klen Basik-basik, Adorns the Tail Section of the Kandala.

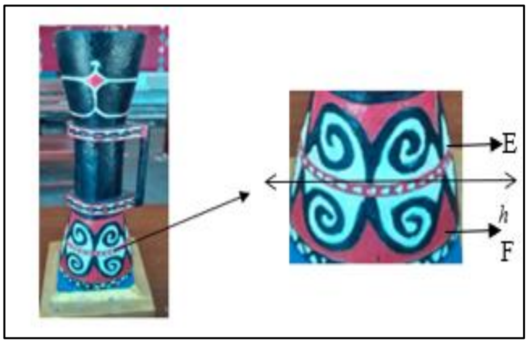

Figure 10b. The Boar Tusk Motif, Referred to as Klen Basik-basik, Adorns the Tail Section of the Kandala.

Figures 10a and 10b illustrate the concept of reflection in geometric transformations through the motifs on the Kandala. In Figure 9a, the reflection of Motif C across the y-axis produces a congruent image, Motif D, with a reversed orientation. Likewise, in Figure 9b, the reflection of Motif E across the x-axis yields a congruent image, Motif D, with an opposite orientation. These examples highlight that a reflection preserves the size and shape of an object while reversing its orientation, and the object and its image are equidistant from the line of reflection.

Other examples of reflections found in Kandala motifs and Papuan motifs encountered in daily life.

Figure 11. Example of Papuan Pattern.

A reflection is a transformation that moves each point in a plane according to the properties of a mirror image (Istiqomah, 2020).

The properties of reflection are as follows:

1) The distance from the original point to the mirror is equal to the distance from the mirror to the image point.
2) The line connecting the original point and the image point is perpendicular to the mirror.
3) Lines formed between corresponding points of the original figure and its image are parallel.

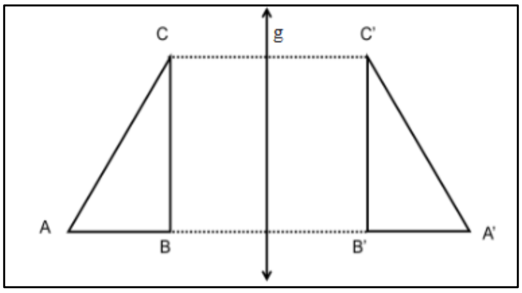

Figure 12. Reflection.

c. Dilation

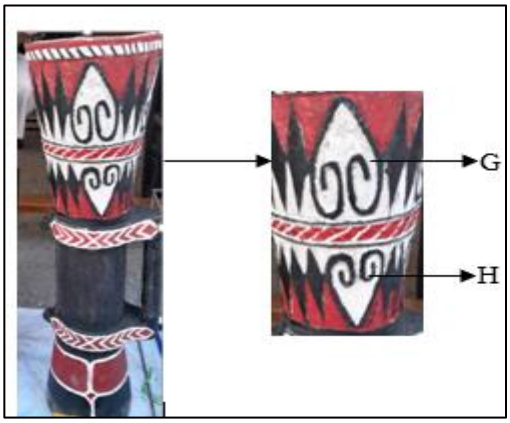

Figure 13. The Boar Tusk Motif, Referred to as Klen Basik-basik, Adorns the Head Section of the Kandala.

Referring to Figure 13, the motif on the Kandala represents a dilation in geometric transformation. Dilation is the process of shrinking or enlarging an object. Motif H is obtained through a dilation of Motif G, where the shape remains unchanged but the size is altered.

A dilation is a transformation that alters the distances of points from a fixed point by a specific scale factor. This scale factor is known as the dilation factor or scale factor, and the fixed point is called the center of dilation (Istiqomah, 2020). A figure that is enlarged or reduced (dilated) by a scale factor of k can change in size but does not change its shape.

1) If $k > 1$, then the figure is enlarged and lies in the same direction as the center of dilation and the original figure.
2) If $k = 1$, then the figure does not undergo any change in size or position.
3) If $0 < k < 1$, then the figure is reduced and lies in the same direction as the center of dilation and the original figure.
4) If $-1 < k < 0$, then the figure is reduced and lies in the opposite direction of the center of dilation compared to the original figure.
5) If $k = -1$, then the figure does not change in shape or size but is located in the opposite direction of the center of dilation compared to the original figure.
6) If $k < -1$, then the figure is enlarged and lies in the opposite direction of the center of dilation compared to the original.

C. Discussion

Ethnomathematics has developed since the 1980s to reveal the relationship between mathematics and culture (D'Ambrosio, 1999). Ethnomathematics research examines a wide range of ideas, including numerical traditions and patterns, as well as educational policies and pedagogy in mathematics education. D'Ambrosio further states that one of the goals of ethnomathematics is to contribute to the understanding of culture and mathematics in particular, to lead to an appreciation of the relationship between the two.

According to the findings of this research, from the interview it was found that they made motifs according to the totems of each Clan derived from natural elements around them. From these motifs, two mathematical concepts are obtained, namely flat geometry and geometric transformations found in Papuan motifs on Kandala musical instruments. This is in line with what is conveyed by (Eglash et al, 2006) that these mathematical ideas, procedures, and practices are related to numerical relationships found in arithmetic, games, geometry, divination, astronomy, modeling, and various kinds of mathematical procedures and other cultural artifacts.

According to informants, the motifs carved on Kandala do not use complicated tools nor do they apply procedures and techniques related to standard mathematics but rather special abilities possessed by people who make them based on experience but can produce flat geometric shapes and geometric transformations resulting from carvings that are representations of the nature around where they live. This is in line with what D'Ambrosio (2006) asserts that mathematical ideas, procedures and practices are developed in different cultures according to the common problems faced in the cultural context.

IV. Conclusion

The Kandala is a traditional musical instrument of the Malind tribe, crafted from wooden artifacts. These artifacts are products of the ancient skills and knowledge of our ancestors. Previously, the knowledge of creating this musical instrument was orally transmitted from generation to generation within the community. The exterior of the instrument is carved with motifs corresponding to the clans within the community.

Based on this research, it can be concluded that the traditional teaching and learning approach in creating motifs involves observation, practice, estimation, and imitation. Moreover, the created motifs contain ethnomathematical aspects related to the material of two-dimensional geometric shapes and geometric transformations. The geometric materials obtained from this research include triangles, trapezoids, squares, rectangles, and circles, while the geometric transformations found are translation, reflection, and dilation. The results of this research are then expected to be applied to learning materials at school later.

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