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ETHNOMATHEMATICAL EXPLORATION OF THE TRADITIONAL FABRIC OF KARAWO GORONTALO IN RELATION TO THE CONCEPT OF TRANSFORMATION GEOMETRY

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ABSTRACT

This study aims to explore the ethnomathematics contained in the traditional fabric motifs of Karawo Gorontalo in relation to the concept of geometry transformation. This research is qualitative in ethnographic design. The subjects of this study were Karawo embroidery craftsmen with research locations in Karawo production houses, Ayula village, Tapa district, Bone Bolango regency, Gorontalo Province. Data collection techniques with observation, interviews, documentation studies, and literature studies are then analyzed using Spradley's domain analysis method. The results showed that Karawo is an embroidery art that has been preserved since 1600 AD and continues to be preserved by Gorontalo women until now. Karawo also has a manufacturing process that includes slicing and plucking yarn, Mo-Karawo or embroidery, and the last stage is to make refinement. The Ethnomathematics of Karawo fabric embroidery patterns is the geometry of transformation, which is some motifs that can apply the concepts of translation, reflection, dilation, and rotation. This application shows a relationship and can explain the relationship between the concept of transformation geometry and Karawo and can also be illustrated in the Cartesian diagram.

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1. INTRODUCTION

Man is a cultured creature. Culture is a habit that is passed down from generation to generation. Mathematics has become part of human culture. However, most people do not realize that they have applied mathematics in everyday life. They view mathematics as just a subject studied in school. Since long ago, the relationship between humans and mathematics has been inseparable, including the use of mathematics in carving, culture, agriculture, building forms, and others [1]. So, it can be concluded that learning mathematics is a must. Mathematics is an integral component of all cultural contexts and the meaning of all cultural contexts is influenced by the interpretation of each individual in that culture so that mathematical and cultural understandings are interrelated because the way each individual interprets and uses mathematics is often influenced by their cultural background [2].

Mathematics is one of the compulsory subjects for students because mathematics is a basic science in the development of science and technology. Mathematical skills are still very lacking in terms of problem-solving which is often caused by the lack of reasoning and solving problems in teaching materials and practice questions to students. Many students who participate in math learning are able to understand and solve math story problems without considering the factual relationships between the situations described in problems related to the real world and the mathematical operations required to be solved, which is evidence that children tend to ignore realistic considerations by not paying attention to knowledge of the real world when they solve math problems [3]. This is unfortunate because the purpose of studying mathematics in school is to prepare students to be able to use mathematics and mathematical mindset in everyday life and learn various sciences.

In the process of teaching and learning mathematics, schools still continue to focus on what is in the textbook so that the use of other solutions related to the problem cannot produce maximum reciprocity. Mathematics lessons should not be considered separately from societies and their lives and cultures [4]. Therefore, linking mathematics material with the social and cultural context and real experience of each student is very important so that learning becomes more meaningful and relevant for them. Learning mathematics meaningfully through a cultural context is not difficult in Indonesia, because of cultural and ethnic diversity. The culture owned by this country can be used in improving mathematical skills, especially in the ability to learn along with preserving culture.

One solution related to the above problem is to utilize an ethnomathematical approach as the beginning of the formal mathematics teaching and learning process following the level of student development that is at a concrete operational stage. The same thing is stated that the presence of culturally nuanced mathematics will contribute greatly to school mathematics because schools are social institutions that are different from others to allow socialization between several cultures. Culture influences individual behavior and has a major role in the development of individual understanding, including mathematics learning [5]. So, the exploration of mathematical values in a civilization or culture through certain ethnomathematical approaches is expected to be a bridge to understanding students' concepts in mathematics learning. Mathematics can have different perspectives between cultures and social groups, so it can develop from various activities based on the practices and experiences of other cultural groups, therefore mathematics is the result of culture, not something separate from culture [6].

Ethnomathematics is a variety of mathematical activities that have or develop in the life of a particular society. Ethnomathematics is a mathematical practice carried out by certain cultural groups, such as tribal communities, certain working groups, children of certain age groups, professional classes, and others. D'Ambrosio defines in another statement [7] that "*Ethnomathematics is the way different cultural groups mathematize (count, measure, relate, classify, and infer)*". "Ethnomathematics is the way different cultural groups do math (calculating, measuring, connecting, classifying, and inferring). In addition to language, to be able to understand and explain the social, cultural, and historical context of different cultural groups, processes are developed that correspond to logical principles related to qualification, measurement, and modeling [8].

According to D'Ambrosio, *ethno* affixes describe all the phenomena that make up cultural identity grouped into languages, codes, values, dialects, beliefs, food, and clothing as well as customs and behaviors [9]. Whereas the word mathematics describes a broad view of mathematics including calculation or solving, arithmetic, classification, sorting, decision-making, and modeling. So ethnomathematics is a way of using mathematics by different cultural groups. Therefore, ethnomathematics actually grows and develops from the culture that exists in a group of people, but people do not realize that they use mathematics. Ethnomathematics

recognizes that there are different ways of doing mathematics by considering the acquisition of mathematical academic knowledge developed by different sectors of society and taking into account the different modes in which different cultures negotiate their mathematical practice[10]. The use of mathematics is used in everyday activities such as farming, trade, and art which are often considered part of tradition or practical skills, even though they have indirectly applied complex mathematical concepts [11].

[6] D'Ambrosio put forward the philosophy of pedagogy in ethnomathematics, that said ethnomathematics is a research program in the history and philosophy of mathematics, with pedagogical implications, which focuses on the explanation of arts and techniques as well as understanding and organizing (mathema) in various socio-cultural contexts (ethno). The ethnomathematical approach enriches students' understanding of mathematical concepts by integrating the use of mathematics found in everyday life into classroom learning [12]. This can allow learners to see the relevance of mathematics in their own cultural context, so they will be more motivated and able to relate abstract concepts to real experiences. This is in line with other opinions that state that through a mathematical approach, mathematical practices from learners' cultures and other cultures can be utilized [13]. In this way, learners can see how mathematical concepts are applied in various cultural contexts so that learners better understand the relevance and usefulness of mathematics in everyday life and appreciate the wealth of knowledge from different cultures.

Ethnomathematics intended in this study is a mathematical activity that develops in Gorontalo society, especially in Tapa Village which includes mathematical concepts on cultural relics in the form of Karawo embroidery cloth patterns. Karawo has been known by the people of Gorontalo since the 17th century and is only practiced by certain women. Karawo embroidery craft is a cultural asset in Gorontalo Province that has received recognition from the government of the Republic of Indonesia. This craft deals with skills in embroidery thread. Embroidery techniques are carried out by removing or plucking several strands of thread from certain fabrics by following pre-prepared motifs or designs [14].

Karawo art is a technique to form ornaments or ornamental varieties on textiles or fabrics. Karawo art products in the form of ornaments on cloth called Karawo ornaments and fabrics decorated with Karawo ornaments are called Karawo fabrics, which means fabrics that are given Karawo ornamental motifs. In general, Karawo fabric has motifs inspired by nature and geometric shapes. In general, Karawo motif designs are grouped into 4 types, namely: geometric motifs, fauna motifs, flora motifs, and natural motifs, and further develop new motifs that appear based on local wisdom [15]. The main elements of Karawo Gorontalo art are more determined by color, plane, combination of lines and points, and texture.

The relationship between Karawo and mathematics can be seen from the fabric motif that is identical to geometry. Looking at the diversity of motifs in traditional Karawo fabric, it can be a very efficient approach for teachers to apply mathematics, especially to transform geometry material. There are two types of isometric transformations, namely facing isometric transformations and direct isometric transformations. Translation and rotation belong to the group of direct isometric transformations while facing isometric transformations include dilation and reflection [16]. Students cannot understand abstract geometric concepts. Ideally, learning geometry involves familiar and available geometric shapes[17]. The ability to analyze in the case of Karawo cloth is expected to be a bridge for students to be able to improve reasoning and problem-solving in mathematics, especially transformation geometry material, and can preserve their respective regional cultures with ethnomathematics. In light of the aforementioned background, research was conducted to explore mathematical practices in cultural groups, or what is commonly referred to as ethnomathematics. This research focused particularly on the traditional fabric of Karawo Gorontalo and its relationship with the mathematical concept of transformation geometry.

2. RESEARCH METHODS

This research is included in the type of exploratory research, which explores the shape of the Karawo pattern that can be utilized in the process of learning transformation geometry. Whereas the approach used in this study is an ethnographic approach, namely an empirical and theoretical approach that aims to obtain an in-depth description and analysis of culture based on intensive field research.

In this study, researchers used qualitative research with an ethnographic approach. Ethnography is used to describe, explain, and analyze the cultural elements of a society or ethnic group. As qualitative research with an ethnographic approach, this research instrument is a human instrument, where researchers act as the

main instrument that cannot be replaced/represented to others. In this case, researchers are directly related to research and act as data collectors through library data collection, interviews, observations, and documentation. The study was carried out with the following procedure.

a. Study of literature to support research
b. Determining the list of interview questions
c. Conducting interviews with Karawo craftsmen
d. Data were analyzed using Spradley's domain analysis method, where the results of interviews with Karawo artisans were identified and grouped, and supplemented with findings from the literature study.

3. RESULTS AND DISCUSSION

3.1 Karawo Gorontalo Embroidery Craft

The original craft from Gorontalo is an openwork craft, commonly called Karawo which is a culture that exists today and makes Karawo its characteristic. The term Karawo is taken from the word "moKarawo" which means to punch holes or slice. The manufacturing process requires patience, accuracy, and foresight because the manufacturing process still uses humans without machine technology (handmade masterpieces), ranging from designing, slicing fabric, and pulling yarn, to embroidering it **[18]**.

Based on historical records of mo-Karawo art or Karawo embroidery art, Gorontalo has existed since the 1600s long before the Dutch ruled in the area, where the Dutch controlled Gorontalo precisely in 1889. When the Dutch came to control this area, they tried to eliminate this Mo-Karawo Tradition. However, Gorontalo women at that time managed to maintain this Gorontalo culture. Initially done only as a side job, Karawo Craft is able to develop dynamically from time to time. This embroidery is usually applied to women's clothing, men's cocoa clothes, mukenah, hijab, pouches, handkerchiefs, tablecloths, ties, and so on **[19]**.

The Mo-Karawo process requires tools and materials, which include cloth, special threads, clamps, razor blades, and needles for embroidery as in **Figure 1**. Not just any cloth can be embroidered Karawo there are several types of fabrics that are widely used including Toyobo fabric, Kin Jaroti, ero cloth, sipon cloth, and other clothes pliers that have a soft texture and are not too thick.

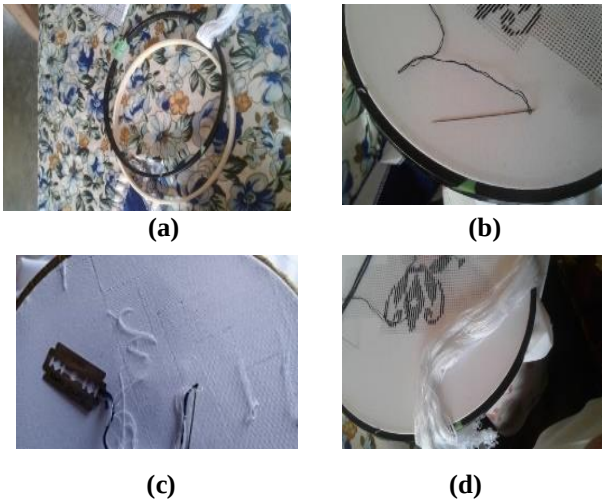

Figure 1. Tools and Materials for Making Karawo Embroidery, (a) Clamping, (b) Needle, (c) Razor, (d) Thread

In the process of making embroidery or commonly called Mo-Karawo, craftsmen must follow the embroidery stages from the beginning of thread removal until it becomes a perfect Karawo motif. At this stage of Karawo embroidery or Mo-Karawo has several stages as follows:

3.1.1 Making Patterns or Seeing Karawo Embroidery Patterns

This process is the initial process of paying attention to what patterns will be embroidered and how the picture will be later in the process of immersion. This process is shown in **Figure 2**. This process is related to the next process, which is slicing and pulling out the thread.

Figure 2. Depiction of the Pattern to be Embroidered

3.1.2 Slicing and Plucking Thread

The next stage is from the previous stage where after measuring the part to be sliced according to the existing pattern, the next stage is irrigating and pulling out the thread to produce holes that will later be embroidered to slice and pull this requires a calculation **Figure 3**. where 1CM = 5 holes and must be aligned to produce a balanced and perfect embroidery.

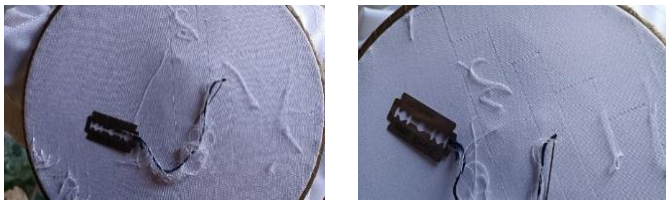

Figure 3. The Process of Slicing and Plucking Thread

3.1.3 Stages of Embroidery

This process is the Mo-Karawo process which is embroidery where this process is carried out by embroidering an existing design pattern. For the cultivation of this Karawo, it takes a varied time between 2-7 days haunted by the level of motive difficulty. This stage includes the completion stage, which is to do embroidery on the empty part.

3.2 Ethnomathematical Exploration of Traditional Fabrics Karawo Gorontalo Material Concept of Transformation Geometry

Based on the results of data collection on Karawo embroidery patterns in *Pilohayanga* production houses, there are several mathematical concepts, especially transformation geometry. The ethnomathematics in the Karawo Gorontalo traditional cloth pattern motif is presented in **Table 1**.

Table1. Ethnomathematical Exploration of Traditional Fabrics Karawo Gorontalo Material Transformation Geometry Concept

Concept	Motifs On Fabrics	Explanation
Translation		The translation of motifs that serve to frame a similar motif is achieved by paying attention to the distance between them to create a collection of motifs.
Reflection		The reflection of two embroideries creates a motif that is both aesthetically pleasing and conceptually coherent.

Concept	Motifs On Fabrics	Explanation
Rotation		Rotation of the part of the motif that produces the floral motif.
Dilation		Dilation or enlargement of the scale of a rhombus-shaped motif.

To clarify the application of the basic concept of Transformation Geometry we can see the following illustrative explanation:

3.2.1 Translation

A Karawo embroidery pattern is shown below for a visual image. If we follow the pattern in the middle, we will see a considerable shift. For example, pattern in **Figure 4** we slide it to the right as far as 5 units and 5 units up. Try sketching the movement of the pattern in the Cartesian plane. Can you find the process of movement of pattern movement?

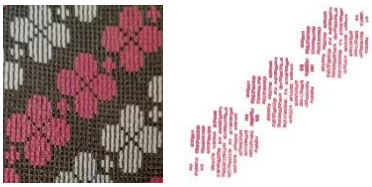

Figure 4. Karawo Embroidery Pattern

To make it easier to understand the concept of translation we can use the Cartesian field approach. We can assume that the shift to the right in the cartesian plane is a positive x-axis, the shift to the left is a negative x-axis, the upward shift is a positive y-axis and the downward shift is a negative y-axis.

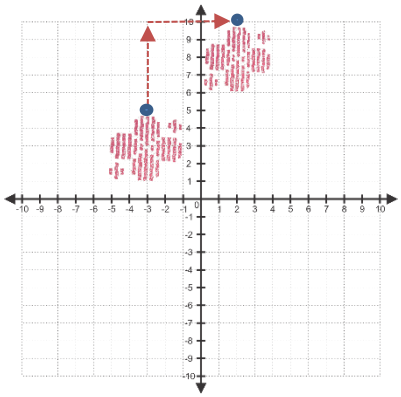

Figure 5. Illustration on a Cartesian Diagram

If we look at the initial position of the Pattern in the Cartesian plane is at one of the coordinates $x = -3$ and $y = 5$. After that, the embroidery pattern shifts up 5 in the plane of Cartesius. Then shift to the right 5 units in the Cartesian plane after that we can see the coordinate point moving at the coordinates $x = 2$ and $y = 10$. This means:

$$\begin{pmatrix} -3 \\ 5 \end{pmatrix} + \begin{pmatrix} 5 \\ 5 \end{pmatrix} = \begin{pmatrix} 2 \\ 10 \end{pmatrix}$$

So, the Pattern Position is now at the coordinates $x = 2$ and $y = 10$.

3.2.2 Reflection

There is a pattern in Karawo embroidery as shown in the original picture below. When observed there is a process of mirroring or reflection on one of the patterns on the side. Then we will get an illustrative shape using auxiliary lines as the reflecting p-axis.

Figure 6. Karawo Embroidery Pattern

Other performances can also be seen in the pattern of **Figure 7** with the application of reflection adapted to the x-axis with illustration as follows:

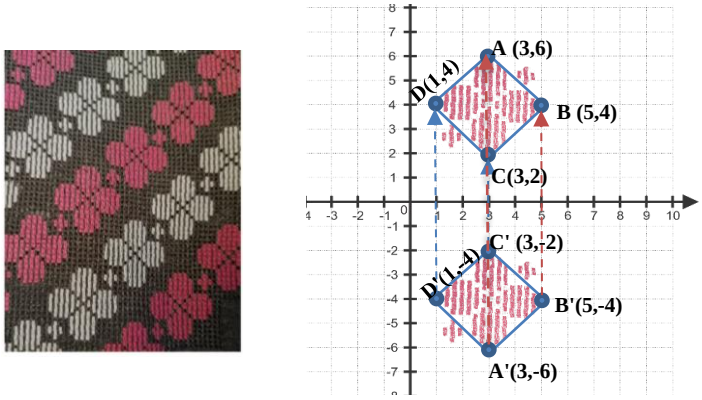

Figure 7. Reflection Illustration of the X-axis

We will discover the concept of mirroring the x -axis by observing the mirroring of the Karawo pattern framed with the ABCD rhombus in the figure above. How does the image of the rhombus ABCD after being reflected against the x-axis? We can see that the rhombus A'B'C'D' is the result of the shadow of the ABCD rhombus after being reflected against the x-axis at the cartesian coordinates.

3.2.3 Rotation

Look at the picture below where in the pattern contained in **Figure 8** we can also apply the concept of rotation where we take one of the elements of the pattern and rotate it. In the example below the pattern is rotated at an angle of 90◦ to the center point $O(0,0)$.

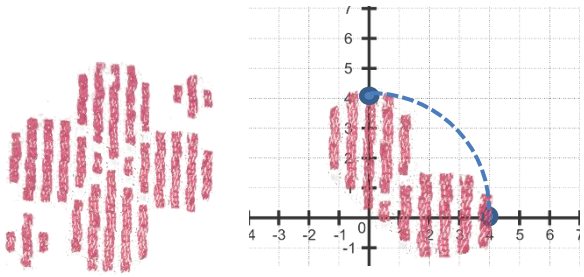

Figure 8. Rotation Illustration Image

3.2.4 Dilation

In dilation, we can observe the following Karawo pattern where there are several rhombus-shaped patterns that undergo dilation. Next, we suppose the cartesian diagram using a rhombus.

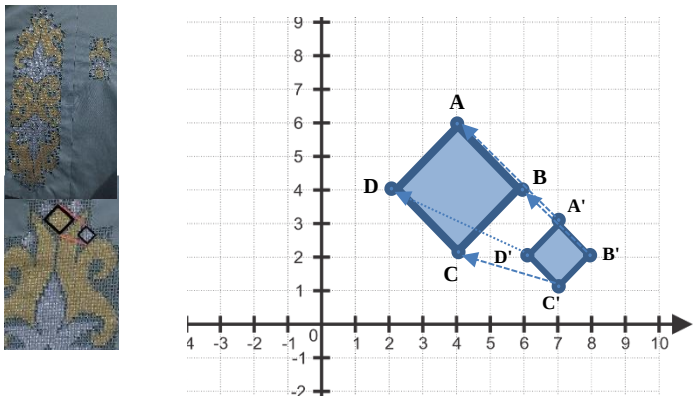

Figure 9. Illustration of the Application of Dilation

If we observe the ABCD rhombus in the picture above, the ABCD rhombus will get bigger with a multiplication scale of 2. Then, the distance OA′ is twice the distance OA, the distance OB′ is twice the distance OB, the distance OC′ is twice the distance OC, and the distance OD′ is twice the distance OD.

4. CONCLUSIONS

The results of the research indicate the presence of ethnomathematical elements in the patterns of Karawo Gorontalo embroidery. Consequently, the following conclusions can be drawn, the presence of ethnomathematics in the production of Karawo traditional fabric embroidery is exemplified by the application of the concept of transformation geometry. This is evidenced by the presence of several motifs that result from the application of the concept of transformation geometry in the forms of translation, reflection, dilation, and rotation.

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