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Ethnomathematics: Exploration of Geometric Concepts in Traditional Paintings and Carvings of Teluk Ampimoi Kepulauan Yapen, Papua, Indonesia, as a Source of School Mathematics Learning

Martinus Y. Ruamba[a], Happy Lumbantobing[b*], Ronaldo Kho[c], Bettisari Napitupulu[d], Ida Mariati Hutabarat[e], Jonner Nainggolan[f], Irfan Wahyudi[j], Citra Ratna Napitupulu[h], Mindo H. Sinambela[i]

[a,b,c,d,e,f,j,h,i]*Postgraduate Master Program of Mathematics Education, Faculty of Teacher Training and Education, University of Cenderawasih, Jayapura, Indonesia*

[e,f,j]*Department of Mathematics, Faculty of Mathematics and Natural Sciences, University of Cenderawasih, Jayapura, Indonesia*

[h,i]*Department of Mathematics Education, College of Teacher Training and Education Abdi Wacana, Wamena, Indonesia*

[a]*Email:marthinusruamba94@gmail.com,* [b]*Email:happytobing1968@gmail.com,*
[c]*Email:ronaldoankho@gmail.com,* [d]*Email:napitupulubettisari@gmail.com,* [e]*Email:ida_mariati@yahoo.com,*
[f]*Email:jonner2766@gmail.com,* [j]*Email:irfanwahyudi2408@gmail.com,*
[h]*Email:citranapitupuluratna@gmail.com,* [i]*Email:mindo261085@gmail.com*

Abstract

This research explored the mathematical concepts contained in the traditional paintings and carvings of Teluk Ampimoi Kepulauan Yapen, an indigenous district in the Kepulauan Yapen Regency, Papua, Indonesia, that can be used in school mathematics instruction and learning. Ethnographic research with an ethnomathematical research model was used. Data was collected using participant observation and in-depth interview techniques and was analysed using taxonomic, domain, and ethnographic methods.

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* Corresponding author.

The results showed that the various forms of traditional paintings and carvings of Teluk Ampimoi, Kepulauan Yapen exhibit mathematical concepts in the form of geometry, namely plane geometry and transformation geometry and approximation, namely, measurement. Based on the taxonomic analysis, it was found that the geometric concepts can be integrated with mathematics learning in schools in the field of geometry concerned with the properties, perimeter, and area of rectangles, parallelograms, and triangles. In addition, the geometric transformation contained in the items related to reflection.

Keywords: ethnomathematics; painting; carving; geometry; reflection; approximation.

1. Introduction

Learning in schools aims to transfer knowledge and explore new knowledge. Exploration of new knowledge aims to develop knowledge itself in order to improve human life. This needs to be done in learning mathematics, where learning mathematics must be related to life and culture. This is because the development of mathematics learning is inseparable from the influence of the human social and cultural environment, [4,9]. Mathematics learning must be more contextual and more meaningful for students' students to make these mathematical lives. Therefore, the learning needs to be designed to involve culture and things that exist in the life around concepts more easily understood by students, [11].

Currently, there is a growing focus on developing mathematics education that is culturally relevant. This has started from the concept of learning mathematics using ethnomathematics introduced by [4]. Ethnomathematics shows how cultural outcomes and interactions in daily activities are analyzed and used to construct mathematical concepts and ideas. This is consistent with the contextual and scientific learning approaches.

Ethnomathematics accords with learning that is based on strengthening student character, because it can increase affection for local wisdom, regional culture and national culture values. Ethnomathematics tries to link noble values in culture with mathematical concepts. Ethnomathematics-based mathematics teaching seeks to investigate local culture in order to connect mathematics in schools with issues relevant to students' daily lives. Thus, students become more interested in learning mathematics and can more easily understand mathematical concepts. In addition, ethnomathematics can foster self-confidence and nationalism.

Some of the results of research related to ethnomathematics in Indonesia are as follows: Puspadewi and Putra [10] studied the geometry concept of weaving craft transformation. Marina and Izzati [8] investigated the concept of symmetry and circle in Marawis musical instruments. Prahmana and D'Ambrosio [9] conducted research on geometry learning through batik patterns. Umbara, Wahyudin and Prabawanto [14] conducted an ethnomathematical research related to determining a good day to build a house in the Cigugur community. In particular, there are several studies related to ethnomathematics in the Papua region, including Ubayanti, Lumbantobing and Manurung [15] who studied ethnomathematics in the sero (set net) culture of the Kokas Fakfak community in West Papua. The focus of the fishermen's activities observed were counting, measuring, designing the construction of the sero, and determining the location of the sero in catching fish. Further, Dumatubun, Kho and Napitupulu [6] conducted research on the exploration of ethnomathematical rules on the

bark painting of the Asei community in Sentani Papua as a source of school mathematics learning. Recently, Kho and Siep [7] investigated the ethnomathematics of the Dani tribe in the Baliem Valley, Wamena Papua. They explored the three-dimensional geometric ideas contained in the design of the traditional house of the Dani tribe.

Ethnomathematically, the cultural products of Papua's tribes, such as paintings and carvings, as well as traditional house structures, are extremely rich. However, until now there is still very limited research exploring ethnomathematics associated with such cultural goods. There is no published ethnomathematical research investigating traditional paintings and carvings of Teluk Ampimoi Kepulauan Yapen. Therefore, this study aims to explore geometric concepts in the traditional paintings and carvings of this indigenous district. The findings of this study are expected to be beneficial to mathematics teachers in developing learning materials or compiling textbooks, as well as in utilizing local culture as a source of mathematics learning in schools.

2. Research Methods

A qualitative research with an ethnographic model was chosen since the purpose of ethnomathematical research is to analyze ideas, concepts, procedures, and processes in the culture of a certain civilization through the perspective of its original members [1, 4]. The research procedure was carried out by setting research subjects in a situation where they were not intervened or treated. The researcher acted as a participant observer in this case.

Data was collected through field studies, observation and conducting interviews with informants. The selection of informants was carried out purposively, namely selecting traditional leaders from Teluk Ampimoi who were considered to be key informants.

The informant selection criteria were based on those employed by Umbara, Wahyudin, and Prabawanto [14], with modifications, as follows: (1) Informants are well-versed in the culture and customs of Teluk Ampimoi's indigenous people; (2) Informants are familiar with and comprehend the paintings and sculptures of Teluk Ampimoi's indigenous people; (3) Informants are willing to spend adequate time and supply necessary information, and (4) Informants can provide complete information.

Data was collected directly with an audio recorder and a camera through participant observation and an in-depth interview. Researchers performed participant observation by direct engagement in the natural situation. Furthermore, in-depth interviews were conducted to investigate informants' ideas, opinions, and experiences, [5].

Research data from observation and interview in the form of field notes, photos, audio and video recordings were analyzed using the content analysis technique and triangulation of data sources, and finally described to explore each finding. The content analysis technique presents detailed data on the culture of painting and carving, and the habits of the research subjects conducted at the research site. The observation technique is carried out by deep search of the mathematical concepts in the traditional painting and carving picture designs of Teluk Ampimoi. In addition to these analytical techniques, taxonomic, domain, and ethnographic analyses were also carried out.

3. Results and Discussion

This research was conducted in the Teluk Ampimoi, District Kepulauan Yapen. Ampimoi is one of the 11 villages in the Kepulauan Yapen Regency in Papua, Indonesia. This region's population is made up of diverse tribes with distinct cultural values. So, even though they are in the same area, the cultural values of these people are very unique and different. The information extracted in this research is in the form of information about (a) the culture that is still preserved by indigenous people in the Teluk Ampimoi, (b) the values of the paintings or carvings of the people in the Teluk Ampimoi, (c) the media of paintings and carvings, tools and materials used for painting and carving, (d) painting and carving processes, (e) forms of painting and carving and their meanings.

- Ethnographic Analysis

The results of data analysis obtained in the field provide an overview of data related to community activities in the Teluk Ampimoi area as follows:

(a) Cultural products that are still preserved in the indigenous people of the Teluk Ampimoi are noken (*rotang*), ornamental boats, war boats (*masisu*), tifa (*fikaninot*), stabbing tools commonly used to catch fish (*aringgoya*), traditional houses (houses with roofs made of wood, sago leaves and walls made of bobo leaves), sero (*je faya* and *je ampehei*), tools for giving information (*tubura*) made of large seashells, arrows and bows (*afai* and *ato*), paddles (*bo*), bamboo combs, tools for drains water from the boat and is made of sago midrib (*waikiri*), a tool for stirring sago into papeda (*daru*), and buckets (*korondami*).

(b) The values of paintings or carvings of the indigenous people of Teluk Ampimoi contain treasure that is considered very important by them. People who understand and can carry out painting or carving activities are seen as people who know about custom, family tree, lineage and rights to customary land.

(c) Containers or places that are often used for carving or painting are areas that are most often seen by the general public such as decorative boats, house walls, house poles, entrance gates, bamboo combs, oars, rowing boats, and motorboats.

(d) The tools and materials used for painting or drawing depend on the type of media used. For surfaces such as walls, the tools and materials used are paints and brushes. When the media is in the form of wood whose texture is not hard, the material used for carving is a small knife.

(e) Painting and carving techniques are typically modified according to the type being produced. There are paintings and carvings that are made personally, for example painting or carving at home as decoration and are usually done without a time pressure. There are paintings and carvings created during a competitive event to liven up special days. Paintings and carvings carried out during competitions are usually accompanied by cultural songs (*anuay/rayato).*

(f) The form of paintings and carvings and their meanings: The types of paintings or carvings found in the indigenous people of the Teluk Ampimoi are embossed. The types of carvings consist of female carvings and male carvings. The female are usually painted in a square-shaped picture design and the position of the carving is always in the middle. Meanwhile, male carvings occur in a triangular shaped

picture design with the make always on the edge of the carving/painting picture design.

- Domain Analysis

Ethnographic analysis of the observed objects revealed the mathematical concepts that inform in the process of making the forms of painting and carving picture designs. The results of the domain analysis are presented in Table 1.

Table 1: Domain Analysis.

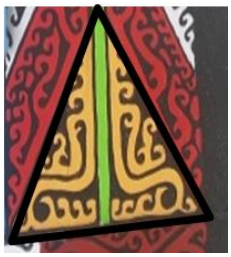
Domain	Linkages	Ethnomathematics
Measurement	The process of making picture designs	In making picture designs for the carving process, no definite measuring tool is used, but the engraver only uses feelings such as estimating, imagining, and adjusting . -
Painting and carving	Patterns and carvings	The types of carvings can be found in various media or places including ornamental boats, tifa, house walls and house pillars/gates.

- Taxonomy Analysis

After doing the domain analysis, the next step is taxonomic analysis. Taxonomic analysis is generally carried out to obtain a general and comprehensive picture of the social situation being studied or the object of research [13]. The result is a general description of the object under study, which had never been known before. In this analysis, the information obtained is not in depth, but has found the domains or categories of the social situation under study. The following are the results of a taxonomic analysis based on picture designs from carvings or paintings found among indigenous people in the Teluk Ampimoi.

Table 2: Taxonomic Analysis.

Geometric Concepts	Ethnomathematics
Rectangle	 Shape: Rectangle Position: Some picture designs on the gate and the walls of the house

Triangle	 Shape: Triangle Position: Home wall picture design
Parallelogram	 Shape: Parallelogram Position: Home wall picture design
Reflection	 Shape: Reflection Position: House wall picture design and tifa
Fractal	 Shape: Fractal Position: Wall picture design, decorative boat

- Ethnomathematical Exploration of Traditional Paintings and Carvings of Teluk Ampimoi

The results of the study show that paintings and carvings are one of the many cultural objects that are still preserved by indigenous people in the Teluk Ampimoi. For the indigenous people of the Teluk Ampimoi, carving is a treasure, meaning that it is very important. Those who understand and can paint or carve are seen as people who know about custom, about family tree, and about customary land rights. Carving and painting

activities in this context are only carried out by persons who genuinely understand the Teluk Ampimoi's traditional customs. According to local beliefs, poor carving or painting might result in unpleasant occurrences or repercussions in life.

Paintings and carvings discovered among the Teluk Ampimoi indigenous people are in the form of paintings and embossed sculptures, usually consisting of female and male carvings. Female carvings are usually painted in a square-shaped picture design with the carving in the middle. The male carvings are in a triangular-shaped picture design with the male carving always on the edge of the design.

The procedure of coloring must be done appropriately in order to make an appealing impact on the observer or those who look. A successful coloring technique may convey the equality of positions between men and women while also making a beautiful impression.

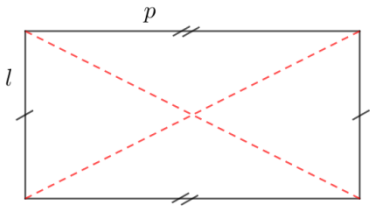
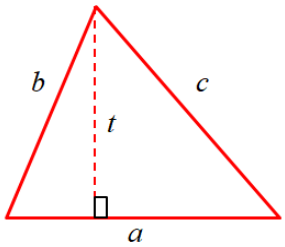
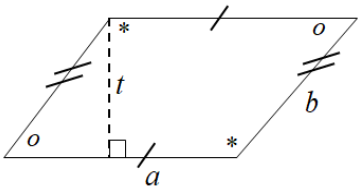
Investigations of paintings and sculptures revealed that these cultural artifacts include ethnomathematical elements connected to the concept of geometry. In addition to geometric ethnomathematical concepts, it was discovered that the non-standard measurement system is still used by the indigenous people for estimation, visualizing, and adjusting. This non-standard measurement activity is connected to the idea of approximation or estimation.

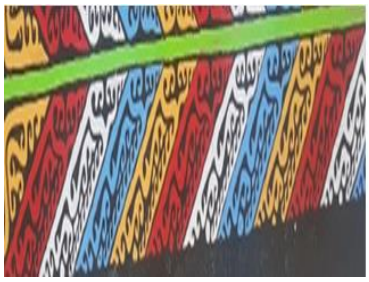
- Teluk Ampimoi traditional paintings and carvings as a source of school mathematics learning

The ethnomathematics related to the concept of geometry, applicable in school mathematics instruction, in the paintings or carvings of indigenous people in the Teluk Ampimoi area are as follows:

Table 3: Geometric Concepts in Traditional Paintings and Carvings of Teluk Ampimoi.

Observation of painting or carving	Geometric concepts	Ethnomathematics
 Shape: Rectangle Position: Several picture designs on the road gate and the wall	Rectangular	Some of the painting or carving picture designs found on the arches and walls of houses are rectangular. A rectangle is a quadrilateral with four right angles and opposing sides that are the same length and parallel. The properties of a rectangle include: 1. The opposite sides are the same length and parallel. 2. The four corners are right angles. 3. The diagonals are the same length and divide the area of the rectangle in two equal parts. The formula for the area (L) and perimeter (K) of a rectangle is $L = p \, x l$ and K = 2 x ($p + l$) , where p is the length and l is the width.

		
 Shape: Triangle Position: Picture design on the wall of the house 	Triangle	Some of the carving picture design found on the walls of the house contain elements of geometry, namely triangles. A triangle is a flat geometry with three sides and three vertices that sum up to180^{o}. The formula for the area (L) and perimeter (K) of a triangle is L =$\frac{1}{2}$ $x\ a\ x\ t$ K = a + b + c, where a is the base, t is the height, and b, c are the other triangle sides
 Shape: Parallelogram Position: Home wall picture design 	Parallelogram	Several picture designs that contain carvings are found on the walls of the house and contain elements of geometry, namely parallelograms. A parallelogram is a flat form with two pairs of parallel and equal sides and two pairs of opposing and equal angles. The formula for the area (L) and perimeter (K) of a parallelogram is L = $a\ x\ t$; K = $2\ x\ (a + b\ )$, where a denotes the base, b the hypotenuse, and t the height

 Shape: Reflection Position: Home wall picture design, tifa, gate	Reflection	Some of the carving or painting picture designs available on the walls of the house and tifa contain transformation geometry, namely reflection. Reflection is a geometric transformation that moves a point or object on a geometric shape by utilizing the qualities of the item and its image on a plane mirror. The item being reflected does not change shape or size due to reflection. The object distance from the mirror is the same as the image distance from the mirror.
 Shape: Fractal Position: Home wall picture design and on the front of decorative boats	Fractal	Some of the picture designs that contain carvings on the walls of the house contain elements of geometry, namely fractal. Fractal is any of a variety of exceedingly irregular curves or forms in which any correctly chosen section, whether magnified or decreased to the same size, has a shape comparable to a particular bigger or smaller part.

Based on the analysis above, the mathematical elements contained in the carvings of indigenous people in the Teluk Ampimoi are flat shapes (rectangles, triangles and parallelograms), transformation geometry (reflection) and fractal geometry. There are other mathematical elements that have not yet been properly identified. In addition to the concept of geometry, there is the concept of approximation in the process of design of paintings and carvings. These ideas must be included into classroom mathematics instruction. Thus, learning mathematics is combined with culture, which can bring benefits for the preservation of national culture and the creation of student character.

Incorporating local cultural understanding into mathematics instruction makes it simpler for students to comprehend mathematical ideas because they learn directly from the outcomes of the culture around them. Furthermore, instructors may readily impart noble cultural ideals that have a direct influence on character education [16].

Integrating ethnomathematics with appropriate learning models and materials can help students enhance their mathematical communication abilities, critical thinking skills, and mathematical literacy skills [2]. In addition, ethnomathematics is mathematics that is applied and used by certain cultural groups.

This is consistent with Sirate [12], who suggested that using ethnomathematics to encourage and engage students can help them overcome boredom and challenges in studying mathematics. We maintain that the inclusion of ethnomathematics into the mathematics learning process would become an additional benefit for students learning mathematics at all levels, from elementary school to higher education.

4. Limitation

This research focuses on the exploration of geometric concepts in traditional paintings and carvings of Teluk Ampimoi, Kepulauan Yapen. However, there may still be other mathematical concepts contained in this cultural heritage. Therefore, further study is required.

5. Conclusions

Geometric concepts from an ethnomathematical analysis of the paintings and carvings of the indigenous people of the Teluk Ampimoi area are found in the picture designs in paintings and carvings on the walls of houses, on the front of decorative boats, road gates and tifa. The mathematical notions discovered are especially connected to geometric concepts that may be applied to classroom mathematics curriculum, such as rectangles, triangles, parallelograms, geometric transformations such as reflection, and fractal geometry.

In addition to the notion of geometry, the concept of approximation or estimation may be found in paintings and sculptures. This is visible in the creation of painting and carving themes that do not employ standard measurement equipment. Painters and carvers only feel, guess, or envision the scale of the painting or carving that will be created.

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