Ethnomathematics in *Boti* tribe culture and its integration

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Abstract. The development of ethnomathematics is an indication of an increase in awareness of the importance of learning mathematics in culture and involves cultural aspects in mathematics learning in schools. As one of the ancient tribes in Timor, *Boti* Tribe is almost unapproachable by the modern culture. Learning mathematics based on *Boti* culture will help students learn mathematics realistically and also introduce *Boti* culture to more people. The present research claims a qualitative approach with an ethnographic design that aims to explore the mathematical elements found in the culture of *Boti* Tribe. The subject of this research is the *Boti Dalam* Tribe, which implements *Boti* cultural traditions in everyday life. The objects examined in this study are the calendar of *Boti* Tribe, *lopo*, and the typical woven fabric of *Boti* Tribe. The results show that the concepts of numbers and their operations, geometry, and algebra are apparent in the culture of *Boti* Tribe. Also, mathematical skills such as representation, spatial, making connections, and problem-solving skills can be developed based on mathematical elements in *Boti* Tribe culture. This study can be used by teachers to create innovative mathematics learning models using ethnomathematics approaches based on *Boti* culture.

1. Introduction

The idea of culture-based mathematics learning shows the importance of involving culture in learning mathematics in schools [1]. Students come from various communities with certain cultural characteristics and will return to their respective communities to apply the knowledge they gain in school. Familiarising students with their local culture and utilizing it as a source of values will help them embrace the Indonesian character as a cultured nation [2,3].

One of the approaches that emphasize the exploration of local cultural elements and their integration in learning mathematics in schools is ethnomathematics. Etymologically, the term ethnomathematics comes from Greek. *Ethno* refers to the socio-cultural context; *mathema* which means understanding, working or explaining; and *techne* (which later turns into *tics*) which means technique or method. These three terms are then synthesized by D’Ambrosio into ethnomathematics and formulated as ways or techniques for learning, understanding, working, and/or overcoming problems in the socio-cultural context [4–6].

Ethnomathematics requires a dynamic interpretation because it describes two dynamic concepts: *Ethno* and mathematics [7]. Ethnomathematics can be understood as mathematical concepts applied in cultural groups that include mathematical ideas, thoughts, and practices that develop within these various communities and are sometimes being implemented without the awareness of the community itself [8–10]. Ethnomathematics serves as a bridge between culture and mathematics which helps revealing various ways of thinking in a society that produces mathematics [11,12].

Timor ethnic group as one of the major ethnic groups in East Nusa Tenggara has various tribes and cultures. One of them is the *Boti* tribe, an ancient tribe of Timorese origin, *Atoin Meto*, from the Dawan
Luar community. Geographically, the Boti tribe lives in Kie Subdistrict, South Central Timor District, precisely in the Boti area which is located approximately 60 km east of Soe City. This tribe is divided into two, namely Boti Dalam Tribe and Boti Luar Tribe. Boti Dalam tribe has its area bounded by wooden fences and is located on a hillside at an altitude of approximately 1500 m above sea level [13].

Even though several studies relating to Boti Tribe have been previously conducted, ethnomathematics, however, has not been the focus so far. The research of Boti Tribe by Jayanti [14] is more focused on the existence of Boti culture in the present era and shows that Boti Tribe consciously resists globalization. Concerning cultural acculturation, Boti Dalam Tribe is far less approachable by outside cultures compared to Boti Luar Tribe that has experienced cultural mixing. They consistently try to minimize the access of other cultures entering their community so as not to affect the cultural order and native life of Boti people. In the field of education, Sandiningtyas and Wiyono [13] conducted a case study research to investigate the practice of local cultural education in SDN-SMPN Satu Atap Oefau, the only school in the Boti Village. The study shows that schoolchildren in Boti Village are taught about local customs and are always actively involved in various socio-cultural activities in Boti Village. This shows that Boti culture is a part of the daily life of Boti children.

Geographically, Boti Village is located on Kie District, South Central Timor Regency, approximately 60 km east of Soe City. Because of its location which is difficult to achieve and its cultural characteristics, the Boti community often has difficulty in obtaining information from outside, especially about education. To help students in the Boti Village learn mathematics, one way that can be done is to involve the daily culture of the Boti tribe community in learning conducted at school. Boti Tribe culture-based mathematics learning will provide a different learning experience for students. This will increase students’ curiosity when learning and foster self-confidence [15]. Moreover, Boti Tribe culture-based learning can also help students to embrace and love their own culture [16]. To achieve this, it is essential to explore the mathematical elements present in Boti Tribe culture. Teachers will later use the results of this study in developing mathematics learning models based on Boti culture.

2. Method
This is qualitative research with an ethnographic design that aims to explore the mathematical concepts present in Boti Tribe culture. The research design used refers to the ethnomathematics research, which is based on four general questions: 1) Where is it to look? 2) How is it to look? 3) What is it? 4) What does it mean? [17–20] [20]. This research begins with a literature study related to the location of the Boti tribe, its culture, and the daily life of its people. From this preliminary study, the Boti Dalam tribe in Boti Village was later chosen as the subject of research because it is less approachable by the modern culture and still maintains the original cultural practice of Boti Tribe until now. Furthermore, the Boti tribe calendar, Lopo (traditional house), and woven fabrics assumed to bear mathematical concepts were used as the objects of the study.

Direct observations were carried out in-depth in the Boti Dalam area together with Usif Boti (King of Boti) and cultural practitioners in Boti Tribe. The observations data was then collected and analyzed which focused on QRS aspects (Quantitative, Relational, and Spatial realities). At this stage, mathematical practices and concepts produced by Boti Tribe culture were identified based on the justification of previous observations. Once identified, mathematical practices and concepts in Boti Tribe culture were then linked to mathematics as a science. This has a role in bridging mathematics as a field of science and the mathematical concepts found in Boti Tribe culture.

3. Result and Discussion
Boti Tribe is one of the ancient tribes in Timor island. It is an exclusive community that holds on to its cultural heritage and almost unapproachable by modern culture. Based on the observations conducted in Boti Tribe culture regarding mathematical concepts, the present study focuses on the traditional calendar, lopo, and weaving motifs typical of the tribe.

3.1. The Boti Traditional Calendar
The Boti tribe has a nine-day calendar system: 1) Neon Ai, which is a good day to carry out activities related to fire; 2) Neon Oe is the day on which Uis Oe sends his gift through water used by Boti people;
3) Neon Besi, the day on which iron tools and equipment are made sacred; 4) Neon Uis Pah ma Uis Neno, the day to perform rituals to the God of Earth and the God of Heaven; 5) Neon Suli, which is a good day to resolve disputes in society; 6) Neon Masikat, a good day for communication to strengthen relations between relatives; 7) Neon Naek, a good day to establish friendship and brotherhood; 8) Neon Li'ana, the day on which children are allowed to play with their friends to their heart's content; and 9) Neon Tokos, the day for family gathering which is usually used to find silence and contemplation. Even though they still use the traditional calendar system, now Boti people are also familiar with the modern calendar system (7 days).

To determine the day in the Boti calendar, the concept of arithmetic modulo is used with the smallest number 1, and the largest number is 9. For example, if today is Neon Ai, then 12 days after today which is Neon Uis Pah Ma Uis Neno can be determined by congruent, \(3 \equiv 12 \mod 9\). Thus, the twelfth day is identical to three days after Neon Ai namely Neon Uis Pah Ma Uis Neno. In a mathematical definition, let \(a\) and \(b\) be integers and \(n\) be a positive integer. An Integer \(a\) is said to be congruent with \(b\) modulo \(n\) if the difference between \(a\) and \(b\) is divisible by \(n\), expressed as \(a \equiv b \mod n\) [21]. A similar method is used to determine the day on the modern calendar that also integrates the concept of modulo arithmetic [22]. If today is Monday, then by congruent \(3 \equiv 10 \mod 7\), the tenth day after Monday is the same as the third day after Monday which is Thursday.

Based on these similarities, the Boti tribe has a way to determine the name of the next day on a traditional calendar if the name of the previous day on the modern calendar is known by using representation. Representation ability is an expression of mathematical ideas, whether in writing, pictures, symbols, graphics, etc. as a tool to explore problems or concepts [23]. Mathematically, if the name of the previous day in the modern calendar is located in position \(a\) in the order of the day, while the \(m\)-day on the traditional calendar sought is located in the \(n\)-th cycle of the traditional calendar, with \(n \geq 2, n \in \mathbb{N}\), by using the representation of traditional and modern calendar, then the name of the next day in the traditional calendar can be determined by 1) determining the name of the previous day in position \(a\) in the order of the day on the traditional calendar; 2) finding the remainder value of \(r\) in the modulo operation \(r \equiv m \mod 9\), and 3) determining the name of the day inquired on the traditional calendar that is the \(r\)-day after the \(a\)-day on the traditional calendar.

3.2. Lopo

Lopo is a half-round house where Boti people gather, for example, to listen to the directions given by the King of Boti (Usif Boti) or just for the usual gathering on the ninth day of the Boti calendar. In terms of shape, lopo has similarities to ume kbubu or round-shape houses are often used by the South-Central Timor community as kitchens or food warehouses and heaters (see figure 1). However, it has a gap between the roof tip and the ground. This follows the function of lopo as a gathering place, where easy access for many people at once is essential.

![Figure 1. Lopo in Boti Village - South Central Timor](image)

Traditional home architecture can be used by the teacher as a learning medium, for example, to teach about the flat field, congruence, transformation, and so on [24]. These concepts are also found in Lopo
**Boti.** The base of a *lopo* is built from stones arranged in a circle around the central pillar. This form integrates the concept of a tube. The circumference of the upper surface of the *lopo* base is not a perfect circle because it is made from a combination of *n* triangles made of flat stones. The more triangles on the edge of the base, the more its upper surface resembles a circle (Figure 2). By observing this form, using the concept of infinite limit is obtained:

\[
L_{\text{the upper surface of the *lopo* base}} = \lim_{n \to \infty} n \cdot \frac{1}{2} r^2 \sin \theta = \lim_{n \to \infty} \frac{n}{n} \cdot \frac{1}{2} r^2 \sin \theta = \lim_{n \to \infty} \frac{n}{n} r^2 \sin \theta = \pi r^2 \lim_{\theta \to \pi} \frac{\sin \theta}{\theta} = \pi r^2
\]

**Figure 2.** The Approximate Area of a Triangle at the *Lopo* Base

The roof of a *lopo* is a conical and divided into two parts, namely the outer cone blanket made of reeds and the inside wooden frame to bind the outer layer of the roof. In the observed *lopo*, the roof frame is formed by 44 *suaf* (ribs) that intersect with 25 parallel circles (Figure 3). The total number of *suaf* in a *lopo* must be an even number; otherwise, it is believed that bad things will happen to the owner’s family. On the inside of the roof, five other circles serve as a roof binder onto the *lopo* body (the bottom circle is also used as a place to store food).

**Figure 3. Lopo Roof Framework**

In Figure 3, field *APB* is congruent with field *CPD* because it has a pair of equal angles, that is \(m(\angle APB) = m(\angle CPD)\), and the same side ratio which is \(PA:PC = PB:PD\). Likewise, field *APB* is congruent with field *EPF* because it has a pair of angles that are the same size, that is \(m(\angle APB) = m(\angle EPF)\) and the same side ratio which is \(PA:PE = PB:PF\). This last statement has implications for field APB, which is congruent with field *EPF*. This shows that the shape of the roof frame of the inner
lopo integrates the concept of congruence of two flat shapes. Two planar shapes are congruent if their sizes and forms are the same [25]. The observation of these congruent shapes relates to spatial abilities. Spatial ability as the ability to see the position of objects in space from various points of view, represent them and manipulate them cognitively [26]. It is formed when someone observes various forms of flat or solid shapes, understand it and make the layout for the shape.

In addition to the surface congruence, the concept of arithmetic sequences and series are also integrated into the lopo roof frame, especially in the 25 circles bound to the suaf of the lopo. The size of the circles differs from one lopo to another. The measurement of the diameter length of 25 circles on the lopo roof frame in the Sonaf Boti area/the residence of the Boti Tribe King shows that the length of the diameter of these circles forms the arrangement of numbers which is partly a monotonous sequence (Figure 3). Notice that the length of the diameter of the first eight circles (from below) has a fixed difference of $-0.15$ With the first term of 5.95, the $n^{th}$ term formula for the first eight circles is: $U_n = 5.95 - 0.15(n - 1)$ with $n = 1, 2, 3, 4, 5, 6, 7, 8$. Furthermore, from the form $U_n$ it can be formed an arithmetic series of: $S_n = -0.075n^2 + 6.025n$, $n = 1, 2, 3, 4, 5, 6, 7, 8$.

3.3. Woven Fabrics
Like in any other South-Central Timor areas, Boti Tribe has three levels of woven fabric quality, namely futus (low quality), lotis (medium quality), and buna (best quality). The difference between the woven fabrics of the Boti tribe those of other regions is in its motif. The Boti tribe has a unique weaving motif (Figure 4). This distinctiveness is observable on several patterns totaling nine which are assumed to symbolize the nine days on the Boti calendar. Dominikus [27] based on his research about Adonara’s weaving motif found that the weavers in Adonara applied the concept of transformation geometry such as translation and dilation in the resulting woven fabric motif. Almost similar to that, the woven fabric of the Boti integrates the geometrical concepts such as flat shapes and geometry transformation. The flat shape is integrated into the fabric motif in the form of an array of shapes consisting of triangles and rectangles. Meanwhile, the geometry transformation is integrated into the arrangement of the flat shapes that display the concepts of reflection, translation, and dilatation.

![Figure 4. The Transformational Geometry Concept on Boti Woven Fabric Motif](image_url)
The Timorese motives contained the concepts of reflection, translation, rotation, and dilation [28]. These concepts also appear in Boti’s motifs. In Figure 4, the reflection on Y-axis maps the rectangle $ABCD$ to the rectangle $A'B'C'D'$. The reflection is an opposite transformation because it reverses orientation (the sequence of circumference $A \rightarrow B \rightarrow C \rightarrow D$ is in the opposite direction of the sequence of circumference $A' \rightarrow B' \rightarrow C' \rightarrow D'$). Next, the translation on X-axis maps the rectangle $A'B'C'D'$ to the rectangle $A''B''C''D''$ such that $A'A'' = B'B'' = C'C'' = D'D''$. Meanwhile, the concept of dilatation can be seen in rhombus $MNOP$ which extends as far as $k$ rhombus $M'N'O'P'$ (or vice versa). By representing shapes, colors, and motifs on the Boti’s woven fabric, students can be more interested in learning mathematics. They can identify, compare their shapes and sizes, and learn the concepts of geometry transformation more meaningfully.

Boti culture-based mathematics learning is an example of how mathematics and the real world are connected. Mathematical connection ability is the ability to build a network of knowledge between mathematical concepts with other concepts and the real world [29]. Connections can be established between mathematical concepts, for instance, the concept of algebra can be used to determine the extent to which an extension or contraction occurs (dilatation), or the extent to which rectangle $ABCD$ moves from room $II$ to room $I$ and reflected room $IV$ (transformation composition) when the concept of transformation is applied to the Boti woven motifs (Figure 4).

4. Conclusion
The Boti Tribe is a native of Timorese who has a distinctive culture that incorporates various mathematical concepts. These concepts emerge from the daily life of Boti people who still closely maintain the customs and beliefs of their ancestors. The results of the current study showed that there are at least three mathematical concepts that can be developed based on mathematical elements present in the Boti Tribe culture: the concept of numbers and their operations, geometry, and algebra. Also, mathematical abilities such as representation, spatial ability, connection ability, and problem-solving ability can be developed based on the mathematical concepts present in the tribe’s culture. The results of this study can be used by teachers to develop a mathematics learning model in the classroom. Mathematics learning using ethnomathematics approach based on the Boti Tribe culture will make the learning more innovative and meaningful.

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