Ethnomathematics: Formal Mathematics Milestones for Primary Education

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Abstract. Ethnomatematics is a study of the different ways in which people solve mathematical problems and practical algorithms based on their perspectives. This study refers to various forms of mathematics as consequences which are embedded in cultural activities. Meanwhile, culture-based mathematics learning is one way that is perceived to make meaningful and contextual mathematical learning highly related to the cultural community and will be applied later in harmony with that community, as well as interesting and enjoyable learning. If this is done habituation from an early age will build the character of students. The researcher proposes possibilities for ethnomatematics to engage the curriculum and have a relatively similar role in formal mathematics, namely; (1) substitute for school mathematics; (2) supply for school mathematics; (3) milestones into school mathematics; (4) motivation for school mathematics and (5) as a local content of school mathematics and scheme to develop student’s character.

1. Introduction
Ethno-mathematics is a study of the different ways people solve mathematical problems and practical algorithms based on their own mathematical perspectives [1]. Ethno-mathematics refers to various forms of mathematics as consequences that are embedded in cultural activities. In this perspective Orey asserts, perhaps ethno-mathematics is characterized as a tool to act in the world and thus, provides insight into the social role of mathematics in the academic field. Ethno-mathematics refers to mathematical concepts embedded in cultural practices and recognizes that all cultures and all people develop unique methods for understanding and changing the reality of cultural communities [2]. Ethno-mathematics can be described as a way in which people from certain cultures use mathematical ideas and concepts through quantitative, relational and spatial aspects of society's life.

On the other hand, mathematics is considered as a branch of science. It is identified in cultural activities in traditional and non-traditional societies ([3], [4]). This means that ethno-mathematics refers to mathematical concepts embedded in cultural practices and recognizes that all cultures and all people develop unique methods to understand and to change the reality of society itself [2]. This is reinforced by Rosa and Orey who say that a cultural mathematics program was developed to face the tabulation in which mathematics is a universal and agricultural field of study [4].

Basically, school is a place of culture because the learning process is a civilizing process that is for students' academic achievement, to cultivate attitudes, characters, knowledge, skills and traditions that exist in a cultural community. Culture is an intact pattern of human behaviour and the products produces thought patterns, oral patterns, action patterns, and artefacts. It is highly dependent on one's ability to learn, to convey their knowledge to the next generation through a variety of tools, languages
and patterns of reasoning. Culture is a thing that cannot be avoided in everyday life. It is because a culture is a whole and a whole unit of various manifestations that are produced and or applied in a community. Culture-based Mathematics Learning is one of the ways that it can be perceived to make meaningful and contextual mathematical learning highly related to the cultural community, where mathematics is studied and will be applied later, and with that cultural community, as well as interesting and enjoyable mathematics learning. The learning conditions that allow the creation of contextual meanings based on experience as a member of a cultural society are one of the basic principles of constructivism theory.

The development of ethno-mathematics in relation to mathematics education was put forward by Gerdes and followed by a reflection in ethno-mathematics and mathematics teacher education [5]. Ethno-mathematics are mathematical activities and ideas, about mathematical aspects of cultural phenomenon, about elements of mathematics in cultural contexts [6]. Ethno-mathematics is relatively new as a source of study material, ethno-mathematics describes as a lesson from ideas and mathematical activities such as embedding concepts in certain cultural contexts.

2. Ethnomatematics of Timorese Culture

The North Central Timor Regency (TTU) is one of the areas inhabited by the Dawan ethnic group. In the Dawan community, settlements generally start from a basic family pattern consisting of father, mother and children. The typical residence of the civil society in the region of North Central Timor and its surroundings is Ume Kbubu. It is the traditional home of the people of Timor Island in general and in particular the people of North Central Timor Regency. Ume Kbubu is a round building with a roof with reeds almost touching the ground. Traditional houses in NTT are different from traditional houses in most of Manggarai, Flores and traditional houses in West Sumba or Southwest Sumba. Geometry concepts start from simple forms such as tubes, cones, circles, rectangles, squares, triangles to more complex shapes. All of this indicates that ethno-mathematics also exists in the TTU regency community.

In the traditional house, it was built using many circles which are arranged so that they form cones and tubes or cones. Although they do not recognize the terms circle, cone and tube, they can make circles, cones and tubes by using the hereditary knowledge inheritance that applies in that culture and integrating them into mathematics learning. The Ume Kbubu house in TTU, a traditional house in Manggarai and a traditional West Sumba house formed a large Mandala pattern. Mandala itself is a complex pattern composed of concentric squares and circles that symbolize the cosmos or the universe. Besides that, it also contains several geometric shapes such as cubes, blocks and pyramid. The implications of geometry learning are using a mathematical context (flat or space) in that culture with horizontal mathematical shape (circles, cones and tubes that exist in a culture in TTU district) and bringing it to vertical mathematics using the realistic mathematics approach or contextual approach.

3. Sasak Culture Ethno-mathematics

There are 31 types of pottery which are divided into 25 types of pottery which have geometric shapes and the rest have non geometric shapes [7]. Geometry concepts found in the form of earthenware are circles, triangles, squares, rectangles, ellipses, polygons, tubes, balls, cones, quadrilateral pyramid,
half spheres, and truncated cones. Of the 23 pottery motifs, 17 motifs are included in the geometric motif and the rest are non-geometric motifs. Geometry concepts found in earthenware motifs are lines, triangles, squares, rhombus, rectangles, trapezoidal, circular, and semicircle, as well as the use of principle, rotation, and translation. In addition, earthenware craftsmen have a concept of how to make a circle and determine its centre point and how to make a square and isosceles triangle. The motif on the Banyumulek pottery which examines the motifs of the Sukarara Sasak woven cloth in Central Lombok. Geometry concepts on earthenware motifs are point, line, triangle, square, rectangle, cube, pentagon, hexagon, triangle, reflection, translation, rotation, and dilation. Ikat motifs have a mathematical concept in the form of applying the concepts of transformation, measurement, estimation, accuracy and equality. The concept of transformation in the form of reflection, translation, rotation and dilation is often used in making patterns of motifs.

Consider the following picture

The image is a variety of Banyumulek Lombok earthen ware crafts. These craft drawings can be formed from the following graphs of functions that are played against the x-axis [8]. This mathematical model can be integrated into rotating objects in high school or in integral calculus courses. Suppose that is given five points namely \((x_1, y_1), (x_2, y_2), (x_3, y_3), (x_4, y_4),\) and \((x_5, y_5)\) with \(x_1 \leq x_2 \leq x_3 \leq x_4 \leq x_5\)

\[
f(x) = \begin{cases} \alpha x^3 + bx^2 + cx + d, & \text{if } x \in [x_1, x_3] \\ \beta x^3 + qx^2 + rx + s, & \text{if } x \in [x_3, x_5] \end{cases}
\]

By using cubic interpolation in which the midpoint as its peak point, this function can be expressed as a function

\[
f(x) = \begin{cases} \alpha x^3 + bx^2 + cx + d, & \text{if } x \in [x_1, x_3] \\ \beta x^3 + qx^2 + rx + s, & \text{if } x \in [x_3, x_5] \end{cases}
\]

Where

\[
\begin{bmatrix}
x_1^3 & x_1^2 & x_1 & 1 \\
x_2^3 & x_2^2 & x_2 & 1 \\
x_3^3 & x_3^2 & x_3 & 1 \\
3x_2^2 & 2x_2 & 1 & 0
\end{bmatrix}
\begin{bmatrix}
a \\ b \\ c \\ d
\end{bmatrix} = \begin{bmatrix}
y_1 \\ y_2 \\ y_3 \\ 0
\end{bmatrix}
\]

and

\[
\begin{bmatrix}
x_3^3 & x_3^2 & x_3 & 1 \\
x_4^3 & x_4^2 & x_4 & 1 \\
x_5^3 & x_5^2 & x_5 & 1 \\
3x_4^2 & 2x_4 & 1 & 0
\end{bmatrix}
\begin{bmatrix}
p \\ q \\ r \\ s
\end{bmatrix} = \begin{bmatrix}
y_3 \\ y_4 \\ y_5 \\ 0
\end{bmatrix}
\]

If we say \(A = \begin{bmatrix}
x_1^3 & x_1^2 & x_1 & 1 \\
x_2^3 & x_2^2 & x_2 & 1 \\
x_3^3 & x_3^2 & x_3 & 1 \\
3x_2^2 & 2x_2 & 1 & 0
\end{bmatrix}\) then using the rules of Cramer is obtained

\[
a = \frac{\det A_1}{\det A}, \quad b = \frac{\det A_2}{\det A}, \quad c = \frac{\det A_3}{\det A}, \quad d = \frac{\det A_4}{\det A}
\]

Where \(A_j\) is the matrix we get by replacing the entries in column \(j\) of \(A\) with entries in the matrix

\[
\begin{bmatrix}
y_1 \\ y_2 \\ y_3 \\ 0
\end{bmatrix}
\]
Whereas if we say 
\[
\begin{bmatrix}
  x_1^2 & x_2^2 & x_3 \\
  x_1^2 & x_2^2 & x_4 \\
  3x_1^2 & 2x_2^4 & 1
\end{bmatrix}
\]
then using the rules of Cramer is obtained

\[
p = \frac{\det B_1}{\det B}, q = \frac{\det B_2}{\det B}, r = \frac{\det B_3}{\det B}, s = \frac{\det B_4}{\det B}
\]

Where \( A_j \) is the matrix we get by replacing the entries in column \( j \) of \( A \) with entries in the matrix

\[
\begin{bmatrix}
y_3 \\
y_4 \\
y_5 \\
0
\end{bmatrix}
\]

By shifting the available points on condition \( x_1 \leq x_2 \leq x_3 \leq x_4 \leq x_5 \) there will be various other forms of pottery. Including the following:

4. Majapahit Culture Ethnomatematics

A broad unit that is still valid today in sugar cane producing areas such as Jombang, Kediri, Sidoarjo, Madiun and Ngawi, namely units related to the sale and purchase of rice fields or gardens. The unit is brick (read boto) which is equivalent to ru [9]. The relationship of brick, ru and standard unit is \( 1 \text{ ru} = 1 \text{ brick} = 14.2 \text{ m}^2 \). In addition, the popular area in southern East Java is odor, with 1 odor equivalent to 7000 m\(^2\). One mask is equivalent to 5000 m\(^2\) and one supply is equal to 2500 m\(^2\). For areas in fish farming, some regions use land area units to buy and sell ponds, such as 100 earths or 200 earths. Up to now, the writer has not been able to get an informant who can explain the relation to the standard unit.

For coastal areas where there are many fish, shrimp or fish farmers, the unit used to buy nener (fish / shrimp tillers) is a rean where 1 rean is equivalent to 5000 nener and specifically some regions in Lamongan 1 rean are equivalent to 5500 nener. The author suspects this difference is due to the existence of a unit culture (buying 10 can be bonus 1). There are also special knitting units for Sombro fish, with 1 knit equivalent to 55 Sombro fish.
Bamboo woven craftsmen in the Banyuwangi area use 1-1, 1-2, 1-3, 2-2, 3-3 and so on patterns [10]. All patterns forming a symmetry and geometric shapes that are found on webbing are triangular, square, rectangular, square and constructed spaces such as cones, cones, half ellipsoids. This opens up the opportunity to look for mathematical models of these structures. And it is integrated into the horizontal mathematical material of number and translation patterns, symmetry and reflection.

5. Etnomatematics of Toraja Culture Traditional

Toraja houses, or commonly called Tongkonan, are houses that are owned for generations by families or clans of the Toraja tribe [11]. This house is rich in cultural elements. One of the most common cultures in this traditional house is unique and beautiful carvings. Inadvertently Toraja tribes have practiced mathematics in their daily culture and life. In other words, this tribe uses mathematical ideas and concepts in making a carving. One of the most widely used geometry concepts is the symmetrical concept [9].

Toraja culture that contains geometric concepts is a carving found in the Toraja traditional house (tongkonan). How to draw a diagonal line on the Tongkonan traditional house carving, which is to draw a line from the upper corner of the opposite corner (from the upper right corner to the lower left corner or from the top left corner to the lower right corner). Circles by the Toraja tribe call it a roundabout or barre. How to make it using a piece of bamboo, one nail and a pencil to draw. To make a circle the first step is to draw a square or square (Toraja tribe calls it quadrilateral). The second step is to divide the quadrilateral into four equal parts and make a diagonal line. The diagonal line and the intersection point that divides the quadrilateral into four equal parts is what is the center of the circle. Then plugged in a piece of bamboo which had been punched at both ends of one end with a nail and the other end with a pencil. Plug the nail into the center point and the tip of a bamboo put on the pencil is rotated to make a circle. The triangle in Toraja is passora. Triangles in tongkonan traditional house carvings are usually placed on the side of the engraving frame so that one of the sisina is the engraving frame, the triangle is mostly samurai triangle where both sides of the triangle are sides that are not the same carving frame. The way of the triangle is the triangular leg, which in their estimation is the same length, while the one side is the side of the engraving frame. Square, rectangle, ceiling, kite, trapezoid and parallelogram found in the carving of traditional Tongkonan houses by the Toraja tribe call it a quadrilateral. The square is made by making four lines that are the same length and each end of the four lines meets.

6. Should Ethnomatematics enter the Curriculum?

Culture-based mathematics learning is one of the perceived ways to make meaningful and contextual mathematical learning highly related to cultural communities, where mathematics is studied and will be applied later in harmony with the cultural community, as well as interesting and enjoyable mathematics learning. The learning conditions that allow the creation of contextual meanings based on experience as a member of a cultural society are one of the basic principles of constructivism theory. Educators and researchers concluded that mathematical knowledge was also obtained outside the structured system of mathematics learning such as schools ([12], [13], [14], [15]). In this perspective, mathematical ideas applied in a unique socio-cultural context refer to the use of mathematical concepts and procedures obtained outside of school as well as the acquisition of other mathematical skills other than school. If this is done habituation from an early age will build the character of students.

Budiarto proposed five possibilities for ethno-mathematics to enter the curriculum and formally have a relatively similar role to mathematics, namely; (1) substitute for school mathematics; (2) supplying school mathematics; (3) stepping stones into school mathematics; or (4) motivation for school mathematics and (5) as a local content of school mathematics and a means of developing character. The results of ethno-mathematics research in Indonesia show that ethno-mathematics can promote more culture and at the same time for mathematics learning. In the end I invited to be kind-minded, to do good, to make good deeds, and to cultivate good things [9].

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