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Ethnomatematics In Typical Crafts Of Kulon Progo, Daerah Istimewa Yogyakarta

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Abstract
Recently only several people know that mathematics and cultures are actually two interrelated. Both can not be separated from human life. The relationship between those two is known as Ethnomatematics. This study aims to find out the mathematical elements that exist in the culture of the Kulonprogo community especially on a variety of customs crafts such as agel, bamboo and batik Geblek Renteng. The data obtained from this research are presented qualitatively which is the result of field studies, interviews and literature studies to describe various mathematical elements found in the customs craft of Kulonprogo. The results of the study explained that there are mathematical elements of space geometry, geometry of bisang, artimatika series and geometry of transformation in a variety of customs crafts of the Kulonprogo. The results of this study is expected to be used as knowledge and learning media for mathematics in elementary to senior high school.
Keywords: *Ethnomatematics, crafts, Kulonprogo, mathematics learning*

INTRODUCTION

Mathematics is a basic science that is used in almost all sciences and is useful for all aspects of life. Many mathematical sciences are related to people's daily life and activities, even simple human activities such as walking and running have mathematics in them, such as measuring footstep length, running speed and so on. But sometimes many people do not realize that the activity they are doing is a mathematical activity. Many experts argue that mathematics has a lot to do with people's lives, one of which is Susilo, who argues that mathematics is not just a collection of abstract numbers, symbols and formulas that are not related to the real world. On the contrary, mathematics is a science that grows and has roots in the real world.

The existence of a connection between mathematics in human life makes mathematics also have a relationship or relationship with the culture of society. Mathematics and culture are something that cannot be separated from people's life. Mathematics is born, grows and develops from a culture where culture is always an inseparable part of a group of people from one era to the next because culture itself is a system of ideas, patterns of behavior, human work that has become a habit and passed down into a hereditary tradition. from a particular society. From this relationship emerges the notion that mathematics is a cultural product that is integrated in people's lives which is called ethnomatematics (Muhtadi, Sukirwan, & Warsito, 2019). Ethnomatematics is briefly defined as mathematics in culture because the word ethnomatematics consists of two words, namely ethno which means ethnicity / culture and mathematics. Currently, many experts have studied ethnomatematics for both research and learning. Ethnomatematics itself was first introduced by a Brazilian mathematician named D'Ambrosio in 1977. D'Ambrosio states that “The prefix ethno is today accepted as a very broad term that refers to the socialcultural context and therefore includes language, jargon, and codes of behavior, myths, and symbols. The derivation of mathema is difficult, but tends to mean to explain, to know, to understand, and to do activities such as ciphering, measuring, classifying, inferring, and modeling. The suffix tics are derived from techné, and has the same root as technique ”(Astri, et al; 2013: 4).

When translated into language, ethnomathematics consists of the prefix “ethno” which means something very broad and refers to the socio-cultural context, including language, jargon, code of behavior, myths, and symbols. The root word "mathema" tends to mean explaining, knowing, understanding, and carrying out activities such as coding, measuring, classifying, concluding, and modeling. The suffix "tics" comes from techne, and means the same as technique (D'Ambrosio in Orey and Rosa, 2011: 35). From D'Ambrosio's opinion, it can be concluded that ethnomatematics is a science used to deepen mathematics adapted from a culture. The purpose of ethno-mathematics is to make the relationship between culture and mathematics easier to understand so that the views of society and students about mathematics become more precise, and mathematics learning can be more adapted to the cultural context of society and students, and mathematics can be more easily understood because students and society are no longer perceived as something 'foreign' (Suwarsono, 2015).

Currently, many researchers are interested and discuss ethnomatematics in their research. Indonesia, which has a wide variety of cultures, is the main attraction in exploring the mathematical elements of various cultures in Indonesia. The large number of studies on ethno-mathematics make it clear that mathematics is indeed growing and developing in the culture of society.

One of the ethnomatematic studies that will be discussed in this study is the relationship between mathematics in the local culture of the Kulonprogo district community. Kulonprogo Regency is one of the regencies located in the province of Yogyakarta Special Region. Like other areas, Kulonprogo Regency also has a culture which is the specialty of the area which will be studied in this study, namely in various forms of handicrafts. Crafts that are characteristic of kulonprogo are handicrafts made of agel and bamboo as well as batik crafts Geblek Renteng which has become an icon of Kulonprogo district. In various cultures which are the uniqueness of Kulonprogo district, there are several elements of mathematics in it which, if examined, can be useful for many things, including learning mathematics in primary to secondary education so that mathematics becomes easier and more interesting to learn. From the various explanations above, the purpose of this study is to explore the mathematical elements that exist in the typical culture of the people of Kulonprogo Regency, especially from their craft culture, especially agel crafts, bamboo and batik. It is hoped that the results of this research can be used for a variety of learning materials related to education from elementary to secondary levels.

RESEARCH METHODS

Based on various descriptions of ethno-mathematics and the scope of research that have been presented at the beginning, this type of research is qualitative research. Researchers dig to find concepts and problems by conducting case studies of various incidents or events (Gulo: 2000). The type of approach used in this research is an ethnographic approach in which the researcher takes a theoretical and empirical approach which aims to obtain in-depth descriptions and analyzes related to the various cultures studied based on research in the field which is then described qualitatively. The method used in this research is field study, interview, literature study and documentation. Field studies and documentation are used to trace the forms of agel and bamboo handicrafts in Kapubaten Kulonprogo, the Geblek Renteng batik motif.

The data subjects of this study were groups of agel craftsmen and groups of batik craftsmen in the sub-district of Sentolo and groups of batik craftsmen in the low district. Interviews were conducted with group and association representatives to obtain more detailed data regarding the history, origin of materials, names, production methods and sales mechanisms, while the objects of this study were handicraft products. After obtaining field data, the researcher conducted a literature study to analyze the existing mathematical elements of the various cultural products. The model of data collection and analysis from this study was carried out inductively through four activities, namely collecting data, reducing data, categorizing data and drawing conclusions.

RESULT AND DISCUSSION

1.Etnomatics in Agel Crafts

Agel handicrafts are one of the handicraft products made from natural fibers. The fiber that comes from the leaves of the gebang tree has been used since the Japanese colonial era. In colonial times when it was quite difficult to find threads, agel or gebang fibers were used to replace threads to make clothes from bagor / sacks or bags for rice and salt. Since the New Order government, the planting of gebang trees has been abandoned because they were replaced by food plants so that products from agel fiber are very rare. Now products derived from gebang / agel fibers are being produced again because they are in great demand and have become export commodities to Europe, America and Asia. Salamrejo Village, located in the Sentolo District, is designated as a craft center made of agel fiber.

Before agel fiber is ready to be used as a base for various handicrafts, agel farmers must carry out several processing processes. The gebang leaves that have been separated from the stick are then dried, then cooked and bleached. After that, the gebang leaves are dried again in the sun, then the gebang fibers are rolled and ready to be used as raw material for various crafts. From various kinds of agel handicraft products, researchers took samples of several products and analyzed the mathematical elements of these handicraft products

Figure 1. Wall decoration from agel material

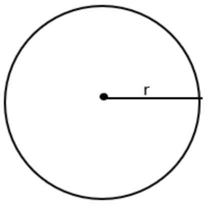


Figure 2. Circle

The product used as a decoration on this wall is a circle with a diameter of 60 cm. This wall decoration product from Agel has gone through a coloring process to make it more attractive. From this product, there are several mathematical elements regarding circles that can be used for learning, namely about the elements of the circle, the area and the circumference of the circle.

a. Area and circumference of wall decoration (circle)

If knowing that r = 30 cm, d = 60 cm, then the circumference of the wall decoration is $C = \pi \times d = \pi \times 60\ cm = 60\pi\ cm$. As for the area of this wall decoration is $A = \pi \times r^2 = \pi \times 30^2 = 900\pi\ cm^2$

b. The length of the agel twist on the wall decoration

If someone wants to make a wall decoration in the form of a circle from agel fibers as shown in figure 1 with radius n, the length of the agel twist needed is

- The winding length for r = 1 then the winding length = $\pi \times 2r = \pi \times 2.1 = 2\pi$
- The length of the winding for r = 2 then the length of the winding = $\pi \times 2r = \pi \times 2.2 = 4\pi$
- The length of the winding for r = 3 then the length of the winding = $\pi \times 2r = \pi \times 2.3 = 6\pi$
- …
- The length of the winding for r = n then the length of the winding n = $\pi \times 2r = \pi \times 2.n = 2n\pi$

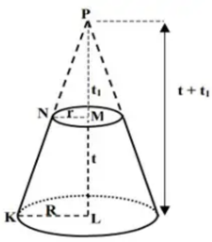
So that the total length of the wall decoration wrap for radius (r) = n is $\sum_{r=1}^{n}(\pi \times 2r)$

For example someone wants to make a wall decoration with a radius of 30 cm, the length of the agel fiber twists needed to make the wall decoration is

Winding Length = $\sum_{r=1}^{30}(\pi \times 2n)$ = (2π + 4π + 6π + ….+ 60π) = 930πcm

Figure 3. Lampshade of agel fiber

Figure 4. A truncated cone space



The lampshade craft as shown in Figure 3 also comes from agel fibers that have been woven. This lampshade is quite large because it has a base diameter of 70cm and a cover diameter of 50cm with a height of 100cm

In this lampshade craft from agel fiber, the mathematical element can be analyzed, namely its shape which is like a truncated cone. The mathematical element that can be taken is the volume of the lampshade.
Lampshade volume = volume of truncated cone
Volume of truncated cone = volume of large cone - volume of small cone (figure 4)
Volume of large cone = $\frac{1}{3} \times \pi \times R^2 \times (t + t_1)$
Volume of small cone = $\frac{1}{3} \times \pi \times r^2 \times t_1$

To find the height (t_1) of the small cone is $\frac{MN}{LK} = \frac{PM}{PL} \Longrightarrow \frac{r}{R} = \frac{t_1}{(t+t_1)}$

$$t_1 R = r\,(t + t_1)$$

$$t_1 = \frac{r \times t}{(R-r)}$$

So to find the height of the small cone with the radius of 50cm (radius of the cover of the lampshade), the radius of the base 70cm and the height of the lampshade 100cm.

$$t_1 = \frac{r \times t}{(R-r)} = \frac{50 \times 100}{(70-50)} = \frac{5000}{20} = 250cm$$

Volume of large cone = $\frac{1}{3} \times \pi \times R^2 \times (t + t_1) = \frac{1}{3} \times \pi \times 70^2 \times (100 + 250)$

$$= \frac{1}{3} \times \pi \times 4900 \times 25000$$

$$= 40.833.333{,}33\ \pi\ cm^3$$

Volume of small cone = $\frac{1}{3} \times \pi \times r^2 \times t \;= \frac{1}{3} \times \pi \times 50^2 \times 250$

$$= \frac{1}{3} \times \pi \times 2500 \times 25000$$

$= 20.833.333,33\ \pi\ cm^3$

So the volume of lampshade is = volume of large cone – volume of small cone

= $40.833.333,33\ \pi\ cm^3$ - $20.833.333,33\pi\ cm^3$ = 20.000.000 $\pi\ cm^3$ = 20 $\pi\ m^3$

Figure 5. Craft tote bag from agel fiber

Figure 5 is one of the handicraft creations of agel natural fibers in the form of a tote bag. This tote bag has also gone through a coloring process so that the appearance of the bag becomes more attractive. This bag made of agel fiber has a mathematical element that can be used as a teaching material, namely this bag has a geometric shape in accordance with the trapezoid concept. A trapezoid is a rectangular shape where this shape has a pair of parallel sides. The bag made of agel fiber has an isosceles trapezoid shape with parallel sides of 40cm and 30 cm and a bag height of 30 cm. An isosceles trapezoid is a trapezoid with two parallel sides and equal vertical sides and no right angles.

Properties of the isosceles trapezoid ABCD

$\overline{AB} \parallel \overline{CD}$

$\overline{AD} = \overline{BC}$

$\angle DAB = \angle ABC$

$\angle ADC = \angle BCD$

$\overline{AC} = \overline{BD}$

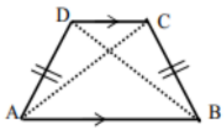


Figure 6. trapezoid

2. Ethnomatematics in bamboo crafts

Bamboo handicrafts are also one of the typical products of Kulonprogo district. Sentolo Subdistrict is one of the centers for craftsmen of bamboo raw materials. To get bamboo raw materials that are ready for weaving, craftsmen need several steps to process the bamboo. The first step for the craftsman to look for bamboo trees that are still young, then the bamboo is divided into smaller sizes and then dried so that the water content in the bamboo stems can be lost. The next step is the bamboo that has been dry, is split into a thinner size and then mashed so that the bamboo is smooth and has even flexibility. Bamboo that is smooth and flexible is ready to be used as raw material for crafts.

The craftsmen in the Kulonprogo area are able to produce various forms of bamboo handicrafts in which there are mathematical elements that can be analyzed further.

Figure 7. Crafts from bamboo lanterns

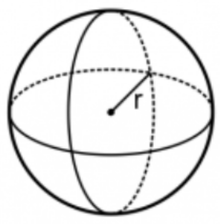


Figure 8. Sphere

The form of handicraft in Figure 7 is a product of handicraft made from bamboo called lanterns. This product is in great demand as a lamp holder that is hung as a decoration both inside and outside the home. There are some lanterns that are still coated with colored paper to get a more attractive finish. However, there are some lanterns that are left with their original bamboo appearance. This bamboo lantern craft has a diameter of 30 cm. The mathematical element that can be taken from this lantern craft is its shape which is similar to the shape of a ball room. The following is a mathematical concept in accordance with the bamboo lantern craft.

Sphere properties:

- Has 1 curved side (ball blanket)
- Don't have ribs
- Has no vertex

a. Lantern volume = volume of sphere = = $\frac{4}{3} \times \pi \times r^2$

if r = 15 cm maka $V_{lantern} = \frac{4}{3} \times \pi \times 15^2$

$V_{lantern} = \frac{4}{3} \times \pi \times 225$

$V_{lantern} = 300\pi\ cm^3$

b. Lantern Surface Area = sphere surface area = $4 \times \pi \times r^2$

If r = 15 cm then Lantern Surface Area = $4 \times \pi \times 15^2$

Lantern Surface Area = $4 \times \pi \times 225$

Lantern Surface Area = $900\pi\ cm^2$

Figure 9 Bamboo handicraft for rice (bumbung)

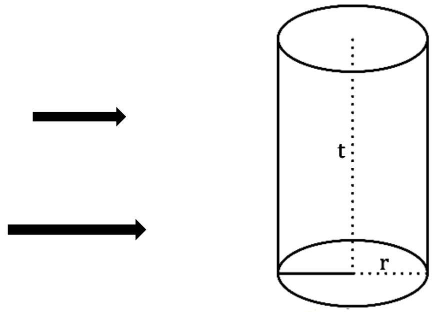


Figure 10. Bamboo craft (bumbung bag)

Figure 11. Cylinder

The handicraft in figure 9 and picture 10 above is a bamboo craft called a bumbung. This craft is also one of the most popular products. There are many variations of bumbung models, including: bumbung bags, rice bumbung holders, bumbung glasses, and bumbung vases. Everything is made with bamboo raw materials. From this bumbung craft, there is a mathematical element, namely a form of bumbung craft which is similar to building a tube space. The tube is a curved side chamber with a lid and a base of a circle with radius r (figure 11). The mathematical elements are as follows:

a. Cylinder properties

- Has a side in the form of a curved plane and 2 sides in the form of a circle.
- Has no vertex
- Has 2 curved ribs

b. Volume of bumbung = volume of cylinder = $\pi \times r^2 \times t$

Bumbung bag with radius 10 cm and height 50 cm so the volume is

$$V_{bumbung} = \pi \times r^2 \times t$$
$$= \pi \times 10^2 \times 50$$
$$= 5000\pi\ cm^3$$

c. Surface area of bumbung = Surface area of cylinder = $2\pi r(r+t)$

Bumbung bag with radius 10 cm and height 50 cm so the volume is

$$A_{bumbung} = 2\pi r(r+t)$$
$$= 2 \times \pi \times 10 \times (10+50)$$
$$= 1200\pi\ cm^2$$

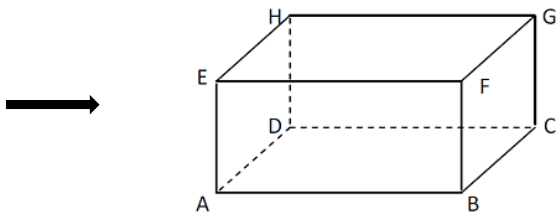


Figure 12. bamboo baskets

Figure 13. Cuboids

The bamboo craft in figure 12 is called besek. Besek made of woven bamboo resembles building cuboidss. Besek is usually used during a celebration as a place for rice and side dishes. However, along with the times, nowadays baskets are widely used as a substitute for cardboard both in restaurants, gift centers or in catering businesses as food containers. The mathematical element contained in this besek craft is of its shape which is similar to a cuboids space building. Besek has many sizes. If we know the length, width and height of the bucket, we can determine the volume and surface area of the bucket.
For example: A basket has a width of 20 cm, a length of 20 cm and a height of 10 cm, then the volume and surface area of the basket is

$$V_{besek} = V_{cuboids} = p \times l \times t$$
$$= 20\ cm \times 20\ cm \times 10\ cm$$
$$= 4000\ cm^3$$
$$A_{besek} = A_{cuboids} = 2(p \times l + p \times t + l \times t)$$
$$= 2(20 \times 20 + 20 \times 10 + 20 \times 10)$$
$$= 2(400 + 200 + 200)$$
$$= 2(800)$$
$$= 1600cm^2$$

The last type of bamboo handicraft product discussed in this study is tutup keong. The conch cover is woven bamboo that is used as a buffer or roof of a house in a village house model so that the roof of the house is stronger from being exposed to the wind. In addition, tutup keong also functions as a cover for the top of the house so that too much wind does not enter the house and prevents rainwater from entering. The size of the cover usually depends on the request of the buyer. In the form of tutup keong, there are mathematical elements that can be used in learning. The shape of tutup keong is similar to the shape of the isosceles triangle so that the elements contained in the isosceles triangle can also be applied to tutup keong.

Figure 14. Tutup keong

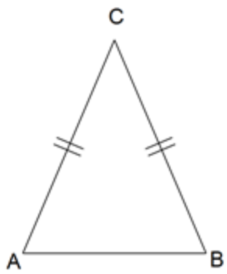


Figure 15. Triangle

The properties of the isosceles triangle ABC (figure 15):

- $\overline{AC} = \overline{BC}$
- $\angle CAB = \angle ABC$
- Has one axis of symmetry

For example, a house owner wants a tutup keong for his house which has a width of 4m and a height of 1.5m of tutup keong, then the area and circumference of the cover is

- Area of triangle = $\frac{1}{2} \times a \ \times t, a = length\ of\ base\ and\ t = height\ of\ triangle$
- Surface area of tutup keong = area of triangle

$$= \frac{1}{2} \times 4\ m \times 1{,}5m$$
$$= 3m^2$$

The circumference of the isosceles triangle = the sum of all its sides
Since tutup keong is an isosceles triangle, the lengths of the two hypotenuse are the same, so you only need to find the length of one of the hypotenuse and the length of the base.
Long slant using Pythagoras

$\overline{BC}^2 = \overline{OC}^2 + \overline{OB}^2$

$\overline{BC}^2 = 1{,}5^2 + 2^2$

$\overline{BC}^2 = 2{,}25 + 4$

$\overline{BC}^2 = 6{,}25$

$\overline{BC} = 2{,}5\ cm$

So that the circumference of tutup keong = the length of the base + the length of the slanted sides.
= 4m + 2,5m + 2,5 m = 9m

3. Ethnomatics in Geblek Renteng's batik craft

The typical batik of Kulonprogo district is widely known by people as Geblek Renteng batik. Batik Geblek Renteng is identical to Kulonprogo Regency because the motif is a picture of the typical food from Kulonprogo, namely geblek. In the beginning, Kulonprogo patented Geblek Renteng batik as a typical Kulonprogo batik when in 2012 the Kulonprogo government created a batik design competition to increase the development of the handicraft industry in Kulonprogo. The batik design that won the competition will be patented into a typical Kulonprogo batik. At that time there were 5 types of batik designs, namely Angguk Putri, Kulonprogo Binangun, Ceplok Kulonprogo, Manggis and Geblek Renteng. Finally, the Geblek Renteng motif design won the competition and was patented as a typical batik from Kulonprogo district. From interviews with the head of the craftsmen group, it was found that the shape of the Geblek which resembles the number eight symbolizes that Kulonprogo has 88 villages and sub-districts. Geblek is a popular food, its combined form (jointly) symbolizes the community standing together to build Kulonprogo. In Geblek Renteng's batik, there are several mathematical elements seen from the batik pattern, namely rotation and translation.

a. Rotation

In the Geblek Renteng motif there is a mathematical element of rotation. This can be seen in Figure 16 below where the geblek motif is rotated 90^o, 180^0 and 270^0 to get a variation of the Geblek Renteng batik motif. The rotation process is shown in Figure 17.


Figure 16. Batik Geblek Renteng

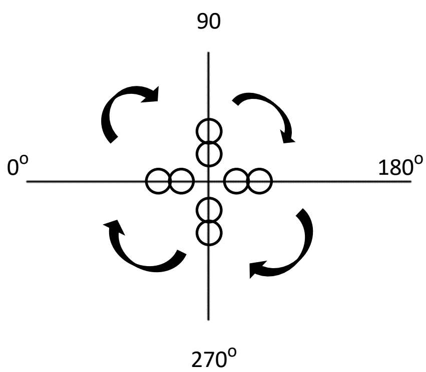


Figure 17. Rotation Process

b. Translation

This Geblek Renteng motif also has a translation concept, this can be seen in Figure 18. The geblek image is shifted several units to a certain position, from a to a 'then shifted again to position a' and so on. By shifting the position of the geblek motif in making batik, it is sufficient to explain that the concept of translation has been applied in the process of making Geblek Renteng batik motifs. Below is a Geblek Renteng motif that utilizes a translational transformation geometry and an illustration of the translation process.

Figure 18. Motif of Batik Geblek Renteng

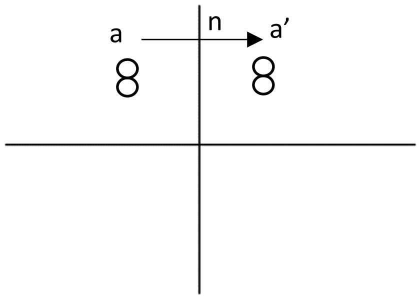


Figure 19. Translation Process

From the above description, it is quite clear that the Geblek Renteng batik motif contains the concept of rotation and translation. It is very possible that other batik motifs also contain geometric transformation concepts such as rotation, translation, dilation and reflection.

Conclusions and suggestions

Conclusion

Mathematics and culture are indeed a combination that cannot be separated from human life. Mathematics grows and develops in a culture known as ethnomatematics. One form of ethno-mathematics is the relationship between mathematics and culture which characterizes Kulonprogo district. Mathematics exists in various handicraft centers that characterize Kulonprogo Regency, namely agel crafts, bamboo crafts and batik crafts. Various mathematical elements contained in various kinds of typical Kulonprogo handicrafts can be used as learning media for primary to secondary education levels. In agel crafts and bamboo crafts, there are several mathematical elements that can be found, namely about the geometry of space, the geometry of the arithmetic sequence. As for the Geblek Renteng batik craft, the mathematical elements that can be found are about the geometry of rotation and translation transformations.

Suggestion

From the results and discussion, the researcher suggests that a more in-depth study be carried out regarding the application of mathematics in the typical handicraft of progo kulon as learning material at a higher level.

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