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BUGINESE ETHNOMATHEMATICS: BARONGKO CAKE EXPLORATIONS AS MATHEMATICS LEARNING RESOURCES

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Abstract

Mathematics is still viewed as a culture-free subject. This forms a negative perception for students on mathematics. Most students assume that mathematics and culture are not related. This may occur because mathematics taught in school is not contextual and far from the reality of everyday life. Historically, mathematics has become a part of daily life. As a maritime nation, Indonesia has a diverse culture. But many teachers are not yet aware of the integration of the culture into mathematics learning. Barongko cake is one of the Buginese cultural heritages. Buginese people have unconsciously been practicing mathematics in making these cakes. Therefore, this research aims to explore activities in making Barongko cakes in the Buginese community that involves mathematical concepts. This research is a qualitative descriptive with an ethnographic approach. The data collection methods are carried out through observation, documentation, interview with an expert in making Barongko cake. This research found that Barongko making process involves mathematics in the concept of division, congruence and similarity, as well as a triangular prism, and half sphere. This cake has the potential to be used as a source of contextual mathematics learning in schools.

Keywords: Ethnomathematics, Barongko, Division, Congruence and Similarity, Geometry

Abstrak

Matematika masih sering dipandang sebagai suatu bidang ilmu yang bebas dari pengaruh budaya. Hal ini membentuk persepsi negative siswa. Sebagian besar siswa beranggapan bahwa matematika tidak terkait dengan budaya. Ini mungkin disebabkan karena matematika yang diajarkan di sekolah seringkali tidak kontekstual dan jauh dari realita kehidupan sehari-hari. Secara historis, matematika telah menjadi bagian dari kehidupan manusia sehari-hari. Sebagai negara kepulauan, Indonesia memiliki kebudayaan yang sangat beragam. Namun banyak guru yang belum menyadari bahwa kekayaan budaya ini dapat diintegrasikan ke dalam pembelajaran matematika. Kue Barongko adalah salah satu warisan budaya Bugis. Tanpa disadari, masyarakat Bugis telah menerapkan konsep-konsep matematika dalam proses pembuatan kue Barongko. Oleh karena itu, penelitian ini bertujuan untuk mengeksplorasi aktivitas yang melibatkan konsep-konsep matematika yang terdapat pada proses pembuatan kue Barongko. Penelitian ini merupakan penelitian kualitatif deskriptif dengan pendekatan etnografi. Teknik pengumpulan data dilakukan melaui observasi, dokumentasi, dan wawancara dengan narasumber yang memahami proses pembuatan Barongko. Penelitian ini menunjukkan bahwa pembuatan Barongko melibatkan konsep-konsep matematika seperti pembagian, kekongruenan dan kesebangunan, serta prisma segitiga dan setengah bola. Hal ini berpotensi untuk digunakan sebagai sumber pembelajaran matematika yang kontekstual di sekolah.

Kata kunci: Etnomatematika, Barongko, Pembagian, Kekongruenan dan Kesebangunan, Geometri

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Mathematics is often taught in schools as a culture-free subject and is not related to the reality of daily life (Rosa & Orey, 2011), whereas, mathematics is deeply rooted in culture and forms an inseparable whole (Abdullah, 2016; Brandt & Chernoff, 2014). The concepts of mathematics appear through the knowledge and perspectives of naturally present and developing people in a certain culture without a formal educational process (Zayyadi, 2017). Some people may never study, but they can practice mathematical concepts well. It indicates that mathematics will always be used in society life, no matter how primitive the community groups are. However, most people are not aware, and the public sometimes thinks that mathematics is difficult. It indirectly forms a complicated perception for students on mathematics. As a result, mathematics has lost its neutral character and is no longer viewed objectively (Gazali, 2016).

The negative perceptions of mathematics appear not without reason. Mathematics contains abstract concepts, so that learning mathematics means learning something abstract (Herawaty et al., 2019). Many students are afraid of mathematics because mathematical problems are generally complicated and difficult to solve. As a result, student's mathematics skills are quite low (Laurens et al., 2018). Besides, the theories taught in schools are sometimes not applicable to the emerging problems in the field, so that mathematics learning should be concrete in order to make students interested, understand, and able to solve mathematical problems (Arisetyawan et al., 2014). Therefore, it should be able to bridge the gap between in the school and in the field by using contextual learning resources (Pathuddin & Raehana, 2019). Furthermore, there is a growing perception that mathematics practiced by teachers and academics should be transformed into social mathematics. It means that mathematics learning should not only be taught but also practiced, particularly in relation to socio-cultural values (Rachmawati, 2012).

One of the contextual learning resources that can be used is local culture. Ethnomathematics is the field of study explaining the relationship between mathematics and culture. The term ethnomathematics is defined as the art of understanding, explaining, studying, copying, and managing the natural, social, and political environments through processes such as calculation, measurement, classification, model, and conclusion resulting from well-identified cultural groups (D'Ambrosio, 1985). In other words, ethnomathematics implies mathematics practiced among identified cultural groups (D'Ambrosio, 1989). The study of mathematics considers culture and appears to understand the reasoning of the mathematical system used by an ethnicity (Septiadi et al., 2017).

Research in term of ethnomathematics has been widely carried out in many countries. Some of the studies carried out in the field of ethnomathematics include the exploration of ethnomathematics in the Malay Songket weavers. In the study, some basical concepts were found such as measurement, estimation, and transformation geometry (Embong et al., 2010). Another study is regarding research on measurement units in social practice. The result of the study found that different units of measurement are used in the standard measurement system, where the reference in the measurement unit is the human body (Santos, 2019). In the different object, ethnomathematics exploration of the Malay culture under the influence of Islam in Malaysia has also been carried out. The result of the study has disclosed the existence of permutation and combination concepts related to Islamic *fiqh* before the entry of Western mathematics (Ismail & Ismail, 2010). In the Philippines, ethnomathematics research on the Kabihug tribe has showed that the community applies many mathematical concepts, such as simple calculations like addition, subtraction, multiplication, and division, as well as concepts of coding, measuring, classifying, composing, making/modeling patterns, and geometry (Panganiban et al., 2016).

In Indonesia, exploring mathematical concepts has been carried out by some researchers. Abdullah (2017) studied ethnomathematics in Sundanese culture. Risdiyanti & Prahmana (2017) explored ethnomathematics of batik in Javanese culture. Furthermore, researchers studied the concept of geometry in Sasaknese architecture (Supiyati et al., 2019), the idea of geometry in Lionese traditional house (Wondo et al., 2020), ethnomathematics in calculating an auspicious day in Javanese society (Imswatama & Setiadi, 2017), and mathematical concepts in Balinese calendar system (Suarjana et al., 2014).

Considering of all these existing studies, few researchers have explored mathematical concepts in Buginese culture. As the largest ethnic group in South Sulawesi, Buginese has many famous cultural heritages, and one of which is Barongko cake. Barongko cake was designated as one of Indonesia's intangible cultural heritages in 2017 (Paluseri et al., 2017) and is one of its traditional foods served at every special event. To preserve this tradition, the younger generation, especially the girls, are taught how to make the cake (Fakhrunnisa et al., 2016). The familiarity of Barongko cake among the public and students in the Buginese community is an opportunity for teachers to explore and use it as a source of contextual learning to make school mathematics learning meaningful. Therefore, the authors investigated the activities in making Barongko cake containing mathematical concepts, which can be used to make mathematics learning design.

METHOD

This research is qualitative descriptive with an ethnographic approach. Qualitative descriptive used to obtain and explain information overall and deeply (Prahmana et al., 2018). While ethnography is a qualitative approach that describes culture (Spradley, 2007). Ethnography provides answers to the question on what the culture of an individual group is (Sulasteri et al., 2020). The purpose of this research is to reveal ethnomathematics in the activities in making Barongko cake among the Buginese community. The design of this research uses the framework of ethnomathematics study developed through four general questions, that are "where is it to look?", "how is it to look?", "what is it?", and "what does it mean?" (Prahmana & D'Ambrosio, 2020; Utami et al., 2019). The design of the research is presented in Table 1.

Data collection was carried out through observation, interview, and documentation. The observations were conducted by observing the process of making Barongko cake. The objects observed were the ingredients, tools, and the steps in making Barongko starting from the selection of the leaves to the steaming of the cake. This research also conducted interviews with the informant having an expertise in making barongko cake and asked as many questions as possible about the process. During the interview, the researcher recorded everything disclosed by the informant using a voice recorder. This research also took pictures of the process as part of the documentation. Data obtained from the observation, interview, and documentation were analyzed using methodological triangulation to explore the relationship between Barongko cake-making activity and mathematical concepts. Methodological triangulation was conducted by comparing the information obtained from the observation, interview, and documentation. Lastly, the data were presented and described in order to obtain the finding.

Table 1. The Design of Research

General Questions	Initial Answers	Starting Point	Specific Activity
Where is it to look	In the activities of making Barongko cake where there are mathematical practices in it.	Culture	Conducting interview with an expert in making Barongko cake.
How is it to look	Investigating QRS (Qualitative, Relational, and Spatial) aspects of making Barongko Cake related to mathematics concepts.	Alternative thinking	Determine what QRS ideas are contained in making Barongko Cake related to mathematics concepts.
What is it	Evidence	Philosophical mathematics	Identifying QRS characteristics in the process of making Barongko Cake.
What does it mean	The significant value of culture and mathematics.	Anthropology	Describe mathematical concepts in the process of making Barongko Cake.

RESULTS AND DISCUSSION

In this research, the ethnomathematics was focused on making barongko cake mostly undertaken by the Buginese people. Ethnomathematics descriptions in these activities were described through the results of the interviews, then confirmed through direct observation of the process of making barongko cakes and through documentation as supporting data. Three mathematical concepts were obtained from the results, namely division, congruence and similarity, and 3D shapes.

Concept of Division

The descriptions of the interview regarding the concept of division in making Barongko cakes are presented in Dialog 1.

Dialog 1

Researcher : "What are the criteria for banana leaves used for making barongko?"

Informant : "To make barongko, choose leaves that are long and wide" (This means long banana midrib with rather broad leaves)

Researcher : "After that?"

Informant : "After that, separate the leaf from the midrib, then divide it into small pieces."

Researcher : "How many leaf sizes will be divided?"

Informant : "About this much" (shows size using fingers).

Researcher : "One span?"

Informant : "No, too short"

Researcher : "Two spans?"

Informant : "No, that's too long. Maybe less than one and a half spans." (Using a ruler, it was found that the leaf size was about 25 cm)

Researcher : "How much is usually produced from one midrib which is about 1.5 meters in size after removing the base and tip?"

Informant : "Maybe about 12 or 14. Each side is 6 or 7 pieces because the base and tip of the leaves are removed first before dividing. But it depends on your handspan."

Dialog 1 stated that this research discloses that the barongko making-process started from selecting banana leaves that were suitable for use. The banana leaves selected are removed from the tip and base. Further steps, the banana leaves are separated from the midrib to obtain long leaves as shown in Figure 1.

Figure 1. Banana Leaves that have been separated from the midrib

Then, dividing the banana leaves into several parts is the way used to wrap Barongko cake as shown in Figure 2.

Figure 2. Banana Leaves Ready to be Divided into Parts

If the length of a banana leaf separated from its midrib is symbolized by X, the length of one side of the leaf used to wrap the barongko is symbolized by Y, and the number of wrapping leaves obtained is symbolized by N, then an equation can be obtained as follows:

$$N = \frac{2X}{Y} \quad (1)$$

Equation (1) denotes that the number of barongko cake wrappings obtained from one banana leaf is equal to twice the length of the banana leaf divided by the length of one side of the leaf that will be used to wrap the barongko.

Concept of Congruence and Similarity

The descriptions of the interview regarding the concept of congruence and similarity in making Barongko cakes are presented in Dialog 2.

Dialog 2

Researcher : “What is the size of the inner leaf layer?”

Informant : “Generally, it has the same size as the outer leaf wrapper.”

Researcher : “Same? Isn’t it smaller?”

Informant : “It depends on the maker and usually also depends on the number of leaves. If the leaves are few, usually the coating is smaller, but if the leaves are many, they are usually the same size. But in general, it is the same.”

Researcher : “If the coating is smaller, how big the size would it be?”

Informant : “Clearly, the shape is the same as the outer wrapper. Both are rectangular. The size depends on the maker” (that is, the size of the coating leaf is proportional to the size of the outer wrap).

Dialog 2 stated that after the banana leaf is divided into several parts, the leaf is then coated with another banana leaf. The size of the coating depends on the availability of the leaves. In general, the coating leaf and the outer leaf size are the same. However, if someone have limited banana leaves, the size of the coating leaves can be made smaller, but with the same shape, that is, a rectangle.

The case where the outer leaves and the coating leaves are equal can be seen in Figure 3.

Figure 3. Concept of Congruence in Rectangles

The two leaves have a geometric concept, namely congruence. According to the concept of congruence, two or more objects are said to be congruent if they have the same shape and size. If the two leaves wrapping the barongko cake are drawn geometrically, the Figure 4 can be obtained.

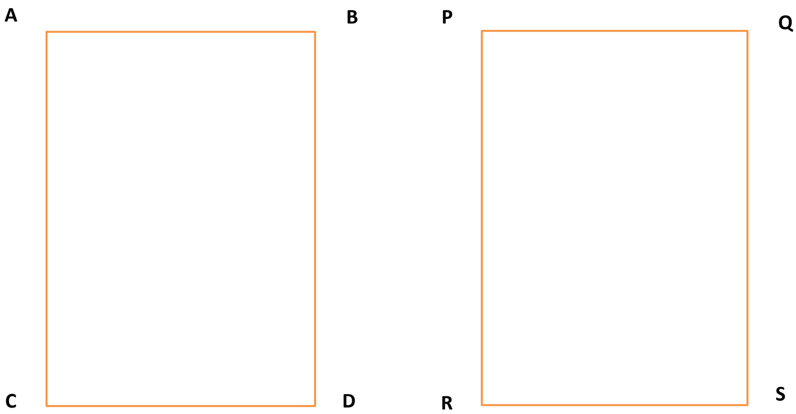

Figure 4. Modelling Congruence in Rectangles

The congruent characteristics based on Figure 4 are as follows:

1. The corresponding angles are the same.

   $\angle A = \angle P$ $\angle C = \angle R$

   $\angle B = \angle Q$ $\angle D = \angle S$

2. The corresponding sides are the same length

   $AB = PQ$ $AC = PR$

   $CD = RS$ $BD = QS$

Furthermore, the case where the coating leaf size is smaller than the outer leaf size can be seen in Figure 5.

Figure 5. Similarity Concept in Rectangles

The two leaves have the concept of geometry, namely similarity. According to the concept of similarity, two or more objects are similar if the corresponding angles have the same size and the corresponding sides have the same proportion. If the two leaves wrapping the barongko cake are drawn geometrically, Figure 6 can be obtained.

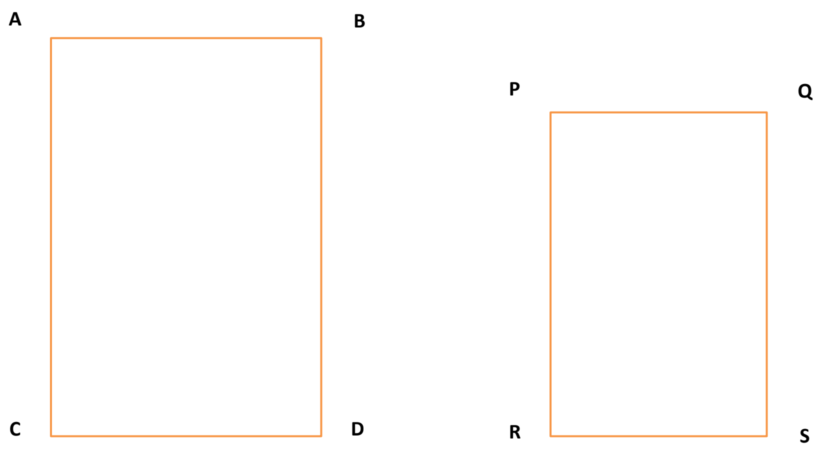

Figure 6. Modelling Similarity in a Rectangle

The similarity properties based on the Figure 6 are as follows:

1. The corresponding angles are the same.

   $\angle A = \angle P$ $\angle C = \angle R$

   $\angle B = \angle Q$ $\angle D = \angle S$

2. The corresponding sides have the same proportion.
$$\frac{AB}{PQ} = \frac{AC}{PR} = \frac{CD}{RS} = \frac{BD}{QS} = \frac{a}{b}$$

Concept of 3D shapes

An interview implying the concept of a 3D shapes in making barongko cake is presented in Dialog 3.

Dialog 3

Researcher : "After the leaves are coated, what are the next steps?"

Informant : "Next, the coated leaves are formed according to the barongko mold. The mold is wood. The size is adjusted to the taste of the maker. After that, mix all the ingredients such as mashed banana, sugar, eggs, and coconut milk."

Researcher : "What is the dose?"

Informant : "According to our taste. There is no definite measure. Usually, if a bunch of bananas, some use 10 eggs, some use 7 eggs, some even use only 5 eggs. The different is in taste. The more eggs the better the taste. Sugar is like that too. If you like it sweet, it has a lot of sugar. If you don't like it, it will be a little sweet. The important thing is that the barongko dough should be runny. After that, take the dough and pour it into the wrapper that was formed earlier"

Researcher : "How much dough to pour?"

Informant : "Generally half. It can't be full, because when the barongko is cooked, it will expand. So if it is full, it will spill. If the dough is poured using a ladle, usually given three spoons."

Dialog 3 stated that this research finds that the process of filling the dough into a wrapper previously shaped according to the mold contains the concepts of a 3D shapes. The concepts of the 3D shapes are described as follows.

- Triangular Prism

The next steps in making barongko cake are to form the wrapping leaves according to the mold. The shape of barongko wrapper is a triangular prism. The cake and mold can be seen in Figure 7.

Figure 7. Barongko Cake Mold (Left) and Barongko Cake (Right)

In geometric terms, the barongko cake can be modeled as shown in Figure 8.

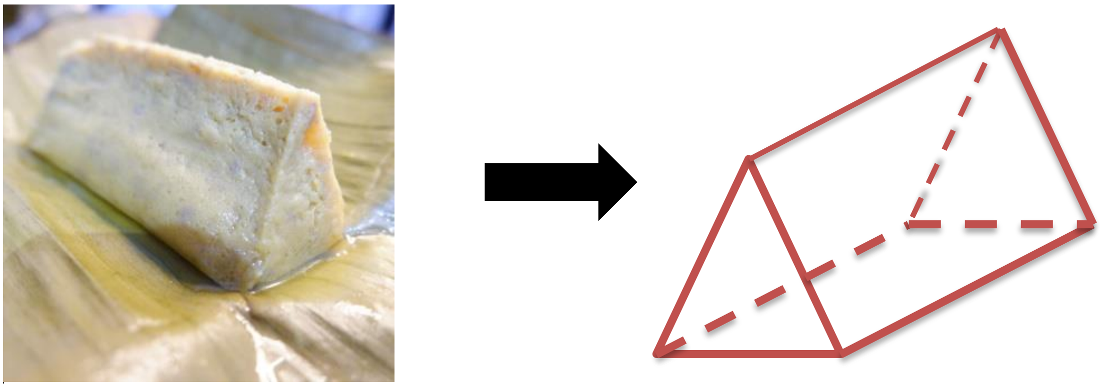

Figure 8. Geometric Model of Barongko Cake

The triangular prism properties based on Figure 8 are as follows:

1. It has five sides consisting of two congruent triangles and three rectangles.
2. It has nine edges.

- Triangular Prism Volume

Barongko cake dough is made from a mixture of bananas, sugar, coconut milk, and eggs. The dough is then poured into a triangular prism-shaped wrapper with the rule that the amount of dough poured is equal to half the volume of the cake wrapper. The process of pouring the dough into barongko wrap is shown in Figure 9.

Because the barongko cake wrapper is in the shape of a triangular prism, the volume can be written as follows:

$$V_{triangular\ prism} = B \times h_{prism} \quad (2)$$

with

$$B = \frac{1}{2} \times b_{triangle} \times h_{triangle} \quad (3)$$

If the number of doughs per pack is symbolized by N, it can be written mathematically as follows:

$$N = \frac{1}{2} \times V_{triangular\ prism} \quad (4)$$

By substituting Equations (2) and (3) into Equation (4), the equation is outlined as follows:

$$N = \frac{1}{2} \times B \times h_{prism}$$

$$N = \frac{1}{2} \times \frac{1}{2} \times b_{triangle} \times h_{triangle} \times h_{prism}$$

$$N = \frac{1}{4} \times b_{triangle} \times h_{triangle} \times h_{prism} \quad (5)$$

Where,

B = the base area of the triangular prism

N = the number of doughs per pack which is expressed in cm^2

$b_{triangle}$ = the triangle base on the base of the prism

$h_{triangle}$ = the triangle height at the base of the prism

h_{prism} = the height of the prism

Figure 9. Pouring the Doughs into the Barongko Wrappers

The shape of the triangular prism can be seen in Figure 10.

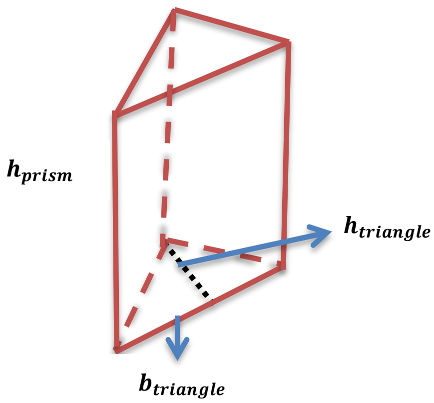

Figure 10. Triangular Prism Shape

- Half Sphere Volume

Based on the result of the interview, another way to determine the amount of barongko dough per pack is by using a half-sphere volume. From the information obtained, the dough can be poured using a half-spherical ladle. Since the ladle is a half sphere, the volume can be written as follows:

$$V_{half\ sphere} = \frac{1}{2} \times \frac{4}{3} \times \pi \times r^3 \quad (6)$$

To fill one wrapper, the dough is usually poured three times by using laddle. If the number of doughs per pack is symbolized by N, it can be written mathematically as follows:

$$N = 3 \times V_{half\ sphere} \quad (7)$$

By substituting Equation (6) into Equation (7), the equation is:

$$N = 3 \times \frac{1}{2} \times \frac{4}{3} \times \pi \times r^3$$
$$N = 2 \times \pi \times r^3 \quad (8)$$

The geometric model of ladle can be seen in Figure 11.

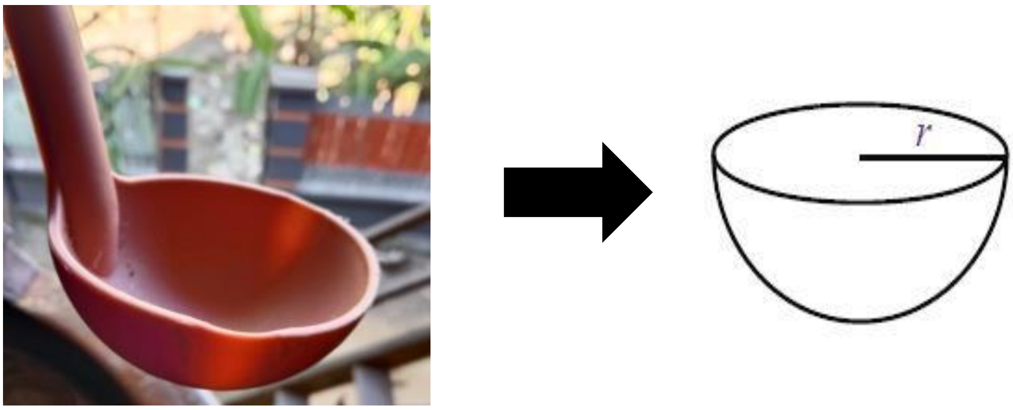

Figure 11. Geometric Model of Ladle

Proposed Barongko Cake in Buginese Culture as a Contextual Problem in Learning Mathematics

The process of making Barongko cake is a contextual problem and can be given and developed in mathematics learning for students. Learning by using contextual problems provides opportunities for students to solve problems in real life. It enables to provide a comprehensive understanding. In the learning process, the teacher and students can demonstrate how to make Barongko, while explaining the mathematical concepts contained in the process. Besides, the teacher can ask students to observe the process of making Barongko in their neighborhood and ask the students to explain each step. Teachers further asserts the mathematical concepts demonstrated in the student's explanation.

The following shows some examples of illustration of mathematics learning based on local culture, especially in making Barongko cakes for use in mathematics learning in schools.

- Concept of Division

From the research results, we find that the first step in the process of making barongko is the process of making cake wrappers. From one banana leaf midrib, some barongko wrappers can be obtained by applying the concept of division. After explaining the material to students, the teacher can end it by asking questions such as:

From one banana midrib, If the length of the midrib is 1.5 meters and the length of a barongko cake wrapper is 20 cm, how many cake wrappers can you get?

- Concept of Congruence and Similarity

The wrappers used in the making Barongko cakes is two leaves consisting of the outer wrapper and the inner wrapper. After the teacher explains the material, the teacher can give assignments to students such as:

Observe wrappers of the barongko cake. From the observations, explain the properties of the congruence or the similarity of the the wrappers.

- Concept of 3D shapes

Based on the result, this research finds that Barongko cake has a triangular prism shape. The teacher can ask students to identify the properties of a triangular prism by observing the shape of the cake. Next, the teacher and students discuss the process of filling Barongko dough into the wrappers made. In this process, the teacher explains material about the volume of a triangular prism. Having explained the material, the teacher can ask questions such as:

Indah plans to make barongko cake. Firstly, she makes a dough made from mashed bananas, eggs, sugar and coconut milk. After that, she takes a banana leaf and makes a barongko wrapper with a base area of 36 cm^2 and a height of 15 cm. So that the dough doesn't spill, the barongko wrappers can only be filled half. How much dough can Indah put in a wrapper?

The results of this study show that Buginese people have applied mathematical concepts in making barongko cake. They studied the concepts by themselves without a formal education. It indicates that mathematics is closely related to the environment and cultural values (Palinussa, 2013). This is in line with the purpose of ethnomathematics which is present to bring mathematics closer to the reality and perceptions of society.

Along with the development of research on ethnomathematics, an idea emerged to bring ethnomathematics into mathematics learning in schools. The reason is that most of the mathematics taught in schools is less relevant to the real world, and many students are unable to apply it. Rosa (2011) stated that the low achievement in mathematics was due to a lack of cultural fit in the curriculum. The findings of ethnomathematics exploration have also been applied in mathematics learning in several schools in Indonesia. As a result, it has been proven that the use of culture in learning can change negative perceptions of students on mathematics which has an impact on increasing student achievement and interest in mathematics.

Changes in students' perceptions of mathematics were shown from previous researchers who have succeeded in developing mathematics learning designs using the context of the exploration of ethnomathematics. The use of culture involving mathematical concepts in schools is found to have a positive influence on both teachers and students (Supriadi et al., 2016). The implementation of ethnomathematics in school learning increases motivation and learning achievement as well as improves students' problem solving abilities (Disnawati & Nahak, 2019; Mahendra, 2017; Prabawa & Zaenuri, 2017; Widada, Herawaty, Falaq, et al., 2019; Widada, Herawaty, Jumri, et al., 2019). In addition, ethnomathematics-based mathematics teaching materials are also attract students' interest in learning mathematics (Imswatama & Lukman, 2018). These findings can be references for making Barongko cake as a starting point in developing learning designs which are also expected to improve critical thinking and increase students' motivation in learning mathematics. This is because Barongko cake is one of the cultural heritages that are close to students' activities and daily life. It means that students have used contextual resources in learning mathematics in schools.

This study found several mathematical concepts such as, the concept of division, congruence and similarity, triangular prism, and half sphere. These mathematical concepts can be brought into formal mathematics learning which has the potential to be used as a contextual learning resource for students in schools. The findings in this study are related to the previous studies which found that several ethnic groups in Indonesia have applied ethnomathematics well and need to be socialized and used as contextual learning resources. Javanese society has applied geometry transformation concepts such as translation, rotation, dilatation, and reflection in the motif of Batik so that it can be used as a starting point in making mathematics learning design (Risdiyanti & Prahmana, 2017). In addition, it was found that Javanese people have also applied mathematical models to calculate an auspicious day for a wedding, which can be used in learning mathematics, for example, in the material of number or residue theory (Imswatama & Setiadi, 2017). Furthermore, Sundanese society has used symbolic mathematical calculations in daily activities such as calculating the length, width, height, area, weight, and time so that it is expected to inspire educators to use ethnomathematics in the realistic mathematics education program (Abdullah, 2017). The concepts of 2D and 3D geometry were also found in Sasaknese and Lionese architecture which can be implemented in learning mathematics in schools (Supiyati et al., 2019; Wondo et al., 2020). Lastly, Balinese society has applied the least common multiple in the Balinese calendar system (Suarjana et al., 2014). Compared to these previous ethnomathematics studies, this study complements the previous findings. These studies both studied ethnomathematics but in a different object. In this study, researchers investigated mathematical concepts in Buginese culture that are rarely explored. Just like other ethnicities such as Javanese, Sundanese, Sasaknese, Lionese, and

Balinese, Buginese is also rich in culture so that this research can be a reference for further research in studying the other Buginese ethnomathematics.

CONCLUSIONS

This research demonstrates that cultural heritage such as Barongko cake is still preserved and kept by the Buginese community. Buginese people have unconsciously been practicing mathematics in making Barongko cakes. These mathematical activities have been used and studied by the Buginese themselves without a formal education. The result of this study has shown that the process of making Barongko implies mathematical concepts and can be used in mathematics learning in schools. The concepts are related to division, congruence and similarity, as well as 3D shapes such as triangular prism and half sphere. Therefore, the cake has the potential to be used as a starting point in making mathematics learning design. This research is expected to provide motivation and inspiration for mathematics teachers to apply culture in mathematics learning activity in the classroom. By applying the local culture, students are led to understand mathematical concepts easily because they are presented contextually. Thus, the students learning process becomes meaningful because their mathematics learning resources come from the local culture and environment. Besides, this research is also expected to be a reference for further research in exploring the other Buginese ethnomathematics.

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