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EXPLORATION OF MATHEMATICAL CONCEPTS IN KITE MAKING WAU BENGKULU

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ABSTRACT
This study aims to analyze the mathematical concepts contained in the making of Wau Bengkulu kites and the exploration of mathematical concepts. This research is descriptive qualitative with ethnographic approach. This research was conducted at a kite-making site located in Suka Raja Village, Kampung Melayu Sub-district, Bengkulu City. The research subjects were kite craftsmen in Bengkulu Province. Data collection methods used were observation, interview, documentation, and literature study. Data analysis techniques were carried out with qualitative analysis techniques, namely, data collection, data reduction, data presentation, and conclusion drawing. The mathematical concepts contained in the making of this traditional game can be utilized to introduce and understand the concept of geometry through local culture. The making of Wau Bengkulu kite shows that there are mathematical concepts contained, namely the concepts of comparison, measurement, volume, folding symmetry and division point.
Keywords: Ethnomathematics, Culture, Traditional Kite Game

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PRELIMINARY

Indonesia is an archipelago that has a diversity of races, tribes, religions, languages and cultures. One of the uniqueness of Indonesia is the diversity of cultures that are not owned by other countries (Fadlilah et al., 2018). The diversity of traditions and customs is one of the historical heritages that must be preserved, because modern life gradually erodes the existence of local culture (Juliana et al., 2023). Indonesian local culture includes the culture of Bengkulu Province, which is developed by generations. The way of life passed down from generation to generation is called culture because it goes through various educational processes to determine the way of life that best suits the environment (Berutu et al., 2023). Various cultures exist in Indonesia ranging from traditional fabrics, traditional foods, buildings with cultural values, traditional games and so on (Merliza, 2022). Various activities in society have a link between culture and mathematics. This statement is reinforced by the opinion (Hardiarti, 2017) which states that mathematics and culture are two interrelated things.

Mathematics is one of the fields of study taught at school and is very close to life. Mathematics is a form of culture that has filled every element of people's lives (Destrianti, 2019). There is nothing that does not involve mathematics including culture. This statement is reinforced by the opinion (Hardiarti, 2017) which states that mathematics and culture are two interrelated things. One of the interesting cultures that can be understood and explored is traditional games (Munawaroh, 2017). Each region in Indonesia has its own traditional games, which were of interest to children in the past even though they were not as sophisticated as they are now (Lestari et al., 2022).

Bengkulu is one of the provinces in Indonesia that has a diversity of traditional games, such as palak babi, cranklek, congklak, and wau kite. Wau kite is one of Indonesia's traditional games that is almost found in every region, with different characteristics (Troulis, 2020). The Bengkulu Wau kite game is one of the cultures that can be an opportunity to explore, identify, and integrate mathematical concepts.

Mathematics contained in a culture is called Ethnomathematics (Lestari et al., 2022). Marsigit, et al., (2014), ethnomathematics is one part of culture-based realistic mathematics education. Realistic Mathematics Education learning based on ethnomathematics is learning that presents mathematical problems into real world problems (Ardianingsih et al., 2020). Ethnomathematics is an effort to integrate and introduce culture and mathematics together (Lisnani et al., 2020). According to Astutiningtyas (2017), ethnomathematics is part of a series of procedures used by a community or cultural group in carrying out mathematical activities. Ethnomathematics is mathematics learning that grows and develops in certain community cultures that can be used in the learning process (Risdiyanti & Prahmana, 2018). Mathematics with cultural nuances can make a major contribution to increasing students' ability to learn mathematics more optimally (Sarwoedi et al., 2018). Mathematics is part of a culture that can be applied and used to assess new ideas (Ummaroh et al., 2023). The link between mathematics and cultural values can be used as a source of learning mathematics that is more meaningful to students.

Several ethnomathematics studies have investigated traditional foods, buildings of cultural value, and traditional games. Research on the process of making Sendaren kites, shows the concept of mathematics during kite making activities regarding the way of thinking and activities of craftsmen related to mathematics (Widiastuti et al., 2022). Research on the traditional game patok lele in West Insana, Timor Island, shows the potential of ethnomathematics on the concept of geometry (Bengu et al., 2023).

Based on the above, ethnomathematics in this study will examine the mathematical concepts contained in the process of making Wau kites in Bengkulu. With the aim of providing insight into how people use math in their daily life activities. The results showed that there was an effect of the application of ethnomathematics through traditional games in improving students' cognitive abilities, and ethnomathematics through traditional games was effective in improving students' cognitive abilities. The researcher hopes to provide a broader picture of how mathematical concepts are embedded in culture, as well as increase the researcher's understanding of mathematics, culture, and society and strengthen the relationship between scientists, traditional communities and educators towards traditional games.

METHODS

This research is a descriptive qualitative research with ethnographic method, in order to explore and describe mathematical concepts in the process of making Wau kites Bengkulu. Descriptive qualitative research is a research strategy that investigates events, phenomena of individual lives and asks a person or group of individuals to tell about their lives (Rusandi & Rusli, 2021). Ethnography is a qualitative approach, to know, describe, and explain elements in the community environment, through data collection in the field (Karimah et al., 2021).

This research was conducted at a kite-making site located in Suka Raja Village, Kampung Melayu Sub-district, Bengkulu City. The subjects of this research are two Bengkulu Wau kite craftsmen. Data collection techniques in this research include observation, documentation, interviews, and literature study directly to the respondents. The interview technique used was semi-structured and documented through audio recordings and photographs. The above data collection techniques referred to in this study are data collection through observation carried out by direct observation of craftsmen in the process of making Wau Kite, and documentation and notes collected related to each activity of craftsmen in the process of making Wau Kite. This data analysis technique uses the Miles and Huberman interactive scheme, consisting of data collection, data reduction, data presentation and conclusion drawing/verification (Abdul, 2020). The data analysis scheme can be seen in Figure 1.

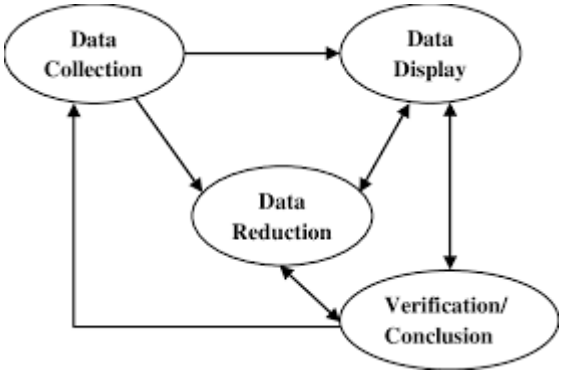

Figure 1. Miles Interactive scheme, Huberman

1. Data collection is data obtained directly in the field, to reveal or capture various phenomena or conditions of the research location in accordance with the research context.
2. Data reduction aims to sort out the main things from the data obtained from the field, and focus on important things. which are recorded carefully and in detail, the more researchers go to the field, the more the amount of data obtained will be, and complex.
3. Data presentation aims to present data about the process of making kites from craftsmen, then describe it in sentence form. Then it will be easier to understand what happened, and design the next work based on what has been understood.
4. Data verification aims to get new findings and is adjusted to the formulation of research problems. Initial conclusions are still provisional and will undergo changes if no strong evidence is found to support the next stage of data collection, and vice versa.

RESULT AND DISCUSSION

Based on the results of observations obtained data related to mathematical concepts in the making of Wau Bengkulu Kites. Kites are one type of game that is familiar to the people of Indonesia, especially Bengkulu, kites are usually played by children, teenagers, and adults who are played in the field, kite games have existed for thousands of years, usually to ward off evil, convey messages, and are even used to determine natural phenomena and measure the weather, but nowadays kites are only flown for fun (Kuswidi et al., 2021). A familiar type of kite played in Bengkulu today is known as "Wau Kites", which has a unique shape such as the shape of a bird and a fish with a cover decorated with traditional Bengkulu motifs.

Figure 2. Wau Kite

Meanwhile, in the process of making Wau Bengkulu kites, there are three stages, namely the preparation stage, the implementation stage, and the completion stage. This preparation stage consists of the preparation of tools and materials, the tools used are scissors, cutters, cleaver saws, knives, glue, and thread, while the materials needed are bamboo, plastic bags, and plastic tape. In the preparation stage of making, craftsmen choose a good type of bamboo, the bamboo used is old bamboo that has been dried with the aim of avoiding breaking and bending to be formed and curved. In the implementation stage, they arrange the smoothed bamboo frame which is tied with thread to form a kite frame. The finishing stage involves attaching the cover to the formed frame, and any additional decoration required.

Researchers found several kite craftsmen in Bengkulu, as the game of kite is currently very familiar to the people of Bengkulu. In early October, the Agro Mitra Abadi Cup kite festival was held on Jl.Semarak, padang serai urban village. Kampung Melayu sub-district, Bengkulu City. One of the craftsmen interviewed named Selo who is usually called (bang Selo) where the kites made do not eliminate the characteristics of Bengkulu, namely the rafflesia flower, the craftsman provides a motif in the form of a rafflesia flower on the cover of the kite he made. Based on the results of the researcher's interview, the information that the researcher can translate from the traditional system into mathematical language.

The mathematical study conducted by researchers during the process of making Wau kites is described based on mathematical activities and mathematical concepts that are in accordance with the mathematics material contained. Mathematical activities in this study refer to activities based on the way of thinking carried out by craftsmen in the process of making wau kites, where these activities are related to mathematics. Meanwhile, mathematical concepts in this study refer to several material topics related to mathematics.

Mathematical concepts are found at the beginning of the kite-making process until it is completed.

“Interview excerpt"

Researcher : What materials and tools are needed to make kites?

Respondent : Materials and tools in making kites, there are two large bamboos, five large plastic bags, if the plastic is used for the cover of the kite later.

Researcher : What type of bamboo is used?

Respondent : Abang uses ordinary bamboo, actually any type of bamboo can be used to make kites.

Researcher : How many kites is that for?

Respondent : For one kite, which measures two fathoms (2 meters)

Researcher : Approximately how long does it take to complete one kite bang?

Respondent : As for the time, some are counted as hours, even up to several days.

Researcher : For a kite measuring 2 fathoms, how many days does it take to complete?

Respondent : One day is finished depending on how big the kite is made.

Researcher : For example, for 4 meters (four fathoms), how many days does it take?

Respondent : It can take up to two days to complete

Researcher : Are the materials needed for a four-fathom kite the same as for a two-fathom kite?

Respondent : No, for materials both plastic and bamboo also increase, the larger the size of the kite made, the more bamboo and plastic we need.

Based on interviews, the activities carried out by craftsmen in making Wau kites include being integrated into several activities, determining the amount of bamboo used, how many plastic bags are needed to make one kite of a certain size, the amount of time to complete one kite of a certain size, and explained that the larger the size of the kite made, the more materials and tools needed. It turns out that when the craftsmen provide an explanation of the above preparation activities, there is a mathematical concept that appears in these activities, namely the concept of value comparison.

A value comparison is a comparison that has the same value. That is, if the initial value gets bigger then the final value also gets bigger. Conversely, if the initial value gets smaller, the final value gets smaller.

For example:

$$\frac{a}{b} = \frac{p}{q} \rightarrow a \times q = b \times p$$

a is proportional to p

b is proportional to q

Ethnomathematics appears in measuring activities, when craftsmen determine the size of bamboo and plastic, craftsmen state that the size/small and length/shortness of the bamboo needed is different according to needs, and uniquely in measuring activities craftsmen still do it traditionally,

"Interview excerpt"

Researcher : To measure the length of bamboo needed, what do you use?

Respondent : To measure it, brother still uses body length measurements, known as onefathom, you know?

(One fathom is from the middle of the chest to the tip of the middle finger, with the position of the arm straight to the side, usually one fathom is equal to 1 meter on the meter)

It's not only the bamboo that is measured but also the length of the thread, and the plastic needed by hand.

Researcher : Is the measurement still traditional?

Respondent : Yes, because according to brother it is easier

Researcher : What was the fathom size to measure?

Respondent :To measure the length of the wing and the center bone of the kite only, later when you get a piece of bamboo that has been measured by the size of the fathom, for example the wing, then cut it again with reference to the bamboo piece obtained earlier, so that the two pieces of bamboo needed for the kite wing frame will be the same length.

Based on the interview, in the activity above, the craftsman stated that when determining the length of bamboo to make a kite by functioning the body part of the arm, and measuring the plastic needed. It turns out that from the activity quoted in the interview above, there is a mathematical concept that emerges, namely the concept of measurement.

Measurement is a number that indicates the comparison between the nature of the object being measured and the same nature of a particular unit of measure which includes short length, low height, light weight, volume, time, temperature and money (Sa'ida et al., 2017). Measurement is one part of the cognitive development aspect, especially the math

aspect that needs to be instilled early on. The concept of measurement is applied by respondents to kite making. In order for the kite to fly high and balanced with the size of the frame and cover that is the same length and the same size. Respondents used body parts as units of measurement in the form of fathoms (hand sleeves).

Figure 3. Volume Concept

Ethnomathematics that appears in Figure 3 when craftsmen determine the size of the thickness / thinness of bamboo in the process of sharpening bamboo, especially in determining the size of each kite frame such as the central bone, wings, tail, and other parts. In this case the craftsman uses a knife to support the activity of seaming bamboo.

Based on interviews, when craftsmen determine the size of the thickness / thinness of bamboo on each part of the kite frame with different sizes, on the grounds that the kite can fly high and does not experience body objections when flying. It turns out that the activity of measuring the thickness / thinness of bamboo in seaming bamboo using a knife has a mathematical concept, namely the concept of volume.

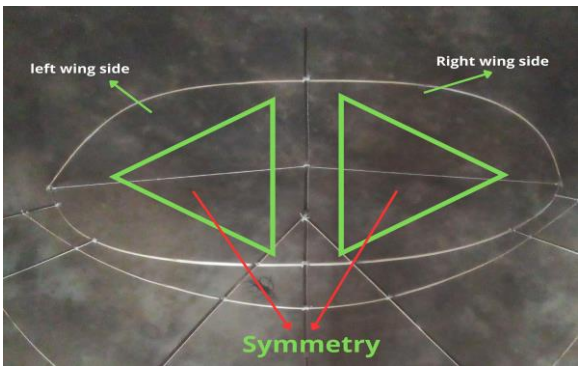

Figure 4. Folding Symmetry Concept

Ethnomathematics that appears in Figure 4 during the process of craftsmen forming kite frames with shapes and sizes on the right and left sides of the kite wings must be the same size and length.

“Interview excerpt"

Researcher : The shape of the wings must be like this (figure 2), if other shapes can?

Respondent : Can, depending on the craftsman

Researcher : Means there are no provisions?

Respondent : No, the shape of the wings that you make is a common shape on kite wings, usually there is also a shape similar to a bird and there is a round shape, various shapes usually depend on the craftsman who wants to shape how

Researcher : Why does the wing size have to be the same?

Respondent : Yes, for the size of the right wing and left wing it must be the same size / comparable and the same length, so that the kite can be balanced when flying and can even fly high.

Researcher : If the size of the right wing and the left wing are different sizes, can the kite still fly?

Respondent : If the size of the kite's wings is different, the kite will have difficulty flying / one-sided weight, so that the kite is difficult to fly and cannot even be flown as a result it often falls in one direction (right / left), because the right wing and left wing are not the same size. If it flies up a little, it immediately fall to the ground.

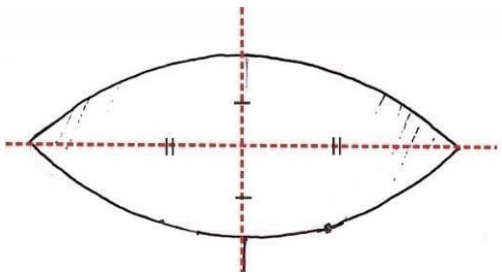

Figure 5. Illustration of The Concept of Fold Symmetry

From pictures 4 and 5 above, we can find out that there is a concept of symmetry on the wings of the kite. The characteristics of folding symmetry that need to be known as follows:

a. Folds cover each other: if a flat shape is folded, the folds will cover each other snugly.

b. Dividing a flat into two equal parts: clay symmetry will divide the flat into two equal parts, both in shape and size.
c. Has an axis of symmetry: an axis of symmetry is a line that can divide a flat shape into two equal parts.

Based on the interview, in the activity of determining the wings of the kite, the craftsman said that the right wing and left wing on the Wau kite must be the same size and the same length, so that the kite can be balanced and can fly high. From this quote, a mathematical concept emerged, namely the concept of folding symmetry on the wings of the kite. Folding symmetry is the number of folds in flat structures such as isosceles and equilateral triangles, squares, rectangles, or others. Folding symmetry will divide two flat shapes that produce shapes of the same shape and size. The concept of folding symmetry is carried out by craftsmen in providing a plastic layer / cover on the wings of the kite. This is done with the aim of producing the same side, so there is folding symmetry in Figure 4.

Figure 6. Concept of Midpoint with Balance

Ethnomathematics that appears in Figure 6 when craftsmen balance after the activity of sharpening bamboo, the balance is carried out using a knife precisely at the midpoint or dividing point of the skeleton on the backbone and ribs of the kite which forms a cut point. With the aim of proving that from end to end on the bamboo reef that will be used later the same size or balanced, so that the kite can fly high and not experience objections when flying, especially on the wings of the kite. Interestingly, craftsmen still do this activity traditionally, namely weighing knives. In geometry states that points can be described but cannot be defined and their location can be determined (Yudianto et al., 2021). In these results, a mathematical concept emerges, namely the concept of the dividing point in the weighing knife activity.

CONCLUSION

Based on the results and discussion above, it can be concluded that Kite is one type of game that is familiar to the people of Indonesia, especially Bengkulu, Wau kites are played by children, teenagers, and adults who are played in the field, kite games have existed for thousands of years, usually to ward off evil, convey messages, and are even used to determine natural phenomena and measure the weather, but nowadays kites are only flown for fun.

Based on the data analysis carried out, it shows the existence of mathematical concepts in the making of the traditional game Kite Wau Bengkulu, namely (1) the concept of value comparison, found when craftsmen calculate the tools and materials used, and the statement that the larger the size of the kite made the materials and tools needed increase. (2) the concept of measuring, found when craftsmen determine the length of bamboo by functioning parts of the body, measuring plastic, and measuring the thickness / thinness of bamboo when seaming bamboo, (3) the concept of volume, appears when craftsmen determine the thickness / thinness of kite corals in bamboo seaming activities using knives, (4) the concept of folding symmetry, (4) the concept of folding symmetry, which appears when craftsmen determine the size of the left wing and right wing of the kite must be the same length and the same size, (5) the concept of the midpoint, which appears when craftsmen balance using a knife right at the midpoint or dividing point of the frame on the backbone and ribs of the kite which forms a cut point. Thus, insight into the mathematical concepts in the traditional game of Wau kite can be used as an object of culture-based mathematics learning.

By utilizing the results of the exploration of mathematical concepts in kite making, educators can create valuable learning experiences for learners, which not only enhance their understanding of scientific and technical concepts, but also develop creative, collaborative and problem-solving skills.

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