

Ethnomathematics Of The Jejahan In Balinese Hindu Ritual

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Abstract

Ethnomathematics is a mathematical concept contained in a culture. The presence of mathematics with cultural nuances will make a significant contribution to learning mathematics. One of the ethnomathematics objects in Balinese Hindu culture is the jejahan which is used as a medium for learning geometry. Jejahan is a means of praying for traditional Balinese Hindu ceremonies made of young coconut leaves or janur, dried double palm leaves, with various supporting materials such as flowers and fruit. The jejahan used in ethnomathematics objects such as taledan, lamak, ituk-ituk, ceniga, tamiang, serembeng daksina, and sampian kapit kacang/canang kojong. At the same time, the applied mathematical concepts (geometry) are square, rectangle, triangle, circle, trapezoid, cylinder, cone, symmetry, width, circumference and volume. Ethnomathematics is very important; apart from being a student learning material, it also serves as a cultural preservation venue.

Keywords: Ethnomathematics; Jejahan; Geometry.



INTRODUCTION

Science and technology are growing along with the times. It contributes significantly to the development of educational technology. Amid developments in educational technology, the educational curriculum also demands cultural involvement in learning in schools to ensure that students can become a generation with character and maintain and preserve culture as the foundation of national character. Education is an essential pillar of a nation towards advanced civilization and being able to compete with other nations. Every human being needs education in order to avoid backwardness following the goals of national education, namely educating the life of the nation and developing a complete Indonesian human being, namely human beings who believe in and are devoted to God Almighty and have a noble character, have knowledge and skills, physical and spiritual health, personality steady and independent as well as a sense of social and national responsibility (Yassa, 2018). Achieving national education goals requires teacher creativity, to provide meaningful learning to students and help students' understanding to explain the abstractness of objects requires various things that are close to students' daily lives, one of which can be done is with culture-based learning that provide space for students to be given solutions contextually (Nanga & Suwarsono, 2019; Temaja, 2021).

The implementation of culture-based learning to meet national education standards enriched with comparative and competitive advantages based on noble cultural values so that students can actively develop their potential so that they become superior, intelligent, visionary, sensitive to the environment and cultural diversity, and responsive towards the environment and cultural diversity, as well as being responsive to world developments (Felani, 2017). Indonesia is already known for its cultural diversity, which is very aesthetic and cannot be found in any other country. Culture has contained elements of educational material, namely mathematics. This culture and mathematics are summarized in ethnomathematics. However, most people are unaware of it (Azizah, 2020). Mathematics and culture are two things that are closely related. However, sometimes mathematics is seen as outside of everyday life. In teaching formal mathematics (school mathematics), teachers should start by exploring informal mathematical knowledge obtained by students and the community life around where they live. The environment can be a source of math problems in real life. The environment is one of them in the form of culture. Mathematics in culture is known as ethnomathematics.



Ethnomathematics is a mathematical concept contained in a culture. The presence of mathematics with cultural nuances will significantly contribute to learning mathematics. One example of a traditional game of marbles can be taken. The traditional game of marbles has ethnomathematics related to mathematical concepts, including geometric concepts such as circles, balls, and triangles and the concept of distance. These mathematical concepts can be used to introduce and understand the concepts of geometry and distance through local culture (Pratiwi & Pujiastuti, 2020). Ethnomathematics can be divided into six basic activities, which can always be found in several cultural groups. The six mathematical activities are counting, locating, measuring, designing, playing, and explaining.

Mathematics has been constructed from the human understanding of the world empirically, with that experience being processed in analysis through experience in cognitive structures, so that mathematical concepts are formed that are easy for people to understand and can be precisely manipulated using mathematical language or mathematical notation that has value. Globally, this concept is obtained from the thinking process; therefore, logic is the basis for the formation of mathematics (Rahmah, 2018).

Digital revolution and era of technological disruption are other terms of industry 4.0. called a digital revolution due to computer proliferation and recording automation in all fields (Ghufron, 2018). The acceleration of the development of the digitalization of the Industrial Revolution 4.0 provides convenience in accessing information, and ease of access can have a positive and negative impact on cultural preservation. For example, because of the influence of globalization allows the process of assimilation and cultural acculturation to advance very fast. The feared impact is the emergence of the shame of the younger generation towards their own culture. The *katrok* 'countrified' view might overshadow the next generation who should struggle to be the holder of the nation's identity in the future.

D'Ambrosio (2001) stated that mathematics taught in schools is academic, while ethnomathematics is mathematics applied to identified cultural groups such as work groups, professional classes, and others. Yusuf et al. (2010) stated that ethnomathematics is mathematics that grows and develops in a particular culture. Therefore, it can be said that ethnomathematics is mathematics that arises from the influence of existing activities in an environment influenced by culture. Because it grows and develops from culture, the existence of ethnomathematics is often not realized by the people who use it. It is because ethnomathematics often looks "simple" than the forms of mathematics found in schools. Local people accustomed to using



ethnomathematics may feel insecure about their ancestral heritage because mathematics in this culture is not equipped with definitions, theorems, and formulas as are usually found in academic mathematics. Studies on ethnomathematics have also reached Balinese culture. Some of them are Suryanatha and Apsari (2013) Suryanatha, who examines the model concept found in the naming system in Bali. Puspadewi and Putra (2014) has also studied ethnomathematics in woven crafts in Bali and their relation to learning. Mathematical elements that can be learned in woven crafts include the concept of tiling, the concept of parallel lines, and angles. Apart from those already mentioned, another element of Balinese culture that is no less interesting is Balinese *jejahitan*. *Jejahitan* is a means of prayer made from young coconut leaves or *janur*, fronds with various supporting materials such as flowers and fruit.



Figure 1. Balinese woman is making *jejahitan*

Seeing the facts above, what needs to be considered is the role of mathematics educators at various levels of education in contributing to the preservation and promotion of culture. In order to answer this question, the presence of an ethnomathematics concept or field of study is one way to show this contribution. Ethnomathematics is very suitable to be applied in the era of the Industrial Revolution 4.0, on this occasion of the development of digitalization. Besides being able to be a place for preserving culture, it also functions as a way to break the assumptions of students and the wider community who always think that the implementation of mathematics lessons in everyday life is only in a small scope or superficial things. Therefore, it is essential to promote ethnomathematics as teaching material at every level of education. This research

explored ethnomathematics in Balinese culture, namely the Balinese Hindu Ritual *jejahitan* model. Balinese *jejahitan* is a product of *jejahitan* activities, namely changing various leaves such as coconut leaves, dark green coconut leaves, palm leaves, and others into certain forms in *banten* or offerings used for religious activities of Hindus in Bali. The forms of Balinese *jejahitan* are triangular, rectangular and round (circle). These *jejahitan* forms are a unique, aesthetic, and contextual medium in mathematics lessons, making mathematics a fascinating, fun, and easy-to-understand lesson. The media in question can be in the form of various geometric shapes or flat shapes.

METHOD

This research is fundamental and aims to obtain information related to ethnomathematics in Balinese *jejahitan*. Therefore, the research design is exploratory. Exploratory research aims to obtain information and data regarding matters that are not yet known. Researchers have yet to obtain initial data; hence they do not have a complete picture of the matter to be studied. Exploratory research does not require hypotheses (Muhammad, 2004). The data on ethnomathematics were collected through literature studies and interviews. Literature study is used to examine in-depth Balinese *jejahitan*. Interviews were conducted with several people who have *jejahitan* skills. Interviews were conducted to clarify the data obtained through the literature study. The data on ethnomathematics were analyzed descriptively.

DISCUSSION

Geometry in Balinese *jejahitan*

The geometry of Balinese *jejahitan* is flat and spatial. The following explanation is the types of *jejahitan*:

Taledan

Explain the results of the research in the form of problem-solving analyzed using relevant theories. The results of the study also revealed the findings of the research. Discussion is accompanied by logical arguments by linking the results of research with theory, the results of other studies.

Taledan in Balinese life is usually used as a base for offerings to God. It is also used as a *lawar* mat (one of the Balinese specialties). *Taledan* is made using *selapan* or green coconut



leaves, stitched with *semat* (made of bamboo and split into small pieces). The shape is rectangular or, more precisely, square, with frames (*sebeh*) on all four sides. In order to make a cutting board, the materials are blades and pins, and the tool is a knife. Cut the *selekan* according to the desired cutting-edge size. If the size is small, short pieces of about one inch and two fingers, but still adjusted to the needs.



Figure 2. Taledan

Taledan is a type of *jejahitan* made by intertwining several pieces of coconut leaves with *semat*. Some of the mathematical concepts in *taledan* form a square shape, and some form a rectangle shape. It depends on the type of *taledan*. There are *taledans* without *sebeh* (edges), and some use *sebeh* (edges). The figure above is *taledan* using *sebeh*, which is square. The material that can be utilized from this *taledan* is identifying square elements. Square elements on the *taledan*: It has four sides of the same length. It has four right angles. The two diagonals are perpendicular.

The circumference of the *taledan* is the same as the circumference of a square which can be calculated using the formula. The edge of the cutting board indicates the circumference of the cutting board, so to find out the circumference of the cutting board, one can make four equal cuts for the edge of the cutting board. The width of the cutting board can also be calculated using the square width. The formula can calculate the width of a square: The width of a foliar gives an interpretation of the number of pieces of leaf needed. The cut of the coconut leaf in question is the cut of the coconut leaf, which is the surface of the cutting board before it is edged. As with a

square shape, *taledan*, as a square figure model, can show folding and rotational symmetry. A square's fold symmetry is the line that cuts the square into two equal parts. Therefore, a square has four-fold symmetries. In addition to the fold symmetry, a square has four rotational symmetries.

Lamak

Lamak is a tablecloth made of palm leaves woven with bamboo sticks. *Lamak* is placed in small rooms in Hindu temple buildings in Bali called *palinggih* as a pedestal for placing offerings and attached to the *penjor* for holidays or essential *yadnya* ceremonies for Hindus in Bali. *Lamak* ornaments with the use of *pis bolong* as a means of the *yadnya* ceremony are said to be the influence and acculturation of Chinese culture on Balinese cultural civilization, which they still respect and use today.



Figure 3. Lamak

Three types of *lamak* are often seen: *Terujungan*, namely *lamak*, which is usually installed on the side of the house, and *natah* or home yard. Small *lamak* is usually attached to shrines such as *Apit Lawang*, wells, *langkiran*, and monuments. The *Lamak Besar* is usually installed at the main shrines such as *Gedong*, *Saren*, *Pelinggih Taksu*, *Gunung Agung*, and *Padmasana*.

As often witnessed in the implementation of the *Dewa Yadnya* ceremony, the *lamak*, which is made of young coconut leaves and old palm leaves, is usually considered a type of *jejaitan* complicated for fathers who are not used to doing it. However, it is relatively easy if we

want to learn it. Inside the *lamak*, various carvings are meaningful as religious symbols, namely the mountain symbols, *kayonan* symbols, *cili-cilian*, moon, stars, sun, and others. Various ornaments are used, such as mountains, believed to be a source of life which is very closely related to *kayonan*. *Cili-cilian* is a symbol of *purusa* and *pradana* which will later have an emphasis on the concept of *rwabhineda* or two worlds. The star is believed to be a symbol of prosperity. As a solar symbol, the sun is believed to be the giver of life. In the later installation, *lamak* is assembled with leaves, offerings, and incense. It is also equipped with a hanging stand.

According to Sudarsana (2010) said that *lamak* is a *jejahitan* that is often used by the Hindu community in Bali specifically for certain sacred events, especially *piodalan* ceremonies. This *lamak* is made from *arenga pinnata* or young coconut leaves, the size varies according to needs. The shape of the *lamak* is elongated with the length and width adjusted to the needs. *Lamak* as a symbol of the base or base of the *pinunas* (the basis for the request to Sang Hyang Widhi is in accordance with karma).

Lamak is a type of *jejahitan* made by *jejahitan* several pieces of *ambu* (palm leaves that are still young and yellowish white) with *semat* (stabs made of bamboo material), then filled with various decorative motifs and decorated with edges in the form of *ron* leaves (palm leaves that are already dark green). The mathematical concept of the *lamak* forms a rectangular shape. One of the flat shape materials used from *lamak* is identifying the *lamak* elements that match the rectangular elements. The rectangular elements in *lamak* have two pairs of parallel sides and the same length. It has four right angles. The diagonals are cut the same length in the middle.

Lamak represents a rectangular shape with the same elements as a rectangle. The circumference and width of the *lamak* can also be determined. The circumference of the *lamak* is known to be the same as the circumference of a rectangle which can be calculated using the formula: The circumference of the *lamak* is indicated by the edge of the *lamak* made of *ron* leaves, hence to find out the circumference of the *lamak*. It can be done by calculating the length and width of the *ron* leaf pieces for the edge of the *lamak*. The palm's width can also be calculated using the terms of the rectangle's width. The width of a rectangle can be calculated using the formula: The width of the *lamak* gives an interpretation of the number of pieces of leaf needed. As with a rectangular shape, if we use it as a model for a rectangle, we can show the folding and rotational symmetry that a rectangle has.

Ituk-ituk



Ituk-ituk is a *jejahitan* that the Balinese often make as a base for offerings or for making *canang*. *Ituk-ituk* is made by making *tagelan* (corner bends) three times and connecting them with pins to form a triangular shape. The mathematical concept in this *ituk-ituk* can be seen from the elements of a triangle, such as having three sides, a height, and a circumference. The triangular elements in the *ituk-ituk* are: It has three sides. It has three corner points. A perpendicular line can be drawn from a particular corner point which produces a height line.

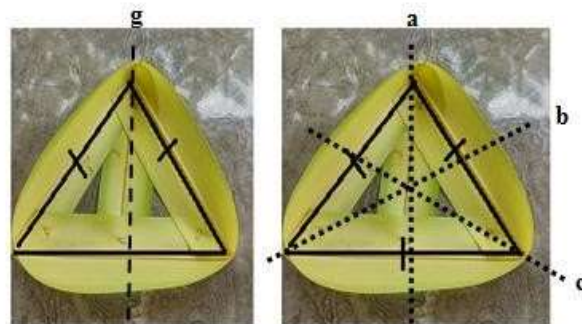


Figure. 3 *Ituk-ituk*

A good squiggle shape will form an equilateral triangle or isosceles triangle. These turtles have elements similar to triangles. The circumference of a triangle can be calculated by adding up the lengths of the sides. The length of the young coconut leaves needed to make the *ituk-ituk* can be determined by adding the triangle's height to the triangle's circumference, which resembles the *ituk-ituk*. The shape's width can determine the width of a triangle. Through the medium of the shape, it makes it easier to find out the triangle's width by looking at the elements of the base and height of the triangle. In addition to circumference and width, triangles have folding and rotational symmetry. The fold symmetry that a triangle has depends on the type of triangle it is. Especially for beautiful turtledoves, most of which form isosceles triangles and equilateral triangles. The fold symmetry for an isosceles triangle has one-fold symmetry, whereas an equilateral triangle has three-fold symmetry. Apart from these two triangles, there are still several types, such as arbitrary and right triangles. The two triangles, both arbitrary and right triangles, do not have any fold symmetry except for isosceles right triangles. In addition to folding symmetry, every plane shape must have rotational symmetry. Rotational symmetry for a triangle also depends on the type of triangle. For example, an equilateral triangle has three rotational symmetries, while any other triangle besides an equilateral triangle has a one-fold.

Ceniga

Ceniga is one of the *jejahitan* that is often used on Galungan, Kuningan, and other significant holy days for Hindus. The place of installation is affixed to shrines or sacred buildings as well as places or statues that have something to do with the celebration being carried out. The installation is used as clothing equipment during ceremonies and unique offerings to signify that the Hindu religious ceremony is being held in the building/place. *Ceniga* is often made from a combination of coconut leaves, *selepan* (green coconut leaves), or *ron*. *Ceniga* is usually arranged with three pieces of coconut leaf linked and shaped so that the lower part is wider, while the upper part is slightly pointed but does not form an angle (flat). The mathematical concept in *ceniga* is that the seams of the *janur* pieces will form a trapezoid. The elements of the isosceles trapezoid in *ceniga* are: It has a pair of parallel opposite sides. It has two opposite sides that are the same length. Adjacent angles are equal.

The math lessons that can be learned from this *jejahitan* are the characteristics of a trapezoidal shape, especially an isosceles trapezoid. One characteristic of an isosceles trapezoid is that it has four sides with a pair of parallel sides and a pair of opposite sides that are the same length. In addition to the characteristics of the trapezoid, the circumference and width of the trapezoid can also be determined. The circumference of the trapezoid is determined by adding up the lengths of the sides of the trapezoid, while the width of the trapezoid is determined by:

Explanation:

$$Width = \pi \frac{1}{2} \times (a + b) \times t$$

a = base

b = top side

t = height



Figure 4. *Ceniga*

In addition to the circumference and width, the mathematics learning that can be learned from the *ceniga* shape is about the folding and rotational symmetry of the trapezoidal shape. The folding and rotational symmetries of the trapezoid in the *ceniga* form are one-fold symmetry and one-rotation symmetry.

Tamiang

This *tamiang* is round in shape, with its form like the tip of a weapon shaped like a chakra weapon. Usually, this *sampian/tamiang* is attached to the sacred building on the left side of the sacred building every Kuningan Day. This *tamiang* is an antidote to disturbances that have the power of Bhuta Bucari; hence they do not reside in the sacred building.

Tamiang comes from the word *tameng* or shield, which means self-protection, symbolizing strength in defending the victory obtained on the Galungan holy day. Apart from that, *tamiang* is also the *niyasa* of Dewa Nawasanga as the guardian of all directions of the compass. It is conceivable that the nine compass directions protect humanity so that it is safe and secure. *Tamiang* is one of the *jejahitan* that is often used during the Kuningan holiday. However, along with the times, now *tamiang* also functions as part of the decoration. *Tamiang* is made by stringing *janur-janur* in one center until it is full to form a circle. The mathematical concept in *tamiang* is a circle. *Tamiang* has characteristics similar to a circle. One of the elements of the circle that is very visible in *tamiang* is the radius. The circle's radius is the initial selection that must be prepared in making *tamiang*. *Tamiang* is in the shape of a full circle; therefore, finding its width and circumference is effortless because we know the radius. The formula for finding the circumference of a circle can be determined using the following formula:

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Figure 5. *Tamiang*

Explanation:

circumference = $2 \pi r$

r = Circle radius

Score $\pi \frac{22}{7}$ or 3,14

Meanwhile, to determine the width can be used the following formula.

width = $\pi \cdot r^2$

Explanation:

r = Circle radius

Score $\pi \frac{22}{7}$ or 3,14

In addition to circumference and width, *tamiang* exhibits folding and rotational symmetry. The folding and rotating symmetries that circles have are infinite.

Serembeng daksina

Serembeng daksina is made from young or old coconut leaves in the form of a tube/cylinder, having two cross-sections up and down, and the cross-section below is tightly closed; hence it resembles a base. This shape symbolizes the earth, a reflection of Hyang Ibu Pertiwi. *Daksina* is a means of offering or a sign of gratitude that always accompanies rather large offerings and manifests asceticism.



Figure 6. Serembeng daksina

Serembeng daksina is a container/place for *daksina* offerings containing coconut, rice, eggs, and other offerings. *Serembeng daksina* is made of coconut leaves which are round and slightly long and have a border on the edges. *Serembeng* in the middle (without edges) symbolizes *akasa* 'space'. *Serembeng* has the characteristics of a tube but does not contain a tube lid. The tube elements in the *daksina* are the base underneath the *daksina*. Tubular blanket, namely the curved side of the *daksina* portion. The radius and diameter of the base circle. *Daksina*'s height. The surface width of the tube without a lid on the *daksina* is:

$$\text{Base} = \pi.r^2$$

$$\text{Blanket cylinder} = 2\pi.r.t$$

$$\text{Tube width without lid} = \pi.r^2 + 2\pi.r.t = \pi.r(r + 2.t)$$

$$\text{Volume of tube without lid} = \pi^2.t$$

Explanation:

r = Circle radius

score $\pi \frac{22}{7}$ or 3,14

t = Height

Sampian kapit udang/canang kojong

Sampian kapit udang/canang kojong are cone-shaped cymbals with protective bones at the edges, usually used for *pejati daksina* with flowers inside. *Sampian kapit udang/canang*



kojong is made from pieces of coconut leaves sewn like *kojong* using pins, with supporting materials such as *plawa* (leaves), betel leaves, flowers, and pandanus. Cone-shaped *jejahitan* is called *sasap gantung*, hung from the corners of the building, stalks of proper tools such as spears, *pajeng* (umbrella), *kober*, and others which have been spiritually purified and are then used for religious ceremonies.



Figure 7. *Sampilan kapit udang/canang kojong*

The mathematical concept of the *sampilan kapit udang/canang kojong* is a cone. A cone is a curved side shape that resembles a pyramid with a circular base. A cone has two sides, one edge and one vertex. The elements of the cone in the *sampilan kapit udang/canang kojong* are the base, which is the side that is a circle, base diameter (d), base radius (r), height (t), cone blanket, and painter line (s).

The volume of a cone can be calculated by multiplying the width of the base of the cone by the height of the cone with the formula: $Volume = 1/3 \times \pi \cdot r^2 \times t$

In addition to volume, a cone has a surface whose width can be calculated. The formula for the surface width of a cone is: $width = \pi \cdot r^2 + \pi r \cdot s$

Balinese *jejahitan* ethnomathematics for students

Bearing that the art of *jejahitan* is practiced almost every day by Balinese women, now even schools have an extracurricular program for *jejahitan*. This extra *jejahitan* aims to preserve Balinese culture in this modern era so that the next generation does not forget the culture passed down from their ancestors. In addition, students who take part in extra *jejahitan* are expected to be able to apply it in the community, such as the *ngayah* or giving service tradition in temples that use offerings with various kinds of *jejahitan*. In this *jejahitan* extracurricular, students are taught to make various types of *jejahitan* ranging from simple to complex. With ethnomathematics, students can practice it in social life, such as *jejahitan* culture. Moreover, ethnomathematics can also support cooperation and solidarity in society.

Jejahitan art is familiar to students. The art of *jejahitan* is rich in mathematical elements which can be used as a source of learning mathematics in class. Therefore, learning mathematics using *jejahitan* is a unique and aesthetic learning. The countless number of Balinese *jejahitan* and their close presence to students can have a massive impact if they can be utilized, especially in learning mathematics at school. The insight into ethnomathematics in the *jejahitan* art tradition, which students are involved in almost every day, is expected to motivate them to learn and to love their culture more indirectly.

Ethnomathematical studies on Balinese culture strongly support implementing mathematics learning, especially at the elementary education level. Primarily, for schools implementing the Merdeka Belajar Curriculum in Bali, learning that utilizes cultural elements is very supportive in building student character.

CONCLUSION

Education cannot be separated from the culture of society itself. It is evident from the many cultures, apart from containing aesthetic and unique elements, indirectly also contain mathematics teaching. Learning that links culture with mathematics is called ethnomathematics. As raised in this paper, namely the ethnomathematics of the Balinese Hindu ritual *jejahitan* is a unique, aesthetic learning medium in learning geometry for elementary school students. *Jejahitan* is a means of praying for traditional Balinese Hindu customs and culture, which is made from coconut leaves or coconut leaves, fronds with various supporting materials such as flowers and fruit.

Ethnomathematics related to *jejahitan* includes: *Taledan*, the geometric concepts applied are square elements, symmetry, width and circumference of a square. *Lamak*, the concept of



geometry that is applied is the elements of a rectangle, symmetry, width and circumference of a rectangle. *Ituk-ituk*, the geometric concept applied is the elements of a triangle, symmetry, width and circumference of the triangle. *Ceniga*, the applied geometry concepts are trapezoidal elements, symmetry, width and circumference of the trapezoid. *Tamiang*, the concept of geometry applied is a circle, symmetry, width and circumference of a circle. *Serembang Daksina*, the geometric concepts applied are the elements of the cylinder, the width and the volume of the cylinder. *Sampian Kapit Udag/Canang Kojong*, the geometric concept applied is the elements of the cone, width, and volume. Ethnomathematics is very important; apart from being a student learning material, it also functions as a means for preserving culture for the next generation, who will then hold the roots of this nation in the future.

Suggestions that can be conveyed on this occasion are that in teaching formal mathematics, educators should more often explore ethnomathematics around students that are related to teaching material so that students are more interested and easier to understand what is conveyed by educators. In addition, to make it easier for students to understand teaching materials, educators have also participated in helping to preserve culture.

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