ISSN 2502-5872 (Print)
ISSN 2622-3627 (Elektronik)

Volume 9 Nomor 1, February 2024, 159-174

ETHNOMATHEMATICAL CONNECTIONS OF INDRAMAYU TRADITIONAL BOAT FORMS: IMPLICATIONS FOR INSTITUTIONALIZATION SCHOOL GEOMETRY CONCEPT

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ABSTRACT

A literature review on ethnomathematics in Indonesia shows that previous research has only emphasized aspects of ethnomathematics exploration in building forms, batik, traditional art, ancient artifacts, and so on. However, there still needs to be more emphasis on the connection between traditional boat building and mathematics. Therefore, this article aims to characterize the ethnomathematics connections built from the traditional Indramayu boat shape. Theoretically, this research is based on ethnomathematics, ethnomathematics connections, and Universal Activity. The research approach used is qualitative by using an ethnographic design. This article's research object is the form of traditional boats in Indramayu—the research data obtained from preliminary studies, observations, interviews, and documentation. Interviews were conducted with three people, namely two builders and crew members (Ship's Crew). Based on the results of the study, it was found that the ethnomathematics connection to traditional boats can be seen in the forms of boat buildings and the accessories that complement them, such as the lunas, haluan, lambung, kemudi, hatch, and storage area. Institutionalizing the parts of the boat can represent the concepts of plane and spatial geometry. Therefore, the implications of this article can enrich students' starting points for learning mathematics and facilitate students' understanding of abstract mathematics using the context of society's culture.
Keywords: Ethnomathematics, Geometry Institutionalization, Mathematical Connection, Indramayu Traditional Boat

How to Cite: Nurafifah, L., Gunadi, F., Sudirman, S., & Wahyudin, W. (2024). Ethnomathematical Connections of Indramayu Traditional Boat Forms: Implications For Institutionalization School Geometry Concept. *Mathline: Jurnal Matematika dan Pendidikan Matematika*, *9*(1), 159-174. http://doi.org/10.31943/mathline.v9i1.561

PRELIMINARY

Mathematics is a part of human life and cultural activities (Kuznetsova et al., 2021). Mathematics, usually considered abstract, will become more concrete if linked to the culture of the environment in which students live (Ekowati, 2017). Explained that mathematical activity is an activity in which there is a process of abstracting from actual experiences in everyday life into mathematics or vice versa, such as grouping activities, counting, measuring, making patterns, and so on (Swanson & Williams, 2014; Tran et al., 2017). Therefore, teaching mathematics must be related to the culture in which students live (Wachira & Mburu, 2017; Bartell, 2011).

Wahyuni et al. (2013) state that ethnomathematics can bridge the gap between culture and mathematics education. In short, ethnomathematics means mathematics in culture (Wahyuni et al., 2013). D'Ambrosio & Rosa (2017), Rosa & Orey(2021), and Jumri et al. (2019) define ethnomathematics as a study of differences in how people solve mathematical problems and practical algorithms based on their mathematical perspective that refers to various forms of mathematics as a consequence embedded in cultural activities. Ethnomathematics has a vital role in learning mathematics (Balamurugan, 2015), namely to bring closer and open students' perspectives regarding the culture surrounding students and as an orientation towards understanding mathematics taught in learning mathematics (Risdiyanti & Prahmana, 2020).

Many studies examine ethnomathematics, primarily in Region 3, including Cirebon, Majalengka, Kuningan, and Indramayu. Research conducted by Sudirman (2017) states that the Sawat Riwog, Obar Abir, and Bunga Setaman motifs in Indramayu can be used to explain transformation geometric concepts such as translation and reflection concepts and the use of tiling principles in one type of tessellation geometric shape, namely a square. Noto et al. (2018), in their research on ethnomathematics on ancient wells in the Kaliwadas village of Cirebon, it was found that the shape of the healthy building describes a flat shape such as a triangle, pentagon, rectangle, parallelogram, trapezoid, circle, and geometric shapes such as blocks and tubes, which are the mathematical aspects of the material geometry.

Other research by Maharani & Maulidia (2018) studied ethnomathematics in the Panjalin traditional house in Majalengka district; the results obtained were that there were mathematical concepts and activities in the process of making the Panjalin traditional house in Majalengka district related to the construction of the traditional home. Based on previous ethnomathematics studies it was only limited to examining the use of ethnomathematics in batik artwork on the concept of geometry, ethnomathematics on ancient wells, which discusses the shape of wells about flat shapes and geometric shapes, ethnomathematics in Panjalin traditional houses discuss constructions related to balanced condition, ethnomathematics on the activities of coastal communities which are only limited to assessing community activities in coastal areas. Therefore, researchers are motivated to research ethnomathematics exploration of traditional ship making in Indramayu Regency.

The results of a preliminary study with residents of Karangsong village, namely Mr. Ipin, a craftsman in making traditional ships, found that traditional ships in

Karangsong were estimated to have existed since 40 years ago. The shape of the former traditional ship was mostly still small compared to the size of the ship now, which is much larger. The small traditional ships in Karangsong are about 7 meters long, the engine is only 5 GT (Gross Ton), and the large ones can be 24 meters wide by 7 meters and 6 meters high. The manufacture of traditional ships can take 5 to 6 months for large ships with an engine size of 150-180 GT (Gross Ton). The costs of making traditional ships, including wood and builders, can reach up to 6 billion.

Based on the preliminary study above, Mr. Ipin and other traditional boat builders have unknowingly used a mathematical concept related to planning, searching for materials, building procedures, and model choices for the construction of traditional boats. Therefore the purpose of this article is to characterize the ethnomathematics connections built from the traditional Indramayu boat shape.

METHODS

This type of research is qualitative research with an ethnographic approach. The method used to obtain data is the method of preliminary study, observation, interviews, and documentation.

Collection through preliminary studies was carried out by reviewing literature on traditional boat making, especially boats in coastal areas. After conducting a preliminary study, the researcher made direct observations by recording all information related to the shapes of traditional boat structures. In the research, the observation process was carried out at the traditional boat making center in Karangsong Village, Indramayu. Based on observations, there are three types of boats made in Karangsong Village, namely dinghy, cengkok, and tembon. During the observation, the researcher also conducted interviews regarding the shape of the boat. There were three participants interviewed, namely Mr. Carma (dinghy boat maker), Mr. Sardi (cengkok boat maker) and Mr. Kasmin (tembon boat maker). Based on interviews with the three participants, information was obtained that there were similar functions in several parts, such as the keel, bow and so on. The researchers then explored parts of the similarities in more depth regarding the form.

This study focused on the culture of the Indramayu people, namely traditional ships. It involved three communities as participants to assist researchers in exploring the mathematical elements found in traditional ships. The research was conducted in May 2023 until completion in the Indramayu area, namely Karangsong village.

This study uses the main instrument and auxiliary instrument. The main instrument in this research is the researcher himself (human instrument), who acts as a data collector from the results of interviews, observations, and documentation. This aligns with what Denzin & Lincoln (2009) said in qualitative research; the main instrument is the researcher himself. At the same time, the auxiliary instrument is an interview guide consisting of several questions and observation guidelines used as the focus to be examined during the research process. After the data is obtained, it is analyzed based on the mathematical elements found and grouped based on the mathematical concepts of traditional ships.

The data analysis technique in this research uses data analysis techniques, according to Miles and Huberman (Sugiyono, 2018),) consisting of data reduction, data presentation, and concluding. Data reduction is used to sharpen, classify and remove data that is not needed in the research. Next, data obtained from interviews, observation, and documentation is reduced by selecting the information needed to obtain valid data. In this research, the data required is only related to the shape of traditional boat parts, such as the keel, bow, hatch, rudder, hull, chimney, and storage. The ethnomathematical connections found in the parts of the boat represent geometric shapes such as right triangles, arbitrary triangles, squares, circles, semicircles, tubes, and cubes. Ethnomathematics connections in research are based on internal connections and external connections. External connection refers to the relationship between the representation of the shape of the boat part and the representation of the geometric shape. Internal connections refer to the relationship of properties inherent in the form. After the data reduction process, it is presented by showing the shape of the boat parts, representations of geometric shapes, and mathematical concepts in schools. Then the final stage concludes by making generalizations about the ethno-mathematical connections in the parts of the boat.

RESULT AND DISCUSSION

Traditional ship

Figure 1.Traditional

Traditional ships are a culture in Indramayu, one of the heritages passed down from generation to generation. In its development, traditional ships have experienced significant developments starting from the shape, size, and planning process to keep up with the times. One of the famous traditional ship manufacturing areas in Indramayu is Karangsong Village. On a traditional ship, there are parts of the ship, including the ship lunas, ship haluan, ship hatch, ship kemudi, ship lambung, ship cerobong, and storage area. Mathematical concepts resulting from designing, making patterns, measuring, and counting can be found in traditional ship making.

Ethnomathematics on Traditional Ships in Indramayu Regency

Based on the results of exploration, interviews, observation, and documentation. The traditional ships in Indramayu have mathematical concepts related to the geometric shapes of the plane shapes and the geometric shapes found in the parts of the ship.

Institutionalization of Geometry Concepts in the Lunas of a Ship

The Lunas is the lowest part of the ship that is submerged below the surface of the water. This Lunas protects the bottom of the ship when there is a shift or friction with the bottom of the waters or when it runs aground and as a counterweight to the ship against the roll that may occur while sailing. The ship's lunas consists of an upright lunas, a basic lunas, and a lambung lunas.

Figure 2a. Ship Lunas Section

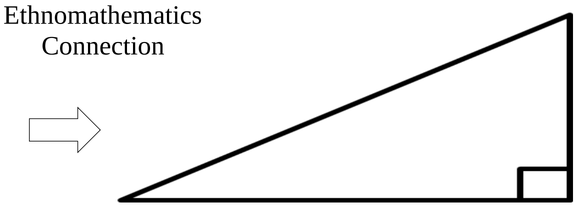

Figure 2b. Institutionalization of Geometry

Figure 2. Ethnomathematics Connections to the Shape of a Ship's Lunas

The ship lunas in Figure 2a can be connected to the geometric concept as shown in Figure 2b. From the figure, it can be seen that the institutionalization of the lunas of a ship is a flat shape which has three sides which are called triangles. Based on this conception, the researchers then analyzed the concept of a right triangle on the lunas of the ship as shown in Figure 3.

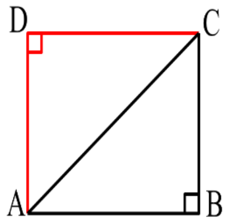

Figure 3. The Concept of a Right Triangle a Ship's Keel

Based on the analysis in Figure 3, it can be concluded that there is a right triangle concept in the lunas of this ship. The field ABCD is a rectangle by pulling the diagonal AC, two equal and congruent right triangles will be formed, namely. The properties of a right triangle that can be found in the lunas modeling of a ship according to Figure 3 are as follows: $\Delta ABC\ dan\ \Delta ADC$

a. In a right triangle, one of the angles is 90°, namely angles B and D.

b. The sum of all the angles is 180°.

c. The AC side is the hypotenuse.

Institutionalization of Geometry Concepts in the Haluan of the Ship

The haluan of the ship is the front of the ship's body. The ship's haluan is designed to reduce prisoners when the ship's haluan breaks the water and must be high enough to prevent water from getting into the ship due to waves or the part of the water when the ship sails. The division of the ship is based on the haluan of the ship vizoblique, upright, elhaluan, stab, spoon, straight, and stick out the bottom.

Figure 4a. Ship Haluan Section

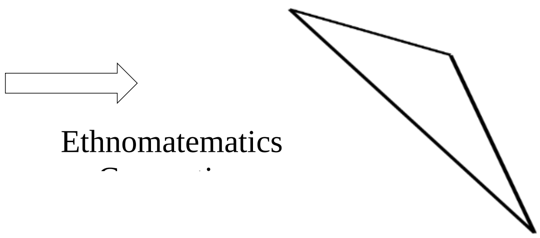

Figure 4b. Institutionalization of Geometry

Figure 4. Ethnomathematics Connections to the Haluan of a Ship

In Figure 4a is the haluan of a ship and can be connected with geometric concepts like Figure 4b. From this figure, it can be seen that the institutionalization of the haluan of the ship represents the concept of an arbitrary triangle. Based on this, the next researcher analyzed the concept of an Scalene triangle at the haluan of the ship. The following below is an image of an Scalene triangle concept on the haluan of the ship. The concept of a triangle on the haluan of the ship will be explained in Figure 5.

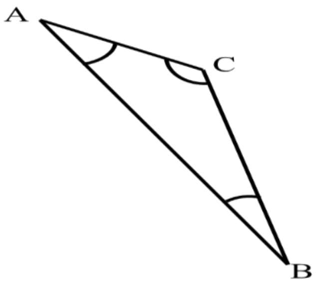

Figure 5. Scalene Triangle Concept

Based on the analysis in Figure 5, it can be concluded that there is an arbitrary triangle concept in the haluan of this ship. The properties of an Scalene triangle triangle found in modeling the haluan of the ship are as follows:

a. The lengths of the three sides are different, $AB \neq AC \neq BC$

b. The measure of the angles are not the same angle, $\angle A \neq \angle B \neq \angle C$

c. It has no fold symmetry.

d. It has only one rotational symmetry.

Institutionalization of Geometry Concepts in Ship Palka

The ship palka is part of the ship which functions to store the catch from fishermen, such as fish, crabs, crabs, shrimp and others.

Figure 6a. Ship Palka Section

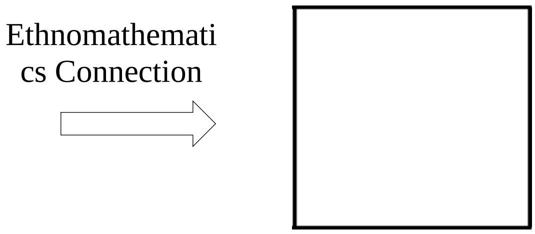

Figure 6b. Institutionalization of Ship Geometry

Figure 6. Ethnomathematics Connections in the Ship Palka

The ship palka in Figure 6a can be connected to represent the geometric concept, as shown in Figure 6b. The institutionalization of geometry on the ship's palka is a flat shape with four equal sides called a square. Based on this, the next researcher conducted a square concept analysis, as shown in Figure 7.

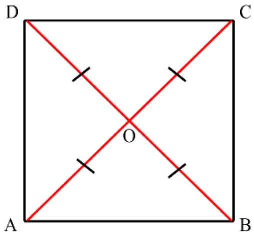

Figure 7. Square Concept

Based on the analysis in Figure 7, it can be concluded that there is a geometric concept in the square shape on the ship palka. The properties of a square that can be taken in Figure 7 are as follows:

a. The four sides are the same length, $AB = BD = CD = AC$

b. Opposite sides are parallel, $AB//CD\ dan\ BD//AC$

c. Each corner is the same size, $\angle A = \angle B = \angle C = \angle D = 90°$

d. The diagonals are the same length, $AD = BC$

e. The diagonals intersect at right angles and bisect each other $AO = OD = BO = OC$

Institutionalization of Geometry Concepts in Ship Kemudi

Kemudi or Jantra is a device or tool used to direct the direction of the ship while sailing.The kemudi is made of wood with a diameter of 50 cm to 100 cm. The following is a picture of a ship kemudi on one of the ships in Indramayu.

Figure 8a. Ship Kemudi

Ethnomathematics Connection

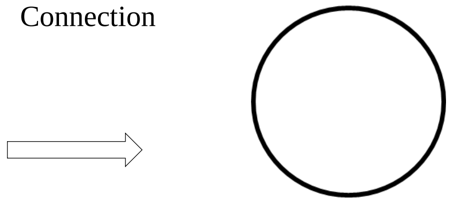

Figure 8b. The institutionalization of geometry

Figure 8. Ethnomathematics Connections in the kemudi of a Ship

The ship kemudi in Figure 8a can be connected to produce a geometric representation as shown in Figure 8b. From the figure, it can be seen that the geometrical institutionalization of the ship's kemudi is in the form of a two-dimensional flat shape, namely a circle. Based on this, the next researcher analyzed the concept of a flat circle shape on the ship's kemudi as in Figure 9.

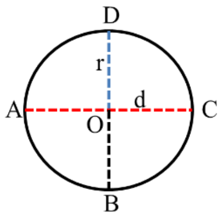

Figure 9. The concept of a circle

Based on the analysis in Figure 9, it can be concluded that there is a circle concept in the ship's kemudi. The circle elements that can be found in the ship kemudi modeling are as follows:

a. Point **O** in the circle is called the center point of the circle.
b. OA, OB, OC, and OD lines called the radius of the circle (r).
c. Line **AC and BD** called the diameter (d).
d. AD line called a chord.

Institutionalization of Geometry Concepts on Ship Lambung

The ship lambung, in English, is called the lambung part of the body of the ship, which is located on the side. The ship lambung functions as buoyancy or buoyancy so the ship does not sink. The various forms of ship lambungs are flat lambungs, catamaran lambungs, V lambungs, tunnel lambungs, and pontoon lambungs.

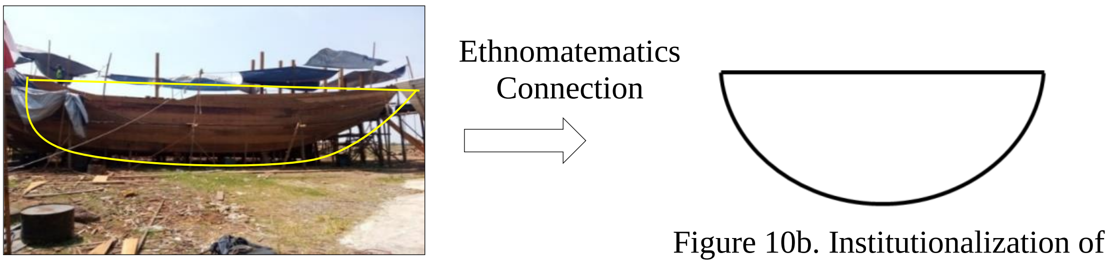

Figure 10a. Ship Lambung

Figure 10b. Institutionalization of Geometry

Figure 10. Ethnomathematics Connections

The ship lambung in Figure 10a can be connected to produce a geometric representation, as shown in Figure 10b. From this figure, it can be seen that the institutionalization of geometry on an elliptical ship lambung. Based on this, the next researcher analyzed the elliptical concept on the ship lambung, as shown in Figure 11.

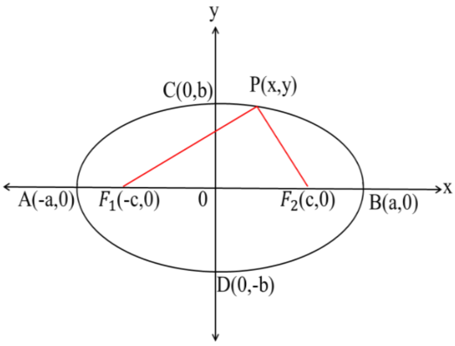

Figure 11.The concept of an ellipse on a ship lambung

From Figure 11 it can be concluded that there is an ellipse concept in. The elements of the ellipse that can be found on the ship lambung are as follows:

a. Ellipse center, $O(0,0)$
b. The axes of symmetry are the x and y axes
c. Focus and$F_1(-c,0)F_2(c,0)$
d. Major axis on the x axis, apex and $A(-a,0)B(a,0)$
e. Minor axis on the y axis, apex and $A(0,b)D(0,-b)$

Institutionalization of Geometry Concepts on Ship Cerobong

The cerobong of the ship is a vent for channeling out or removing hot steam or smoke from the ship's engine or ship's exhaust. The location of this cerobong is usually near the stern of the ship facing upwards. The height exceeds the height of the ship so that it does not contaminate the ship and can go straight into the air.

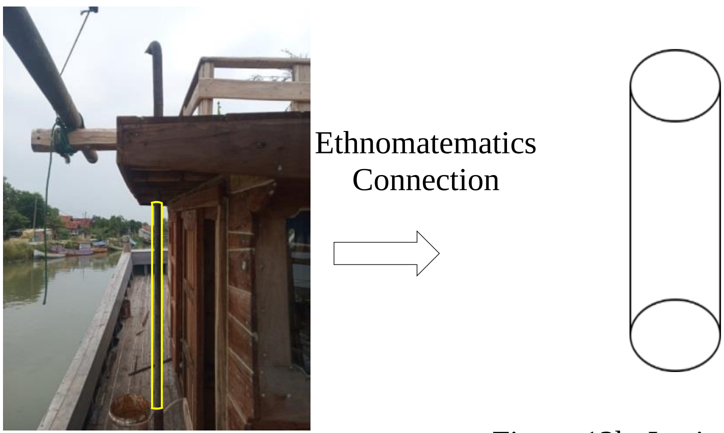

Figure 12a. Ship Cerobong

Figure 12b. Institutionalization of Geometry

Figure 12. Ethnomathematics Connections on a Ship Cerobong

The ship cerobong in Figure 12a can be connected to produce a geometric representation, as shown in Figure 12b. Furthermore, based on Figure 12, the institutionalization of the concept of geometry in the tube-shaped cerobong. Therefore, the next researcher analyzes related to the concept of a cylinder shape in Figure 12.

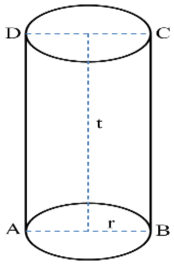

Figure 13.The Concept of a Cylinder

From Figure 13 after analysis, it can be concluded that there is a mathematical concept of cylinder shape. The mathematical concepts related to the properties of the tube which can be found in the cerobong modeling of the ship according to Figure 12 are as follows:

a. Has three sides, namely the base, cover and blanket (upright side).
b. The base and lid are circular.
c. $r$is the radius and is the height of the cylinder (t)
d. The upright side is a curved plane called a tube blanket.
e. The height of the cylinder (t) is the distance from the center of the base to the center of the lid.
f. The radius of the base circle and the cap are the same size.

Institutionalization of Geometry Concepts in Goods Storage

The place to store goods is a place that is used to store all the needs of traditional ships.

Ethnomathematics Connection

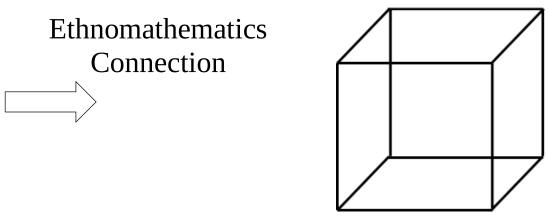

Figure 14a. Goods Storage

Figure 14b. Institutionalization of Geometry

Figure 14. Ethnomathematics Connections in the Storage Section of the Ship

The place for storing goods in Figure 14a can be connected to produce a geometric representation of the concept, as shown in Figure 14b. Furthermore, based on Figure 14, the geometric institutionalization of the goods storage section is in the form of a geometric equivalent to a cube. Based on this, the next researcher analyzed the cube concept, as shown in Figure 15.

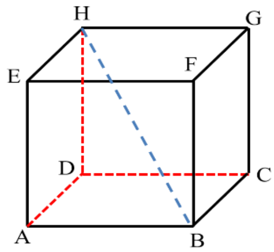

Figure 15.Concept of Cubes on Storage of Goods

Based on the analysis in Figure 15, it can be concluded that it is proven that there is a cube concept in the storage area for these items. These mathematical concepts are related to the properties of the cube, namely as follows:

a. It has six square sides which are: $ABCD = EFGH = ABEF = CDGH = BCFG = ADEH$
b. It has eight vertices namely, A, B, C, D, E, F, G, H
c. Has twelve ribs of the same length, namely, $AB = CD = BC = AD = EF = GH = FG = EH = AE = DH = BF = CG$

Discussion

Based on the research findings, the ethnomathematics connections to traditional ships represent geometric concepts, namely (1) the lunas of the ship, which represents a right triangle, (2) the haluan of the ship, which represents an Scalene triangle triangle, (3) the lambung of the ship which represents an ellipse, (4) the kemudi which representing a circle, (5) a ship hatch representing a square, (6) a storage area representing a cube, (7) a ship's cerobong representing a cylinder shape. In addition to geometric concepts, there are other mathematical concepts in measuring and designing activities by traditional ship builders.

The existence of the concept of geometry contained in ethnomathematics in the form of cultural heritage is in line with the research by Sudirman et al. (2017; 2018), who conducted ethnomathematics exploration of Indramayu paoman batik and the results of his research concluded that there are geometrical concepts such as rectangles, triangles, circles, and geometric transformations. The results of this study support the opinion of

Hasanah et al. (2019), which briefly state that the architectural forms of the main English Dormitory buildings have what are considered representations of geometric concepts, namely lines, angles, plane shapes, flat side shapes, congruence and congruence, symmetry, and geometric transformations. The results of this study also support the opinion of Fauzi & Setiawan (2020), who said that mathematical concepts, especially geometric concepts, namely the traditional sesekan Sasak weaving motif, contain elements of flat shapes in the form of squares, rectangles, kites, parallelograms, triangles, rhombuses, angle concepts, and congruence concepts. Then the traditional nyiru craft contains the concept of a flat shape in the form of a circle and an ellipse. Furthermore, besek and tembolaq crafts contain geometric concepts in the form of geometric shapes, namely blocks, cubes, and half spheres.

The results of this study as wellin line with research Hardiarti (2017) entitled "Ethnomathematics: Application of Quadrilateral Shapes in Muaro Jambi Temple". This study’s results state a quadrilateral flat shape concept in several Muaro Jambi temple structures. The structures are square, rectangular, parallelogram, trapezoidal, and irregular quadrilateral. Learning mathematics using ethnomathematics objects can enrich existing mathematical applications around students and facilitate students' understanding of abstract mathematics using concrete ethnomathematics objects. Sulistyani et al. (2019) state that building elements such as pillars, doors, and roofs of the Joglo Tulungagung Traditional House contain geometric concepts that can be implemented as a medium for learning mathematics in materials: flat shapes, spatial shapes, congruence, congruence, phytagoras, geometric transformations (translation, reflection, dilation).

The implications of this research can contribute to the development of mathematics curriculum in schools, especially geometry material through an ethnomathematics approach. Ethnomathematics connections to Indramayu traditional boat shapes can be integrated and institutionalized into learning to improve students' understanding of geometry. Furthermore, this research also has limitations, namely (a) the research results may not be directly applicable in other mathematical cultural contexts, because each community has a unique cultural context and heritage. (b) Integrating Indramayu traditional boat shapes in geometry teaching may have challenges in terms of sustainability of implementation, especially if there is no adequate support and resources. (c) The process of institutionalizing ethnomathematics concepts in the school curriculum may face challenges, such as resistance from parties who are not familiar with or do not agree with this approach.

CONCLUSION

Based on the results and discussion previously described, it can be concluded that the research results show that traditional ship culture in Indramayu contains elements and mathematical concepts. Without understanding mathematical concepts, the people of Indramayu have applied mathematical concepts so that it is evident that there is ethnomathematics in traditional ships, as seen in the architecture of the ship buildings. The results of the exploration show that ethnomathematics is found in traditional ships . These namely simple mathematical concepts can be related to the shape of ships and parts of traditional ships. The parts and shapes of traditional ships can be used to study the concept of flat and spatial shapes. By linking the culture around students (ethnomathematics), mathematical learning becomes a bridge for mathematics learning activities, which are more meaningful for students.

This research provides suggestions, namely (1) there is a need to prepare geometry teaching materials that integrate concepts from the shape of traditional Indramayu boats. This material can be used as a supplement in the school curriculum to provide contextual and cultural dimensions to geometry learning. (2) research can be continued to measure the impact of teaching geometry using an ethnomathematics approach. This evaluation can include improvements in student understanding, changes in teacher attitudes, and long-term effects on their understanding of mathematics.

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