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ETHNOMATHEMATICS: EXPLORATION OF MATHEMATICAL CONCEPTS IN THE GATE OF JAMIK MOSQUE SUMENEP

(Etnomatematika: Eksplorasi Konsep-Konsep Matematika pada Gerbang Masjid Jamik Sumenep)

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Abstract

This ethnomathematics research aims to reveal the mathematical concepts and cultural values inherent in the gate of the Sumenep Jamik Mosque. A qualitative method with an ethnography type was used in this research. The ethnographic approach involves digging up information directly on a cultural group. This information was extracted by visiting, observing, measuring, and interviewing experts who have long been engaged in related cultures. Research data were collected through observation, interviews, documentation, and literature studies. The results showed the existence of mathematical concepts in the ornament of the Mosque Jamik Sumenep in fractal geometry and the idea of reflection on the transformation of geometry, ratio, and angle. Also, cultural values include the meaning of the swastika symbol, the T key motif, and the value of cultural acculturation. The findings of this study can be developed in learning tools and become a reference for ethnomathematics-based learning in the classroom.

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Abstrak

This ethnomathematics research aims to reveal the mathematical concepts and cultural values inherent in the gate of the Sumenep Jamik Mosque. A qualitative method with an ethnography type was used in this research. The ethnographic approach involves digging up information directly on a cultural group. This information was extracted by visiting, observing, measuring, and interviewing experts who have long been engaged in related cultures. Research data were collected through observation, interviews, documentation, and literature studies. The results showed the existence of mathematical concepts in the ornament of the Mosque Jamik Sumenep in fractal geometry and the idea of reflection on the transformation of geometry, ratio, and angle. Also, cultural values include the meaning of the swastika symbol, the T key motif, and the value of cultural acculturation. The findings of this study can be developed in learning tools and become a reference for ethnomathematics-based learning in the classroom.

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INTRODUCTION

One part of the learning process experienced by students is solving problems related to everyday life (Rosa and Orey, 2019). According to D'Ambrosio (1985), mathematics was born from human activities to solve various problems; therefore, mathematics will always be related to human life. Furthermore, mathematics is formed from everyday phenomena

manifested in specific actions to solve problems, such as counting, classifying, comparing, and analyzing (Akbar et al. 2023; Albanese and Perales 2020). Felbrich et al. (2014) argue that mathematics is dynamic and must be applied to building human civilization.

However, students' views on math are far from life. According to Jesus and Madruga (2023), many students do not consider math important because it only studies formulas and numbers, making it less useful in life. In addition, some students can solve math problems in books, but when faced with mathematical problems in real life, they are confused about finding solutions to these problems (Rosa and Orey 2019; Santos and Madruga 2021). This is supported by the PISA results in Indonesia, which show that Indonesian students cannot solve math problems related to life (Yusmar and Fadilah 2023). That means connecting mathematics with everyday life is essential to mathematics education today, so a wedge between mathematics and daily life is needed.

One approach that bridges the gap between mathematics and everyday life is ethnomathematics. Ethnomathematics has its roots in the anthropological study of the ideas and practices of mathematics that are created, developed, and applied in various cultural groups and communities (Alghar, Susanti, and Marhayati 2022; Rosa and Orey 2022). Ethnomathematics forges deep connections between school mathematics and societal culture (Alghar, Walidah, and Marhayati 2023; Jesus and Madruga 2023). Ethnomathematics plays a role in developing students' cultural abilities by teaching them mathematical ideas, procedures, and applications developed in their cultural context (Rosa and Orey 2022; Santos and Madruga 2021). Thus, ethnomathematics not only studies mathematics within the artistic scope of the community but also introduces cultural values and appreciation of mathematics that develop in the community.

One of the objects of study in ethnomathematics is artifacts. Artifacts are related to physical and material manifestations developed by cultural communities that contain specific values (D'Ambrosio 2015). Artifacts are classified as objects of ethnomathematics study because they provide information and noble values related to a cultural group to its ancestors (Dutra, Orey, and Rosa 2023; Rosa and Orey 2022). Some examples of artifacts are buildings, historical objects, forts, and houses of worship.

Although many cultural artifacts in Indonesia are hundreds of years old, not all are well maintained and in good condition (Pratikno, Rahmat, and Sumantri 2020; Rahardjo 2013). Of the many artifacts in Indonesia, one of the hundreds of years old, well-preserved, and still functioning is the Sumenep Jamik Mosque (Fajariyah 2021; Selviana 2013). In addition, the artifact in the form of the Sumenep Jamik Mosque has high cultural value, especially the value of acculturation of Madurese, Chinese, and Dutch cultures (Fajariyah

2021; Rohman 2018). So, researchers focus ethnomathematics studies on artifacts with good conditions and rich culture, namely the Mosque of Jamik Sumenep.

Figure 1.
Front view and minaret of the Jamik Mosque Sumenep

Jamik Sumenep Mosque is a relic mosque of the Sumenep Sultanate built in 1779 AD during the reign of Panembahan Sumolo (Alghar and Marhayati 2023; Fajariyah 2021). The construction of this Mosque was designed by Lauw Piango, who is of Chinese descent. Panembahan Sumolo made this Mosque a symbol of community life under the Sumenep Sultanate's rule, consisting of various ethnicities and religions that coexist (Atthalibi, Amiuza, and Ridjal 2016). This is represented by parts of the Mosque that show the acculturation of the Madurese and Chinese cultures, such as the Mosque Jamik Sumenep gate ornament (Fajariyah 2021; Rohman 2018).

Figure 2.
Ornaments on the gate of the Jamik Mosque Sumenep

Besides having social and religious functions in its time, the Jamik Mosque of Sumenep is decorated with aesthetic ornaments (Alghar and Marhayati 2023; Selviana 2013). The ornaments envelop the gate of the Mosque, thus providing an atmosphere of harmony with Madurese-Chinese culture (Halim and Royandi 2022; Rohman 2018). The shape of the ornament is not only regular but also seems complicated, repetitive, and uninterrupted. So, this ornament contains some mathematical concepts.

Based on the previous description, researchers must explore the mathematical concepts in the Jamik Mosque Sumenep gate ornament. In line with D'Ambrosio's (2015) ethnomathematics principle, the exploration includes mathematical concepts and their meaning and cultural values. For mathematics education research, this study provides a range of mathematical concepts aligned with cultural values and contributes to the development of ethnomathematics research. For teachers and practitioners, this research contributes to ideas, theoretical studies, and mathematical studies that can be brought into school mathematics learning or the development of mathematics learning tools. For other researchers, this research contributes to providing insight into the concept of mathematics combined with culture in the artefacts of the Sumenep Jamik Mosque. So, this research aims to explore the concept of mathematics at the gate of the Jamik Mosque Sumenep.

METHODS

This research uses a qualitative approach with an ethnographic type. The qualitative approach allows the data to be presented descriptively (Creswell and Creswell 2017). The ethnographic type was used because the researcher wanted to explore information directly related to the culture of a society. This information was extracted by visiting, observing, measuring, and interviewing experts who have long been involved in related cultures. (Spradley 1997). This research includes six steps: (1) Preliminary: Researchers begin to determine the theme, location, and object of research. (2) Problem formulation: The researcher determines the problem to be studied in the Jamik Mosque Sumenep ethnomathematics research. (3) Data collection: data collected by field studies, interviews, literature studies, and documentation. (4) Data analysis: The data obtained is then analyzed by triangulating methods sourced from literature, interview results, and researcher observations. The literature is from books, articles, and documents related to mathematics, the Mosque of Jamik Sumenep, and Chinese-style ornaments. Interviews were conducted with Mr Mohamad Suyuti, a mosque administrator and information staff member at the Masjid Jamik Sumenep. Observations made include direct measurement of ornaments, sketching, and taking pictures. The validity of the research data was obtained through method triangulation. Triangulation is done by completing and verifying the results of measurements, observations, and interviews to obtain complete information. (Creswell and Creswell 2017). (5) Results and discussion: The findings of this research are presented in detail and discussed with various relevant literature. (6) Conclusion: The findings and discussion are then summarized into a conclusion that answers the research problem. The five stages are represented in Figure 3.

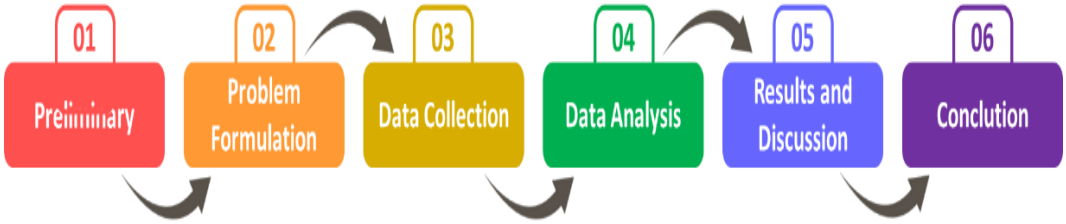

Figure 3.
Research steps

RESULTS

A. Results of the Literature Review

1. History of Masjid Jamik Sumenep

Jamik Mosque Sumenep is a large mosque in the square area of Sumenep City, Indonesia. This Mosque was founded in the 16th century during the Sumenep Sultanate under the leadership of Panembahan Sumolo. The Mosque served as a place of worship for Muslims, a gathering place for the royal community during holidays, and a prison for people who committed unlawful acts at that time (Alghar and Marhayati 2023; Fajariyah 2021). The Mosque was designed by a Chinese architect, Lauw Piango, and was completed in 1779 AD (Atthalibi et al. 2016). The values of acculturation of Madurese, Chinese, Dutch, and Islamic cultures can be seen in several parts of the Mosque (Alghar and Marhayati 2023; Selviana 2013). One of the most striking parts is the ornamentation of the mosque gate.

2. Swastika Shape

The swastika, symbolized as 卐, is the oldest sacred symbol in human history (Mohamed and Mostafa 2022; Zidan 2020). The swastika is the Sanskritization of *svastika*, which means blessing, pleasure, and prosperity (Alghar and Marhayati 2023; Shomakhmadov 2012). The swastika is symbolized by two lines that intersect each other perpendicularly, with the intersection forming a 90° angle. In addition, the swastika is characterized by four arms that bend to the left and right, matching in size and length (Beer 2004).

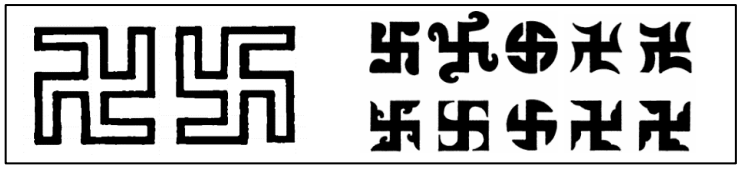

Figure 4.
Different types of swastika shapes

3. T-Shape Key Pattern

The T-shape motif is one of the key patterns used by engravers since Greek times (Yao and Peng 2020). The T motif has a basic shape like the letter T. This motif has undergone development, modification, and acculturation in various civilizations, such as European, Persian, Arabic, and Chinese civilizations (Beer 2004). The shape is easy to develop,

making the T motif often immortalized in the outline or filling the space of an object (Dye 2012; Yao and Peng 2020). Chinese artists always favor the presence of specific motifs in empty spaces, such as T-shapes on walls, frames, and doors (Alghar et al. 2023; Dye 2012).

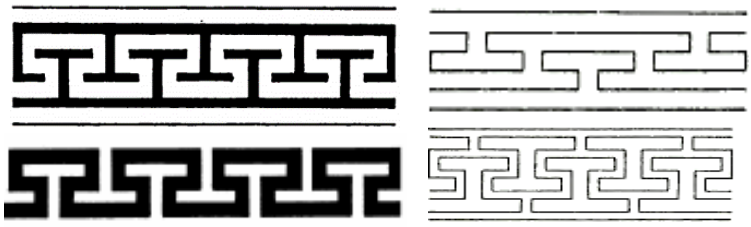

Figure 5.
Various types of T key motifs

B. Interview Results

An interview with Mr. Mohamad Suyuti, a historian and caretaker of the Sumenep Jamik Mosque, revealed that the ornament has existed since the royal era. The restoration of the ornament is only done by painting the color of the ornament, which was initially white to yellow and green. This coloring is done to beautify the shape of the ornament with typical Madurese colors. He also explained that the ornament symbolizes community acculturation at the time of Panembahan Sumolo. In that era, the Sumenep, Chinese, and Dutch communities lived harmoniously and respected each other. The shape of the Chinese-style intersecting ornaments on the mosque gate realizes the acculturation. A fragment of the researcher's interview with Mr. Suyuti is presented in Figure 6 below.

Researcher	:	What is the history of this ornament?
Mr. Suyuti	:	This ornament is a relic from the time of King Panembahan Sumolo. Like this mosque, the ornaments remain as original as when it was first built.
Researcher	:	Does that mean there is no change in the shape of the ornament?
Mr. Suyuti	:	No. The shape remains as it was at the beginning of construction. The ornaments were only repainted around 2010. This was done to beautify the ornaments only.
Researcher	:	For the shape, how is it made? Have previous generations told you?
Mr. Suyuti	:	I do not understand the manufacturing process. The twisting shape has been like this for a long time. I was also never told by my predecessor about installing this ornament.

Figure 6.
Excerpts from the researcher's interview with Mr. Suyuti

C. Measurement Results

The researcher made direct measurements of the ornaments to find mathematical concepts in the ornaments. Measurements were made with the help of a ruler, protractor, and raffia. The measurement process is shown in Figure 7.

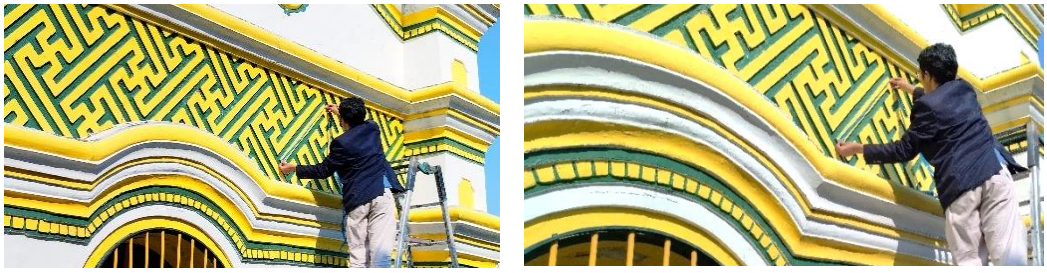

Figure 7.
Ornament measurement process

Measurements were made of the ornament's length, the ornament's slope, and the ornament's angle. The measurement results were then recorded by the researcher, analyzed, and compared with the sketches made by the researcher. The measurement results were used as a reference for the researcher to see the mathematical concepts in the ornament. The measurement results show that the parts of the ornament have a length of 10 cm, 30 cm, 35 cm, and 70 cm. At the same time, the angle measurement results show that the angles in the ornament have a large 45^o, 90^o, 135^o, and 180^o.

D. Mathematical Concepts in the Jamik Mosque of Sumenep

1. Fractal Geometry

Fractal geometry is one of the fields studied in non-Euclid geometry. If Euclid geometry discusses geometry in integer-dimensional spaces, such as dimension two and dimension three, then fractal geometry studies mathematics in fractional-dimensional spaces, such as 1/3, 2/3, and 5/2 (Widodo 2021). In other words, fractal space uses dimensions different from Euclid geometry, so fractal space is categorized as non-Euclid geometry (Juhari and Alghar 2021; Widodo 2021). Some characteristics of fractal shapes include self-similarity, repetition, and recursive (Barnsley 2014). The fractal shapes that make up the ornament are shown in Figure 8.

Figure 8.
The fractal shape (left) was constructed using the l-system method on the Jamik Mosque Sumenep ornament (right).

2. Reflection in Transformation Geometry

The study of geometry transformation is one of the studies in Euclid geometry that shows the change in position and size of an object in the same geometry space (Mulyati 2000).

Objects that change can be a point, line, or plane. Geometric transformations are taught from high school to college and are divided into translation, rotation, reflection, and dilation.

Reflection or mirroring is the displacement of an object's point on the plane according to the nature of shadow formation on a flat mirror. The properties of reflection are (1) the distance of the initial point of the object to the mirror is equal to the distance of the object's endpoint to the mirror, (2) The x-axis or y-axis is analogous to a mirror, (3) The connecting line between the initial and final object is always perpendicular to the mirror (Mulyati 2000; Soebari 1995). The Jamik Sumenep Mosque ornament contains the concept of geometric transformation of reflection by mirroring the X-axis and Y-axis, as shown in Figure 9.

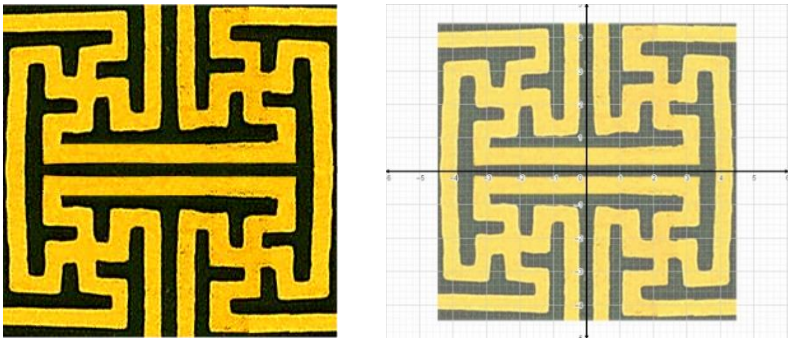

Figure 9.
The shape of the ornament of the Mosque Jamik Sumenep (left) and the mirroring of the ornament on the X-axis and Y-axis (right).

Based on Figure 6, there is a mirroring of the X-axis and the Y-axis in the ornament of the Mosque Jamik Sumenep. The mathematical form of mirroring the Y-axis is shown as

$$R(x, y) \rightarrow R'(-x, y)$$

with Y-axis mirroring matrix form

$$R_y \begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix} \text{ become } R'_y \begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$

While the mathematical form of mirroring the X-axis is shown as

$$R(x, y) \rightarrow R'(x, -y)$$

with X-axis mirroring matrix form

$$R_x \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix} \text{ become } R'_x \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$

3. Comparison and Ratio

Based on the results of the measurements, the parts of the ornament on the Mosque Jamik Sumenep have different sizes. However, the difference forms a pattern in terms of comparison and ratio. Comparison compares the value of two similar quantities

(Abdussakir 2017; Radjak, Alghar, and Cholidiyah 2023). At the same time, the ratio compares two or more quantities that show the size or relationship with each other (Abdussakir 2017). The results of the measurement of ornaments in the form of lines are represented in Figure 10.

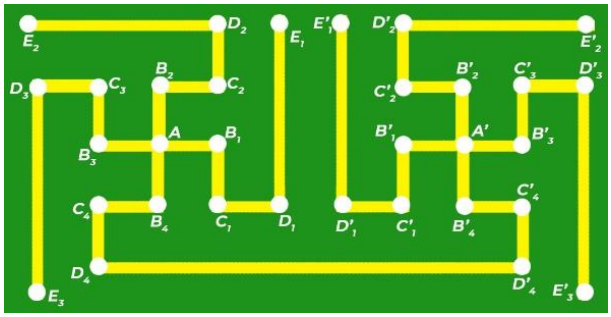

Figure 10.
Sketch of the Jamik Mosque ornament Sumenep

Based on the representation in Figure 7 and the results of measurements, the concept of comparison and ratio in the ornament of the Mosque Jamik Sumenep. The measurement results show that the parts of the ornament have a length of 10 cm, 30 cm, 35 cm, and 70 cm. The measurement results have a ratio of 5 cm. Hence, the ratio formed is 1:2, 1:6, 1:7, and 1:8. The measurement results and the ratio of the Mosque Jamik Sumenep ornament based on the points represented in Figure 7 are shown in Table 1.

Table 1.
Measurement results and the ratio of the ornament of the Mosque Jamik Sumenep

Ornamental parts in Figure 7	Length	Ratio (5 cm)
$AB_1, AB_2, AB_3, AB_4, A'B_1, A'B_2, A'B_3, A'B_4, B_1C_1, B_2C_2, B_3C_3, B_4C_4, B'_1C'_1$ $B'_2C'_2, B'_3C'_3, B'_4C'_4, C_1D_1, C_2D_2, C_3D_3, C_4D_4, C'_1D'_1, C'_2D'_2, C'_3D'_3, C'_4D'_4$	10 cm	1:2
$D_1E_1, D_2E_2, D'_1E'_1, D'_2E'_2$	30 cm	1:6
$D_3E_3, D'_3E'_3$	35 cm	1:7
$D_4D'_4$	70 cm	1:14

4. Angles

An angle is the area created by two lines that intersect around their intersection point (Mulyati 2000). In Euclid geometry, angles are categorized into several parts, namely right angles, acute angles, obtuse angles, and straight angles. A right angle is an angle whose magnitude is 90°. An acute angle is an angle whose magnitude is less than 90°. An obtuse angle is greater than 90° but less than 180°. A straight angle is an angle of 180° (Mulyati 2000). The results of angle measurements on the ornament are represented in Figure 11.

Figure 11.
Various types of angles in the sketch of the Jamik Mosque ornament Sumenep

Based on the results of measurements, the ornaments on the Mosque Jamik Sumenep have various types of angles. The measurement results show that the angles in the Jamik Sumenep Mosque ornament have a large 45°, 90°, 135°, and 180°. The measurement results and the angles of the Mosque Jamik Sumenep ornament based on the points represented in Figure 8 are shown in Table 2.

Table 2.
The results of measuring the angle on the ornament of the Mosque Jamik Sumenep

Ornamental parts in Figure 8	Angles
$\angle AB_3B_4, \angle AB_4B_3, \angle C_2B_4D_3, \angle C_2D_3B_4, \angle D_1E_1D_3, , \angle I_1J_1E_1$	45°
$\angle A, \angle B_1, \angle B_2, \angle B_4, \angle C_1, \angle C_2, \angle C_3, \angle D_1, \angle D_2, \angle F, \angle G_1, \angle G_2, \angle G_3, \angle H_1, \angle H_2, \angle H_3, \angle I_1, \angle I_2, , \angle K_1, \angle K_3, \angle K_4, \angle L, \angle M_1, \angle M_2, \angle N_1, \angle N_2, \angle O_1$	90°
$\angle D_2E_3B_3, \angle D_1E_1J_1, \angle I_1J_1K_5$	135°
$\angle E_1B_3B_4, \angle B_3B_4D_3, \angle B_4D_3E_1$	180°

DISCUSSIONS

A. Mathematical Concepts in the Ornaments of the Jamik Mosque Sumenep

Based on the results of observations and measurements, ornaments in the Mosque Jamik Sumenep have a unique form. This uniqueness is characterized by its repetitive and recursive form. The repetition that occurs forms a similar wake with each other. In addition, these ornaments are connected without ends. These conditions indicate that the Mosque Jamik Sumenep ornament fulfills the concept of fractal geometry.

In line with the research conducted by Alghar & Marhayati (2023), the ornaments on the Mosque Jamik Sumenep contain the concept of fractal geometry. The fractal shape is realized in Figure 4 with the l-system method. The same thing is also conveyed by Alghar, Walidah, et al. (2023) and Lee & Tiong (2013), that Chinese ornaments on Tian Ti Pagoda and other Chinese-style ornaments fulfill the concept of fractal geometry. That shows that fractal forms are found in natural phenomena such as clouds, plants, and lightning and in cultural artifacts, such as in the ornament of the Mosque of Jamik Sumenep.

Furthermore, based on the results and observations of the research, the ornamentation at the Jamik Mosque Sumenep has the concept of reflection and contains a specific ratio value. This is in line with what Alghar and Marhayati (2023) and Dye (2012) explained: Chinese-style ornaments prioritize balance, so the concepts of reflection and

ratio are used in various ornaments. In addition, the concepts of *Ying-Yang* and *Feng-shui*, which always mean balance and harmony between humans and their surroundings, are represented by opposing forms (Alghar and Fauzan 2024).

In addition, one type of Chinese ornament is the geometric type. Some Chinese ornaments of this type use basic geometric shapes, such as squares, triangles, and circles (Dye 2012). These shapes are combined with Greek key shapes, such as the T-key, L-key, and G-key (Beer 2004). This combination results in other complex geometric shapes with aesthetic value. Because they are derived from geometric shapes, the combination of these ornaments contains angles representing the basic geometry shape. So, the presence of angles in geometric Chinese ornaments is a necessity that cannot be separated.

B. The cultural value inherent in the ornament of the Mosque Jamik Sumenep

1. Value of Swastika Shape

The shape of the swastika is reflected in the ornament of the Mosque Jamik Sumenep. The reflected swastika faces left and right. The swastika shape to the left symbolizes the virile nature of the god, while the swastika shape to the right symbolizes the feminine nature of the goddess (Beer 2004; Dye 2012). Mr. Suyuti, the historian of the Jamik Sumenep Mosque, confirmed the shape of the swastika in the Jamik Sumenep Mosque ornament. He said that the swastika in the mosque gate became an icon of Chinese cultural acculturation in the Mosque. Alghar and Jamaluddin (2024) also conveyed the same thing, that this swastika symbol means the purity of the Buddha's heart and a thousand goodness. In other words, this symbol represents the purity of the heart and the goodness worshipers experience when worshiping at the Sumenep Jamik Mosque.

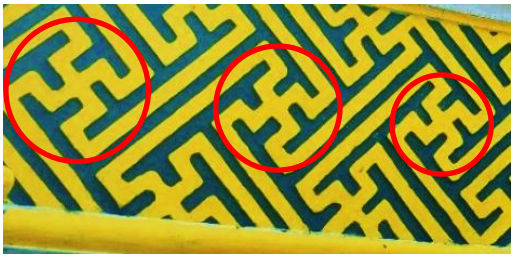

Figure 12.
Swastika shape on the Jamik Mosque ornament Sumenep

2. Value of T-Shape Motif

Chinese-style ornaments often use the T motif to decorate various objects, such as the Tian Ti Pagoda, Sumenep Jamik Mosque, Cheng Hoo Mosque, and other Chinese-style buildings (Alghar, Walidah, et al., 2023; Alghar & Marhayati, 2023; Beer, 2004; Dye, 2012). In addition to being ornamental, the T motif ornament is full of meaning and philosophy. According to Dye (2012), the T motif is usually installed endlessly

interconnected, which means longevity for the object and its owner. Beer (2004) explains that the T motif is often combined with the lightning motif, symbolizing firmness, courage, and harmony. Alghar & Marhayati (2023) said that the T motif on the gate of the Mosque gives hope and prayer for a long life for worshipers who will worship at the Jamik Mosque Sumenep.

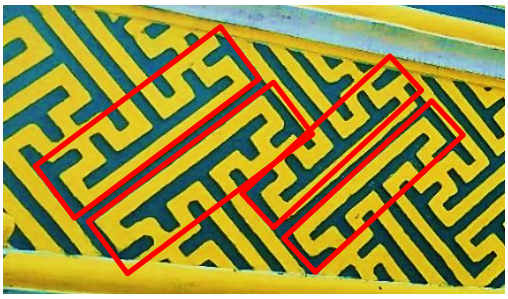

Figure 13.
T motif on the Jamik Mosque ornament Sumenep

3. Acculturation Value of Chinese-style Ornaments

Jamik Mosque Sumenep is a mosque built along with the Sumenep Palace during the leadership of Panembahan Sumolo (Selviana 2013). According to historical records and interviews with Mr. Suyuti as a historian of the Jamik Mosque Sumenep, there were various races, tribes, cultures, and religions during the leadership of Panembahan Sumolo, including the people of Madura, Java, China, and the Netherlands. Although they have different backgrounds, all elements of society live in harmony (Atthalibi et al. 2016; Rohman 2018). Panembahan Sumolo immortalized this tolerance, acculturation, and unity by constructing the Jamik Mosque Sumenep and the Madura, Chinese, and Dutch Sumenep Palace. The construction project was led by a Chinese descendant, Lauw Piango (Fajariyah 2021; Selviana 2013). In other words, the value of cultural acculturation in the Mosque Jamik Sumenep describes the atmosphere of harmony and harmony of the people of Sumenep at that time.

The value of acculturation of Madura, Chinese, and Dutch cultures also manifests in various architectural styles, ornaments, colors, and building layouts. Especially in the Jamik Sumenep mosque, yellow and green ornaments are typical colors of Madura, meaning the glory, prosperity, and religiosity of the Sumenep community (Fajariyah 2021; Selviana 2013). In addition, the shape of the ornaments on the Mosque gives a nuance of Chinese acculturation that can blend and harmonize with Islamic nuances (Alghar and Marhayati 2023). In the Dutch colonial style, the gate characterizes the Sumenep community as having coexisted with the Dutch population at that time (Atthalibi et al. 2016; Rohman 2018).

CONCLUSION

The ornaments on the gate of Masjid Jamik Sumenep contain various mathematical concepts. The concepts found include fractal geometry, reflection, ratio, and angle. In addition, cultural values are attached to the gate ornament of the Jamik Mosque Sumenep. The values include the value of the swastika symbol, the value of the T key motif, and the value of cultural acculturation. This ethnomathematics research is still limited to exploring mathematical and cultural concepts in the ornament of the Mosque Jamik Sumenep. Researchers hope similar research can be done on other Sumenep Kingdom relics, such as the Sumenep Palace and Asta Tinggi. Researchers also hope this study can be developed as a learning tool and a reference for ethnomathematics-based learning in the classroom.

CONFLICT OF INTEREST

The author of this manuscript declares that I am free from conflicts of interest regarding the publication of this manuscript. In addition, the author has fully resolved and accounted for matters relating to plagiarism violations, data falsification or duplication of publications, and matters relating to publication ethics issues.

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