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Artifacts exploration of the Sumenep great mosque through ethnomathematics for mathematics and social learning

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ABSTRACT

Ethnomathematics research is a part of qualitative research that uses the ethnographic method. This study aims to explore, describe, and interpret the patterns, values, and beliefs found in the artifacts and ornaments of the Great Mosque of Sumenep. The researcher is the primary instrument in data collection through interviews, observations, and documentation. Informants are selected using purposive sampling. Data validation is carried out using triangulation methods to be analyzed using descriptive analysis techniques. The study results indicate that these artifacts can be used as objects for learning mathematics and socio-cultural subjects. Students in their surroundings frequently encounter these objects. This research implies a student-centered learning approach based on ethnomathematics, where they are encouraged to explore the mosque's artifacts. Thus fostering a sense of ownership and meaning in the learning process.

Eksplorasi artefak pada masjid agung Sumenep melalui etnomatematika untuk pembelajaran matematika dan sosial

Kata Kunci:

Etnomatematika
Sumenep
Masjid
Pendidikan matematika
Sosial budaya

ABSTRAK

Penelitian etnomatematika merupakan bagian dari penelitian kualitatif yang menggunakan metode etnografi. Tujuan dari penelitian ini adalah untuk mengeksplorasi, menguraikan, dan menginterpretasikan pola, nilai-nilai, dan keyakinan yang terdapat pada artefak bangunan dan ornamen Masjid Agung Sumenep. Peneliti berperan sebagai instrumen utama dalam pengumpulan data melalui wawancara, observasi, dan dokumentasi. Informan dipilih menggunakan metode *purposive sampling*. Validasi data dilakukan dengan metode triangulasi dan dianalisis menggunakan teknik analisis deskriptif. Hasil penelitian menunjukkan bahwa artefak-artefak tersebut dapat digunakan sebagai objek pembelajaran matematika dan sosial budaya. Objek-objek ini sering dijumpai oleh para siswa di lingkungan sekitar mereka. Penelitian ini berimplikasi pada pembelajaran yang berpusat pada siswa berbasis etnomatematika, di mana siswa diajak untuk mengeksplorasi artefak-artefak masjid sehingga esensi kepemilikan dan kebermaknaan muncul dalam proses pembelajaran.

1. INTRODUCTION

Sumenep is one of the provinces of East Java, which is on the eastern tip of Madura island. Sumenep is also an area that is considered cultural because it has historical and tourism value [1]. The famous tourist attractions are *Kraton Sumenep, Alon-Alon,* and the burial complex for the kings and their descendants (Asta Tinggi) which has a European-style building concept. Currently, Sumenep is improving itself to become a religious tourism object. Religious tourism that has the potential is the Sumenep Great Mosque because it has many historical relics. Besides, this mosque is close to *Kraton* and *Alon-Alon.*

The Sumenep Great Mosque was built during the reign of Prince Natakusuma I in the 18th Century. We will see the white and yellow gates when we enter the mosque. This grand mosque is the pride of the people of Sumenep. In addition, the Sumenep Great Mosque stands firmly facing the sunrise and is one of the markers of Sumenep city. In the east of the mosque, The *Kraton,* now the Sumenep museum, is on the eastern side, and the *Alon-Alon* is in the center of the mosque. If we see from above, the distance between the mosque and *Kraton* will form the inscription of Allah [2]. Symbolically, it means that the relationship between humans and nature is required to always remember Allah [3].

The Sumenep Great Mosque, also known as the Sumenep *Kraton* State Mosque, is the building of the monument of *Kraton* [4]. This mosque has ancient, magnificent, and unique architecture. It has three old buildings that still retain their original shape: the main mosque building, the mosque gate building, and the mosque tower building [5]. The Sumenep Great Mosque also contains building elements in other mosques, like pillars, roofs, windows, doors, etc.

The history and culture of the Sumenep Great Mosque is one of the essential sciences for the world of education because we can learn about the implied message of culture. One alternative to connecting education and culture is ethnomathematics. Ethnomathematics is the mathematics science practiced in cultural groups, such as societies, tribes, labor groups, children from certain groups, and professionals [6]. Ethnomathematics can bridge education, especially mathematics, and culture [7]. Culture comes from daily human actions that have a philosophical meaning. It is divided into three forms: ideas, behavior, and artifacts [8]. Mathematics applied to social culture becomes unique knowledge and always includes mathematical elements.

A cultural object that contains mathematical concepts can be used as a learning material [9]. Teachers can use it to explain mathematical concepts and introduce Indonesian culture [10]. It teaches students the relationship between mathematics and daily human activities. They can explore Indonesian culture and discover mathematical concepts in it independently. They will see that daily human activities involving numbers, geometric patterns, and calculations are the application of mathematical knowledge to the local culture of society [11]. Mathematics learning at school can play a role in developing students' mathematical thinking processes [12]. Therefore, teachers must provide students with suitable learning methods to achieve the learning objectives.

Based on initial observations and interviews, the researchers found several data that explain that the mosque building followed mathematical concepts and had philosophical meaning. The architecture of the Sumenep Grand Mosque is thought to follow one of the mathematical concepts, such as measurements and geometric shapes. The mosque's pillars, roofs, doors, and windows are similar to geometric shapes, such as tubes, pyramids, and rectangles. Many geometric shapes are found in the architecture of the Sumenep Great Mosque indirectly [13]. In ancient times, humans had applied mathematical concepts in the construction of buildings. Apart from the geometric concepts found, the shape of the mosque building is thought to have a philosophical meaning. For example, the *swastika* ornament means salvation. It is suspected that there are many philosophical meanings in the mosque building.

Certain societal cultures have given birth to mathematical concepts based on the knowledge and views of ethnic groups, community groups, or individuals without formal education [14]. Mathematics with cultural nuances (ethnomathematics) can significantly contribute to education, especially mathematics learning. An example is the artifacts found in the Sumenep Grand Mosque. These artifacts can be connected to geometric concepts, such as those learned in mathematics classes at school.

Studies regarding mosque exploration had previously been conducted in ethnomathematics studies, like the exploration of ethnomathematics on the geometry concept at the Great Mosque of Al-Barkah [15], the ethnomathematics exploration on the Cut Meutia mosque [16], the ethnomathematics exploration on the mosque of Al-Alam Marunda [17], the ethnomathematics exploration on the Bandung Great Mosque [18], and the ethnomathematics exploration on the concept of geometry and algebra at the Great Mosque of Cimahi [19]. From many ethnomathematics studies on mosques, no research discusses the ethnomathematics exploration of the Sumenep Great Mosque. The Sumenep Great Mosque is a historical heritage with many cultural values. However, the Sumenep Great Mosque has not been registered as one of Indonesia's cultural heritage buildings [20]. On the other hand, the people of Sumenep know this mosque as a symbol of tolerance [3]. The community, including Muslims and non-muslims, live in harmony together around the mosque. In fact, they help each other in social activities. The mosque's *takmir* disbanded the Sumenep Anniversary Road Race activity because it was felt that the activity was disturbing worship activities at the mosque [21].

Based on these empirical data, the researchers conducted research about artifacts exploration of the Sumenep Great Mosque based on the ethnomathematics perspective. This research is done to dig deeper into the history and culture of the mosque, where the building and ornaments artifacts in the Sumenep Great Mosque have high artistic value. Different from previous research, this research discusses socio-cultural learning, which can be explored through the meaning of the mosque building structure. Therefore, the learning offered is mathematical concepts and socio-cultural learning for the students.

Contribution to the literature

This research contributes to:

- Bridging the gap between mathematics education and cultural heritage by integrating ethnomathematics into the learning process.
- Providing a model for designing student-centered learning modules based on ethnomathematics.
- Highlighting the potential use of cultural artifacts for socio-cultural learning.

2. METHOD

This study applied qualitative research combined with an ethnographic method. A qualitative study is used to understand conditions from a context, leading to a detailed and in-depth description of what happened according to the field [22]. The purpose of this study is to explore the mathematical concepts contained in cultural elements. Here, the cultural elements studied were artifacts. The collected data was formed into words and pictures. At the same time, the ethnographic method was applied to understand socio-language and culture from artifacts [23].

The researchers played a role as research instruments and data collectors through interviews, observation, and documentation. The researchers also used field notes as supporting instruments during the observation. The observation method used was passive partition observation. The researchers came to the location of the research. However, the researchers only visited the location without being involved in the activities at the research site. The researchers described real conditions obtained from observations and interviews with informants without manipulating and changing variables.

Those chosen as informants knew about the building and ornamental artifacts of the Sumenep Great Mosque and people who had been involved in mosque activities for a long time. The number of informants taken was not emphasized; the quality of the information provided was emphasized. In this research, the researchers obtained five informants to ask for in-depth information: the chairman, the exchequer, and three staff members at the Sumenep Great Mosque, which is located on Jl. Trunojoyo No. 184, Sumenep City, Madura, East Java.

The interview questions were prepared in advance before interviewing the informant. The researcher then made an interview and observation sheet as a research guide. The researchers observed the shape of mosque artifacts and discovered historical and cultural meanings through interviews to obtain primary [16], [24].

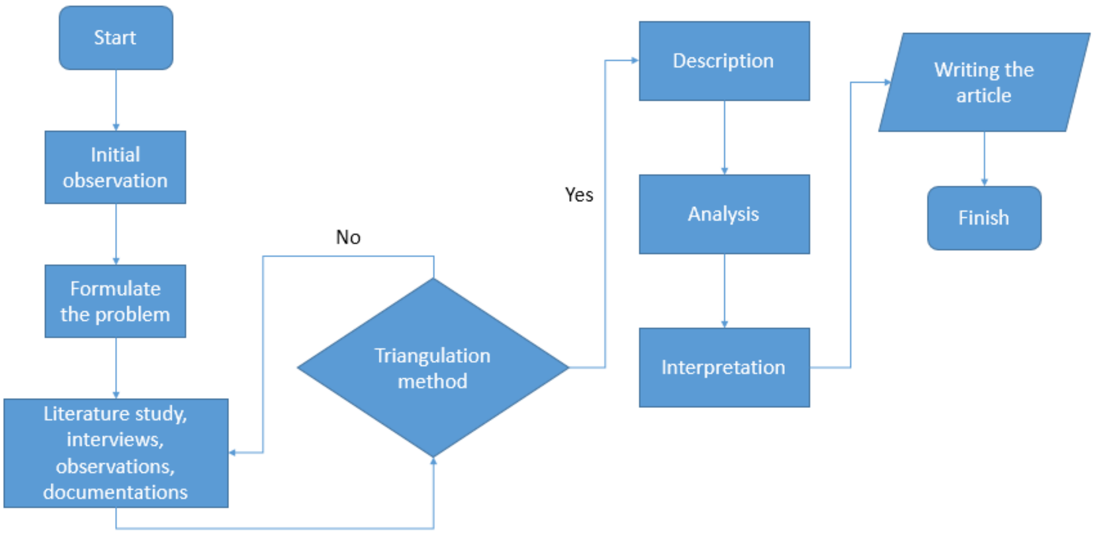

Figure 1. The Flow of Ethnomathematics Explorational at the Sumenep Great Mosque.

In the observation, the researchers observed and recorded parts of the mosque that contained mathematical concepts. Data observations were obtained using measurement and temporary hypotheses from parts of the mosque. The researchers also documented the observation results in photos/pictures and field notes. The interviews were conducted to find and know several pieces of information researchers need, such as the philosophy on parts of the mosque, the type of ornament, mosque building, and so on. To support the results, the researchers conducted a literature study as the secondary data by reviewing articles, theses, and scientific journals. This study analyzed data using a descriptive analysis technique, such as description, analysis, and interpretation [15]. The triangulation method was used to validate data [25]. Thus, the researchers obtained data that was accurate. The validated primary data was obtained from interviews, observation, and documentation in this research. Figure 1 shows the flow of ethnomathematics explorations at the Sumenep Great Mosque.

3. RESULTS AND DISCUSSION

3.1 History and Architecture of the Sumenep Great Mosque

Based on the results of interviews with the informant, Sumenep City's urban planning has theological value and is also the embodiment of the Sumenep people. Sumenep city, which Penembahan Somala built, has historical heritage, such as *Kraton*, *Alon-Alon*, the mosque, and Asta Tinggi. According to [26], this inheritance manifests the pattern of relations: *"Hablum Minal Allah, Hablum Minannas, Hablum Minal Alam."* The Sumenep Great Mosque, or the Sumenep *Kraton* Mosque, is a symbol of *"Hablum Minal Allah."* Meanwhile, the *Kraton* is a symbol of "*Hablum Minannas*," and the *Alon-Alon* is a symbol of *"Hablum Minal Alam."* Around the Sumenep Great Mosque is a gate in the form of *Gapura.* The word *gapura* comes from the word "*Hafura"* which means forgiveness from Allah.

During the reign of Prince Natakusuma I, Islam was growing so fast that the Sumenep people buil*t language* in every house and mosque in every village. The background for the construction of the Sumenep Great Mosque was the old mosque which cannot accommodate the increasing number of congregations. Therefore, this mosque was built to strengthen the unity and integrity of the Muslim community [1]. In the mosque, there is an inscription which is a testament from Prince Natakusuma I. This inscription explains that the Sumenep Great Mosque was built by Prince Natakusuma and was given in the way of Allah to become a means of obedience to Allah [3].

Figure 2. The *Gapura* of Sumenep Great Mosque

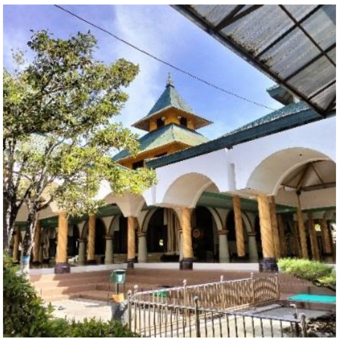

Figure 3. The Main Mosque Building

The Sumenep great mosque consists of three unique building parts: the tower, mosque, and gate. First, the gate is the characteristic and identity of the mosque. Visitors always pass through this gate before entering the mosque. There are several unique ornaments, such as *swastika* ornaments or images of upside-down rice. Second, the tower is located at the back of the mosque. However, the height of this tower is not higher than the mosque building. In the past, this tower was used to announce the *azan sholat* (calling for prayer). Third, the mosque is divided into two buildings, namely, the main room of the mosque and the foyer. In the main room, there is *mimbar, mihrab, maksurah,* dan pillars. There are thirteen big pillars. There are also large doors and windows, specifically nine and ten. Next, in the foyer, there are two pillars: the pillars around the main room and the surrounding pillars. The number of pillars around the main room is 21, while the number of pillars in the foyer is 62. These pillars support the load from the top of the mosque. This mosque looks like a Javanese mosque. Generally, Javanese mosques have a roof shape like a triangle. This roof shape is also found in the Sumenep Grand Mosque. This roof shape can be called a *tajug* roof. Furthermore, this mosque has two pavilion buildings at the front. The pavilion is a place for prayer and rest for the congregation.

Based on its history and architectural form, the Sumenep Grand Mosque can be a relevant learning object for students, especially geometric concepts and socio-cultural. From this object, teachers can design learning according to the student's life and cultural context involving communities. Therefore, suitable learning focuses on students' or ethnomathematics-based student-centered learning, where the environment and family background are considerations for teachers in making learning and assessments. One of the benefits of this learning is strengthening students' identity as part of the environment, developing community life skills, and providing a positive environment so that students feel comfortable in learning [27].

3.2 Geometry Concepts on the Sumenep Great Mosque

To understand the geometry of the Sumenep Great Mosque, the researchers divided it into four objects: the number of pillars, the mosque's ornament, the number of mosque doors and windows, and the pavilion.

3.2.1 The Number of Pillars

The Sumenep Great Mosque has several pillars. The main mosque buildings have two rooms, namely the main room and the mosque portico. The main room has 13 pillars. Around the main room, there are 21 pillars. Meanwhile, at the mosque *entrance,* there are 62 pillars. These pillars are used to support the weight of roofs. The number of pillars has several philosophies, such as 13 pillars in the main room mean *13 rukun sholat* (the pillars of prayers) and 21 pillars around the main room represent *aqoid* or the properties of Allah (20 *jaiz* property, 20 mandatory properties, and one imposibble property of Allah). The following are three pillars of the Sumenep Great Mosque.

(a) (b) (c)

Figure 4. The Pillars of Mosque: (a) In the Main Room, (b) Around the Main Room, (c) In the Mosque Foyer

In their observation, the researchers discovered the mathematical principles that can be found in the pillars. Figures 4a and 4c show that the pillars are in the shape of a tube. The characteristics of a tube are: 1) it is built by two circles and a rectangle that surrounds the two circles; 2) the two circles are called with the side of base and lid; 3) it has a central point; 4) it has a diameter and a radius; 5) tube high which is denoted by h can be determined from the distance between the center point of base to lid. In Figure 5, a diameter is represented with a yellow line, and it is denoted by d. Meanwhile, a radius is represented with a red line, and it is denoted by r [28]. Furthermore, the volume and surface area of the tube can be determined through high and radius of the tube. Using $\pi = \frac{22}{7}$ or 3.14, tube volume and surface area can be found with $V = \pi \times r^2 \times t$ and $L = 2 \times \pi \times r \times (r + t)$, respectively [29].


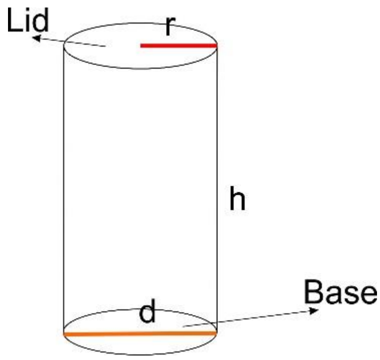

Figure 5. The Pillars of Mosque

From Figure 4b, it can be seen that the pillars have shifted uniformly by 4.2 meters. If the pillars around the main room are visualized using a Cartesian diagram, then it shows a geometrical transformation, namely translation. The translation is a change in plane position with the same distance and direction without changing shape [28]. Figure 6 shows that the pillars shift on the x-axis as far as 4.2 meters. The following is the shifting of pillars on the Cartesian diagram.

Figure 5 and Figure 6 show that the size and distance of pillars are illustrated through geometry concepts. The pillars can be used as a learning object for teachers that can provide an overview to 9th-grade students about curved side space geometry concept following basic competence 4.7, "solving contextual problems related to the surface area and volume of curved side space geometry as well as the combination of curved side space geometry" and geometry transformation concept following basic competence 4.7 "draw and determine the coordinates of image of transformation object in Cartesian diagram" [28]. From the picture above, students can relate the geometry material to the pole's shape. Through observation, they can find the picture's volume and surface area and imagine the pole's shape visually. Furthermore, students can also study through the number of pillars, namely it is about what are *13 rukun sholat* and the properties of Allah.


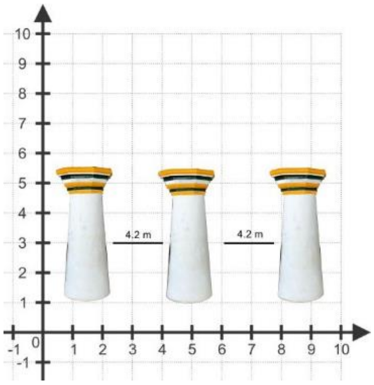

Figure 6. The Shifting of Pillars

3.2.2 The Ornament of Mosque

Based on the interviews with informants, the Sumenep Great Mosque is a mosque rich in cultural acculturation, such as Chinese, Java, Madura, and Netherlands. This can be seen from the overall design of the mosque complex. For example, in the ornament of the mosque, the Sumenep Great Mosque has several ornaments that are unique and rich with meanings. Table 1 below are ornaments that can be found in the mosque.

Table 1. The Meaning of Ornaments in the Sumenep Great Mosque *Source* [30], [31]

Name	Location	Meanings
Starflower	*Maksurah* and *Mimbar*	This decoration symbolizes a deity
Forest flower	*Maksurah*, *Mimbar*, and *mihrab*	The decoration symbolizes the diversity of life
Chinese flower	Door	Chinese flower decoration symbolizes sincerity
Pomegranate flower	Door ventilation	This decoration symbolizes dignity and honor
Swastika	*Gapura*	*Swastika* decoration (wan) means infinity
Two bound circles	*Gapura*	This shape symbolizes that fellow Muslims must maintain the bonds of brotherhood.
Bat ornament	Minaret	The decoration on the tower in the shape of a bat symbolizes luck, happiness, and longevity.

As seen through the Cartesian diagram, the ornament of the mosque can be visualized as a geometrical transformation, namely reflection and translation. Reflection is a type of transformation that uses the properties of flat mirrors so that each point/plane can be moved with the same distance and size [17]. The shape of the ornament that represents the reflection concept can be seen in Chinese flower ornament. When the y-axis is considered a mirror, the left door side will be the same as the right (see Figure 7).

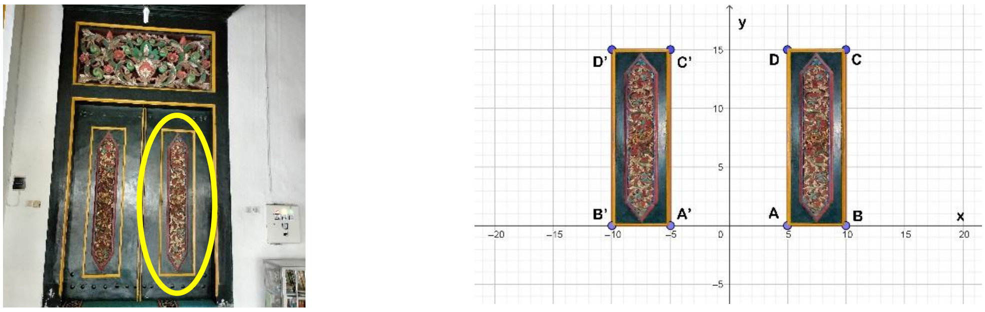

Figure 7. The Reflection on Chinese Flower Ornament

Based on the analysis results, the reflection of the ornament that occurs on the y-axis makes the carving and shape of each side of the ornament have similarities. If the researcher creates coordinate points using data in the field, then it can be obtained the following coordinate points $A(0.5,0)$, $A'(-0.5,0)$, $B(1,0)$, $B'(-1,0)$, $C(0.5,1.5)$, $C'(-0.5,1.5)$, and $D(1,1.5)$, $C'(-1,1.5)$. The point A' is the opposite of point A with a fixed y coordinate. Mathematically, it can be written the following equation.

$$A(x,y) \xrightarrow{M_y} A'(-x,y), M_y = \begin{pmatrix} -1 & 0 \\ 0 & 1 \end{pmatrix} \qquad (1)$$

Equation (1) is a matrix form of reflection. Thus, it can produce:

$$\begin{gathered} A(0.5,0) \xrightarrow{M_y} A'(-0.5,0), \\ B(1,0) \xrightarrow{M_y} B'(-1,0), \\ C(0.5,1.5) \xrightarrow{M_y} C'(-0.5,1.5), \\ D(1,1.5) \xrightarrow{M_y} D'(-1,1.5), \end{gathered} \qquad (2)$$

The analysis's results show that the ornament follows a transformation concept, namely reflection.

After observing through the Cartesian diagram, at the *swastika* ornament, there is a translation element that shifts on the x-axis. According to the informant, it can be seen that *swastika* ornaments have shifted uniformly by 60 cm. The following is a translation of *the swastika* ornament drawn on the Cartesian plane.

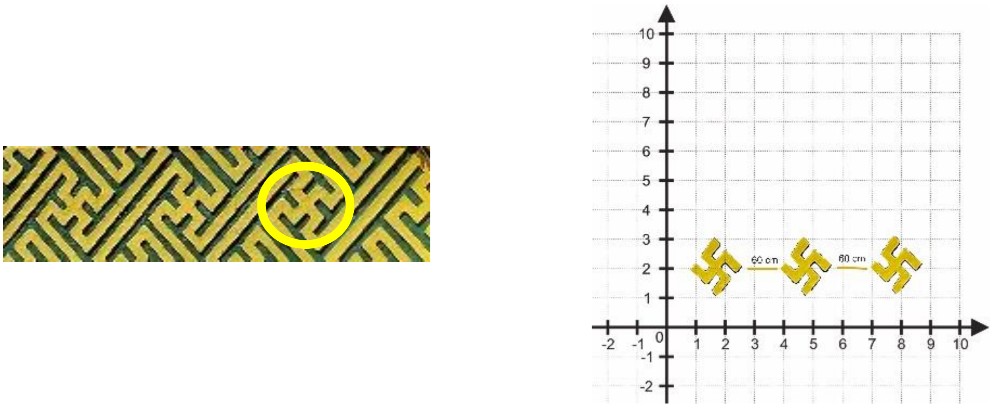

Figure 8. The Translation of *Swastika* Ornament

In Figure 8, the *swastika* ornament's position shifts on the x-axis as far as 60 cm. Based on the data analysis, the plane's translation makes the plane position change with the same distance and direction, but the carving and shape of the ornament have similarities. This analysis shows that the change in plane position with respect to the x-axis produces a geometrical transformation, namely translation.

The researcher illustrates Chinese flower and *swastika* ornament through geometry transformation concepts as in Figure 7 and Figure 8. These ornaments can be used as mathematics teaching materials for teachers in the class. The ethnomathematics-based student-centered learning can provide an experience to 9th-grade students about reflection and translation. They can imagine the shape of ornaments visually. They can also easily connect geometric material, especially transformation, to mosque ornaments from this learning object. Same as in [32], the development of ethnomathematics-based mathematics teaching materials on Jepara woodcarving can stated as teaching materials that are suitable and easy to understand for use in the learning. Furthermore, students can learn the social side through the meaning of ornaments, such as Table 1 about sensitivity, tolerance, and responsiveness to social culture in society, strengthen students' identity as Indonesians, and provide reflection on experiences of diversity and respect for national values and culture.

3.2.3 The Number of Mosque Doors and Windows

The existence of various cultures in the design of the Sumenep Great Mosque is not only to display beauty and comfort when worshiping Allah but also to convey messages. Based on the observation and interviews with informants, the Sumenep Great Mosque has nine doors arranged neatly with a fairly large size. The width is 2.5 meters, and the height is 3.5 meters (see Figure 9). The height of the door, which is more than three meters, is similar to the size of the Dutch [4]. Meanwhile, the number of windows in the Sumenep Great Mosque is ten windows, 3 meters long and 2 meters wide (see Figure 10). According to informants, Ancient people did not have building measuring tools so they used a lot of teak wood to build a building. Finally, the size of the building looks huge.

Figure 9. The Mosque Door

The number of doors and windows has a meaning in the design of the Sumenep Great Mosque. The number of doors symbolizes that the five doors in the east show the five daily prayers that humans must do, and the two doors in the south and north show the characteristics of Prophet Muhammad SAW., namely *Siddiq*, *Amanah*, *tabligh*, and *Katonah*. Meanwhile, the ten windows symbolize the number of angles. The nine doors also symbolize the nine *wali songo*. It means that humans must emulate the noble behavior of 9 *Wali Songo*.

Under observation, at the doors and windows, it can be seen that the doors and windows are in the form of rectangles. The rectangle is a geometric shape having four sides whose opposite sides are congruent and four angles 90°. Furthermore, the rectangle has two axes and two diagonals. The size of doors and windows can be used to determine rectangle area and rectangle circumferences with the area formula is $L = p \times l$ and the circumferences formula is $K = 2 \times (p + l)$.

An ethnomathematical concept found in doors and windows is a rectangle. These doors and windows can be a learning medium for teachers teaching mathematics to 7th-grade students. By looking at these tools, students can analyze and calculate the rectangle area and rectangle circumferences of doors and windows. Furthermore, doors and windows as learning media can be used as teaching materials to fulfill the basic competence 3.11, "solving contextual problems related to area and circumference of rectangular and triangle" in grade 7 middle school learning [33]. From the social side, students can derive historical and religious values from the meaning of the shape and number of mosque doors. Students can also learn tolerance towards ethnic, racial, and religious diversity. This is in line with the history of the Sumenep Grand Mosque as a symbol of tolerance in Sumenep [3].

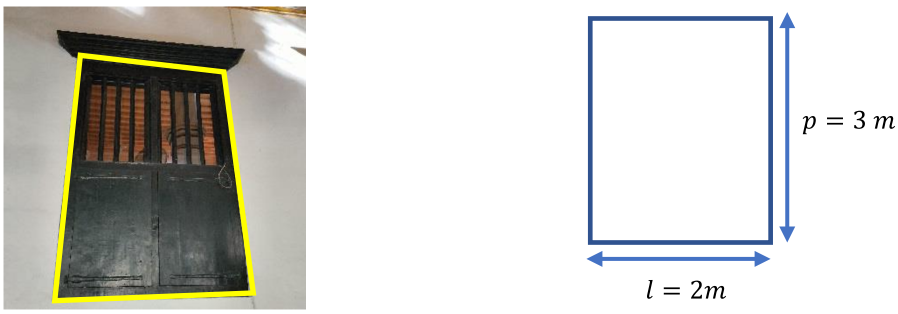

Figure 10. The Mosque Windows

3.2.4 The Pavilion of Mosque

Both have something special to offer at the mosque's roof and pavilion. The uniqueness produced by the building is inseparable from the geometric concept. For example, the mosque's roof has the basic shape of a pyramid. The Sumenep Great Mosque has three types of roof: the *tajug* roof stacked one, two, and three. Furthermore, the shape of a roof like this also has a philosophical meaning. Based on interviews with the informant, the *jug* roof stacked one symbolizes *Iman*, the *jug* roof stacked two symbolizes *Islam*, and the *jug* roof stacked three symbolizes *Ikhsan*. One of the buildings with the *tajug* roof stacked is the pavilion of the mosque located at the front of the mosque. The pavilion of the mosque is divided into two rooms, namely, the pavilion for the male congregation and the female congregation. The function of this building is to be used as the resting place for the male and female congregations.

The basic shape of the pavilion is a combination of a beam and a pyramid. In Figure 11, the beam is drawn with red lines, while the pyramid is drawn with yellow lines. Upon closer inspection, the roof of the pavilion obeys a geometric plane, specifically a pyramid with dimensions of 9 meters long, 9 meters wide, and 2 meters high. The pyramid also follows these geometrical properties: 1) it is built with a square base and four slanted sides, 2) the apex of the pyramid is located directly above the point in the center of the base, and 3) the four slanted sides are isosceles triangles [34]. Meanwhile, the pavilion's main hall is shaped like a beam 8 meters long, 8 meters wide, and 3 meters high. The beam exhibits the following geometrical characteristics: 1) it has six rectangular planes and 12 edges, 2) opposing planes are the same size or harmonious, and 3) it has eight angles [34]. Because the length and width of the pavilion's main hall are the same, Madura people call it *setting ander*.

Figure 11. The Pavilion of Mosque

Students' difficulties in solving the problem of flat side space were caused by their mistakes in determining formulas and making models [35], [36]. This difficulty could occur because students were still unable to differentiate the surface area of the beam from the volume of the beam [35] and could still not differentiate the height of a triangle from the height of a pyramid [36]. External factors also caused students' difficulties, students' interest in learning mathematics was lacking, and there was no motivation to learn. These difficulties can be overcome through ethnomathematics-based learning [37]. Ethnomathematics provides a conducive learning environment and creates good learning motivation to avoid perceiving mathematics as difficult.

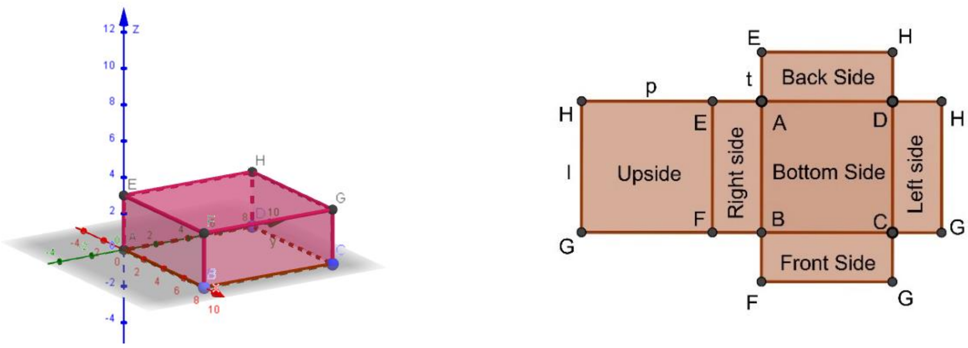

Figure 12. Geometry Modelling of Beam

The mosque pavilion, which combines beams and pyramids, can help students understand the flat side space. Figure 12 is the geometry model of a beam drawn through a beam mesh.The surface area of the beam can be obtained through the beam mesh above. The volume of the beam can be obtained later. As in Figure 12, there are congruent planes. These planes can be searched in field areas. Thus, it is obtained the following equation.

$$\begin{aligned} ABCD &\cong EFGH \rightarrow L = p \times l, \\ ADHE &\cong BCGF \rightarrow L = l \times t, \\ ABFE &\cong CDHG \rightarrow L = p \times t, \end{aligned} \tag{3}$$

From equation (3), the surface area of the beam is $Lp = 2 \times [(p \times l) + (l \times t) + (p \times t)]$. Meanwhile, the volume of the beam is obtained from the beam's length, width, and height. Therefore, the volume of the beam is $V = p \times l \times t$.

Figure 13 shows that the pavilion roof is in a pyramid shape. As in equation (4), the pyramid has four congruent triangular areas and a square base.

$$\Delta TAB \cong \Delta TBC \cong \Delta TCD \cong \Delta TDA \tag{4}$$

To get the surface area of a pyramid, the height of TE first needs to be focused on the Pythagorean formula, namely, $TE^2 = OE^2 + OT^2$, where $OE = BF$. Therefore, the surface area of the pyramid can be suitable as in equation (5).

$$\begin{aligned} Lp &= base\ area + 4 \times triangular\ areaLL \\ &= AB^2 + \left(4 \times \frac{1}{2} \times TE \times AB\right). \end{aligned} \tag{5}$$

Meanwhile, the a pyramid's volume is obtained through throug its base area and height. Thus, the volume of the pyramid is as in equation (6) below.

$$V = \frac{1}{3} \times base\ area \times height, = \frac{1}{3} \times AB^2 \times OT. \tag{6}$$

The pavilion of the mosque can also be used as a learning object for students. From Figure 12 and Figure 13, students can try to study about volume, surface area, and mesh of beams and pyramids. Using ethnomathematics-based student-centered learning, students can feel comfortable learning and visualize a building easily because this learning can provide a positive environment for them and the compatibility between learning at school, at home, and in the community environment where students live and develop. From this learning, they can instill a sense of ownership of the learning process. Here, it is hoped that student difficulties can be resolved. Furthermore, they can study *Islam*, *Iman*, and *Ikhsan.* Thus, religious values can be included in learning about what is meant by *Islam*, what is meant by *Iman,* and what is meant by *ikhsan.*

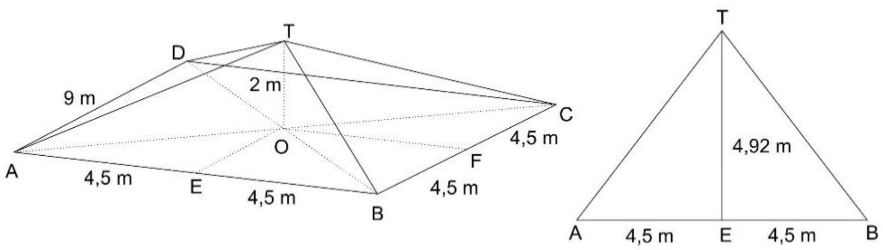

Figure 13. The Pyramid Shape

The pavilion of the mosque can also be used as a learning object for students. From Figure 12 and Figure 13, students can try to study about volume, surface area, and mesh of beams and pyramids. Using ethnomathematics-based student-centered learning, students can feel comfortable learning and visualize a building easily because this learning can provide a positive environment for them and the compatibility between learning at school, at home, and in the community environment where students live and develop. From this learning, they can instill a sense of ownership of the learning process. Here, it is hoped that student difficulties can be resolved. Furthermore, they can study *Islam, Iman,* and *Ikhsan.* Thus, religious values can be included in learning about what is meant by *Islam,* what is meant by *Iman,* and what is meant by *ikhsan.*

This research aligns with previous studies examining the application of ethnomathematics [38], [39], all of which indicate that integrating culture into mathematics education can enhance students' understanding and appreciation of mathematical concepts and their cultural heritage. The limitations of this study lie in the sample size and geographical scope. This research only involved five informants selected purposively, so the results may not fully represent all views regarding the artifacts of the Great Mosque of Sumenep. The study's focus on the Great Mosque of Sumenep means that the findings and implications may not be generalizable to other cultural or geographical contexts. Therefore, future research should involve more informants from various backgrounds and conduct comparative studies with other mosques or cultural sites in different regions to gain a more comprehensive perspective and ensure broader generalization of the results.

4. CONCLUSION

This research shows that integrating ethnomathematics into the Great Mosque of Sumenep artifacts can enhance contextual and relevant mathematics learning, strengthen students' cultural identity, and promote cultural heritage preservation through education. Thus, this study contributes to the ethnomathematics literature and offers practical approaches that can be applied in mathematics teaching and socio-cultural education in various contexts.

Through student-centered learning based on ethnomathematics, students can independently explore the forms of mosque artifacts, fostering a sense of ownership in the learning process and enhancing their cultural identity within their environment. Therefore, teachers must consider the student's environment and family background to design learning and assessments appropriate to the student's conditions. This aligns with the independent curriculum, as the learning process involves self and peer assessment, instills a sense of ownership of the learning process, and positions the teacher as a facilitator.

AUTHOR CONTRIBUTION STATEMENT

ALF was responsible for the conceptualization, methodology design, supervision, and data collection and made significant contributions to the writing and revision of the manuscript. MF assisted in data analysis, interpretation, and literature review and contributed critically to the drafting and revision of the manuscript. ALH participated in fieldwork, data documentation, validation, and analysis of cultural and mathematical aspects and assisted in drafting the manuscript.

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