AlphaMath
Journal of Mathematics Education, 10(2) November 2024
p-ISSN 2477-409X, e-ISSN: 2549-9084
Available online: https://jurnalnasional.ump.ac.id/index.php/alphamath/

Ethnomathematics Exploration in The Joglo House of Banyumas

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http://dx.doi.org/10.30595/alphamath.v10i2.22505

ABSTRACT
Indonesia is known as a country with cultural diversity, one of which is the traditional house, a symbol of each tribe and region. In its implementation, the Joglo house is only used as a residence and a place to protect against exposure to sunlight. Still, after exploring it in more depth, the structure of the traditional house can be used as learning material in the field of education. One field of education that can study culture through the structure of conventional house buildings is mathematics. Learning mathematics that includes culture can help students improve their understanding of abstract mathematics. However, not many mathematics lessons in corporate culture into the material. So, this research aims to explore Banyumas Joglo houses regarding geometric concepts. The type of research used is qualitative research with an ethnographic approach. Data collection methods include observation, documentation and interviews. The data analysis consists of data reduction, data presentation, and conclusion. This research shows that the Banyumas Joglo traditional house is an example of a conventional house rich in ethnomathematics, where elements of traditional culture contain mathematical knowledge in the form of geometric concepts.
Keywords: Culture, Ethnomathematics, Geometry, Joglo House

ABSTRAK
Indonesia dikenal sebagai negara yang memiliki keberagaman budaya, salah satunya adalah rumah adat yang menjadi simbol dari masing-masing suku dan daerah. Dalam implementasi rumah Joglo baru digunakan sebatas tempat tinggal dan tempat pelindung dari paparan sinar matahari, tetapi setelah ditelusuri lebih mendalam struktur rumah adat dapat dijadikan sebagai bahan pembelajaran dalam bidang pendidikan. Salah satu bidang pendidikan yang dapat mengkaji budaya melalui struktur bangunan rumah adat adalah ilmu matematika. Pembelajaran matematika yang memasukkan budaya dapat membantu peserta didik untuk meningkatkan pemahaman matematika abstrak. Namun, belum banyak pembelajaran matematika yang memasukkan budaya ke dalam materinya. Maka, penelitian ini bertujuan untuk mengeksplorasi rumah Joglo Banyumas terhadap konsep geometri. Jenis penelitian yang digunakan yaitu penelitian kualitatif dengan pendekatan etnografi. Metode pengumpulan data berupa observasi, dokumentasi, dan wawancara. Analisis data yang digunakan terdiri dari reduksi data, penyajian data, dan penarikan kesimpulan. Hasil penelitian ini menunjukkan bahwa rumah adat Joglo Banyumas merupakan contoh rumah adat yang kaya akan etnomatematika, di mana elemen budaya tradisional mengandung pengetahuan matematika berupa konsep-konsep geometri.
Kata kunci: Budaya, Etnomatematika, Geometri, Rumah Joglo

Received : June 13, 2024
Accepted : November 27, 2024
Published : November 27, 2024

Introduction

Indonesia is known as a pluralistic country because it has different ethnicities, cultures, religions, languages, and customs (Safitri, 2023). This is due to the vast territory of Indonesia which consists of five large islands namely Java, Kalimantan, Sulawesi,

Sumatra and Papua, and consists of approximately 34 provinces where each province has cities and districts that have different cultures (Fx et al., 2022). Each existing culture contains its own meaning and philosophical values. Globalization can make the younger generation think more modern, which can have an impact on the decline in the younger generation's interest in Indonesian culture (Ekaputri et al., 2023). Each existing culture contains its own meaning and philosophical values. Globalization can make the younger generation think more modern, which can have an impact on the decline in the younger generation's interest in Indonesian culture (Abdullah & Rahmawati, 2021).

One of Indonesia's cultural heritages is traditional houses that have been passed down from generation to generation (Pitaloka & Susanti, 2022). Traditional houses are buildings in each region that have certain characteristics that describe or symbolize the culture of the people in that area (Nurfauziah & Putra, 2022). The architecture of traditional houses represents real culture (Yunanto, 2021). In ancient times, the most beautiful traditional houses were usually owned by nobles or local traditional leaders. The making of traditional houses uses selected wood and the construction is done traditionally by involving experts in their fields (Abdulghani & Sati, 2019). The shape and architecture of traditional houses in Indonesia vary depending on the nuances of local customs. The diversity of traditional houses in Indonesia contains important meanings from the perspective of history, heritage and social development in a civilization (Eka, 2018). The Javanese tribe has a Joglo traditional house which is a special traditional house among the Javanese people.

Joglo house is a Javanese traditional house built by ancient ancestors as a place to live in 1835 and the sequence of building the house is a standard custom or procedure carried out by the people of the Java region (Pratama et al., 2018). In the understanding of the Javanese community, Joglo houses reflect the attitudes, insights, and economic, social, and cultural levels of the community (Meiruloh, 2021). The Joglo house was originally owned by wealthy people or financially considered capable because making a Joglo house requires more and expensive materials than other forms of houses and also has a high moral value. With the development of community civilization, especially the people of Central Java, Joglo houses have now been converted to various functions in various walks of life, such as meeting rooms, offices, hotels, restaurants, and even apartments (Moniaga, 2019). The Joglo traditional house has many types, this is influenced by the creativity of the surrounding community. Banyumas Joglo traditional house is one of the Joglo traditional houses in Central Java. The distinctive feature of the Banyumas Joglo house is that the roof of the middle part of the house is in the form of a *tikelan* or a pile of wood that has an odd number of stacks. Many ornaments and parts of the Banyumas Joglo house contain geomerti concepts such as

the concept of transformation geometry, the concept of flat buildings, the concept of building space, the concept of congruence, and many more geometry concepts. This shows that mathematical concepts, especially geometry, are unconsciously used and strongly embedded in the culture of the Banyumas community.

The combination of culture and mathematics is called ethnomathematics (Ulum, 2018). Ethnomathematics is a collection of different knowledge resulting from the discovery of mathematical concepts in a particular culture (Prahmana & D'Ambrosio, 2020). In other words, ethnomathematics is a method of learning mathematics that involves environmental activities or culture so that it can make it easier for someone to understand mathematical concepts (Syahdan, 2021). The role of ethnomathematics in mathematics education is to show that ethnomathematics provides an important framework for mathematics education that helps transform mathematics into a stronger discipline (Rosa et al., n.d., 2016). The use of ethnomathematics objects in mathematics learning can help students make mathematics more practical and improve their understanding of abstract mathematics (Hardiarti, 2017). However, in reality there are not many mathematics lessons that include culture in learning materials (Purnama et al, 2020).

In everyday life, culture and mathematics are always related because culture is a whole and integrated unit applied in society, while mathematics is knowledge used by humans to solve everyday problems (Hardiarti, 2017). In mathematical activities there is a process of abstracting from real experiences that occur in everyday life into mathematics or vice versa, such as grouping activities, calculations, measurements, modeling, and others (Sudirman et al., 2017). According to Rahman (2018), the purpose of mathematics in education is to help students understand mathematical concepts, explain relationships between concepts and apply mathematical concepts accurately, efficiently and precisely (Kase et al., 2024).

Based on research conducted by Zulkifli & Rahmawati (2020), it shows that the traditional Joglo house in Japan Village type Bucu has geometry concepts, including the concept of flat shapes consisting of square, rectangle, trapezoid, rhombus and triangle. As well as there is the concept of geometry of space consisting of pyramids and blocks. This is in line with research conducted by Kholisa (2021), which explains that there are mathematical concepts in the Semar Tinandhu Joglo house. The concepts contained are the concept of flat shapes, namely square, rectangle, triangle, trapezoid, rhombus; the concept of space, including cubes, blocks, pyramids, and prisms; as well as the concepts of congruence and geometric transformation. In this case, it shows that it turns out that the Joglo traditional house contains mathematical concepts so that researchers are interested in researching the Banyumas Joglo traditional house because

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p-ISSN 2477-409X, e-ISSN: 2549-9084

researchers have not found ethnomathematics research on the Banyumas Joglo traditional house. Therefore, this study aims to explore the Banyumas Joglo house on the concept of geometry. It is hoped that the Banyumas Joglo house can be used in learning mathematics geometry material and mathematical concepts can be explored in other Banyumas customs.

Research Methods

This research uses qualitative research with an ethnographic approach. The ethnographic approach aims to obtain an in-depth description of cultural objects and ancestral values through field research conducted within a certain period of time. The object studied is the Banyumas Joglo house located in Klahang Village, Sokaraja District, Banyumas Regency, Central Java Province, Indonesia. The data collection methods used were observation, documentation, and interviews. Observation activities were carried out by observing the entire Banyumas Joglo house building that contains the concept of geometry. The observation was conducted on May 5, 2024 until May 28, 2024. Documentation conducted in this research is taking photos of every part in the Banyumas Joglo house which is used to strengthen the researcher's claim and provide concrete visual evidence of the geometry concept of the Banyumas Joglo house. The type of interview used in this research is a semi-structured interview with the speakers, namely the owner of the Banyumas Joglo house named Mr. Narto, the Joglo house builder named Mr. Adi, and a historian named Prof. Dr. Sugeng Priyadi Mhum. The purpose of this interview was to find out the history of the Banyumas Joglo house, find out the characteristics of the Banyumas Joglo house form, and find out the name and function of each building in the Banyumas Joglo house. The data analysis used consisted of data reduction, data presentation, and conclusion drawing. In the reduction stage, the results of data research are classified to be used to collect the next data. Furthermore, presenting the data means arranging the data in a coherent and easy to understand manner and finally drawing conclusions is identifying the cultural relationship that exists in the Banyumas Joglo house architecture with mathematics.

Result and Discussions

Traditional houses are a form of art in the field of architecture and are a form of exploration of human thought that represents the characteristics of a particular culture or society (Wikaningtyas et al., 2022). This causes traditional houses in Indonesia to be very diverse and each region has different traditional houses. One concrete manifestation of culture can be seen from the architecture of traditional houses (Yunanto, 2021). The architectural style of a traditional house in the Central Java region is the Joglo traditional house (Moniaga & Gunawan, 2019). The Joglo house comes from the words "tajug" and "loro", which means two tajugs combined on the roof of

the house in a shape resembling a mountain. Javanese people believe that mountains are a sacred symbol and the abode of the gods, so this roof was made with the aim of being closer to God (Pitaloka & Susanti, 2022). In line with this, based on the results of interviews with Prof. Sugeng Priyadi, M.Hum., the roof of the Banyumas Joglo house has its own uniqueness. Apart from being shaped like a mountain, the middle part of the roof of the house is made of wood which is installed in steps (tikel-tikel). Pak Adi, as the maker of the Joglo house, stated that the middle part of the Banyumas Joglo house or 4 saka guru forms a cube. The piles of wood on the roof of the house overlap in an odd collection and the quantity is smaller because the wood used is large in size. Thus, Banyumas Joglo houses are often referred to as tikelan Joglo houses and this is what differentiates Banyumas Joglo houses from other Joglo houses.

For the community, traditional houses are often only seen as icons that reflect the uniqueness of an area. In fact, in some areas, traditional houses have a sacred meaning and are only used by *priyayi* (influential people in the area) or used for certain traditional events. In fact, if you study the structure of traditional houses in more depth, they can be used as learning material for the millennial generation, especially in education. The field of education that is able to study culture through the structure of traditional house buildings is mathematics (Kholisa, 2021). Mathematical science that adopts culture within it is called ethnomathematics. In other words, ethnomathematics is a branch of mathematics that is practiced by certain cultural groups, such as tribal communities, worker groups, children in certain age ranges, professional workers, and others (Sulistyani et al., 2019). Evidence that culture can be adapted to mathematics is shown in research conducted by Sekarpandan et al. (2022) shows that the structure and shape of the Baduy traditional house, known as the Sulah Nyanda traditional house, uses many two-dimensional and three-dimensional geometric representations. Some of the mathematical aspects found in this traditional house include: geometric, translational and rotational aspects. The roof of Sulah Nyanda's house is parallelogram-shaped and triangular, the supporting pillars are cube-shaped, and the floor is rectangular. The walls of the house made from woven bamboo have a rhombus geometric shape, and the woven motif also shows aspects of translation and rotation in geometry. The architectural form of a Joglo house also has a mathematical concept, as research conducted by Zulkifli & Rahmawati (2020) shows that traditional Joglo houses in Japanese villages have geometric concepts including the concepts of flat construction and spatial construction. The flat building concepts in Joglo houses in Japanese villages are square, rectangle, trapezoid, rhombus and triangle; and the concept of building space consisting of pyramids and blocks. Apart from that, research conducted by Kholisa (2021) also shows that the Semar Tinandu Joglo house has a mathematical concept. The concepts involved are the concept of flat shapes such as squares, rectangles, triangles, trapezoids and rhombuses; the concept

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p-ISSN 2477-409X, e-ISSN: 2549-9084

of geometric shapes includes cubes, blocks, pyramids and prisms; and there are concepts of similarity and congruence as well as geometric transformations. It's not just the Joglo houses in Japanese villages and the Semar Tinandu Joglos that contain mathematical elements, the Banyumas traditional Joglo houses also have mathematical concepts in every part of their traditional houses.

The Banyumas Joglo traditional house has a roof shaped like a mountain which means that the highest place or holy place for the Javanese people and is considered the abode of the gods. The roof of the Banyumas Joglo house contains mathematical elements such as flat shapes and congruence. Take a look at the picture below:

Figure 1. The Roof of the Joglo House Outside the Front

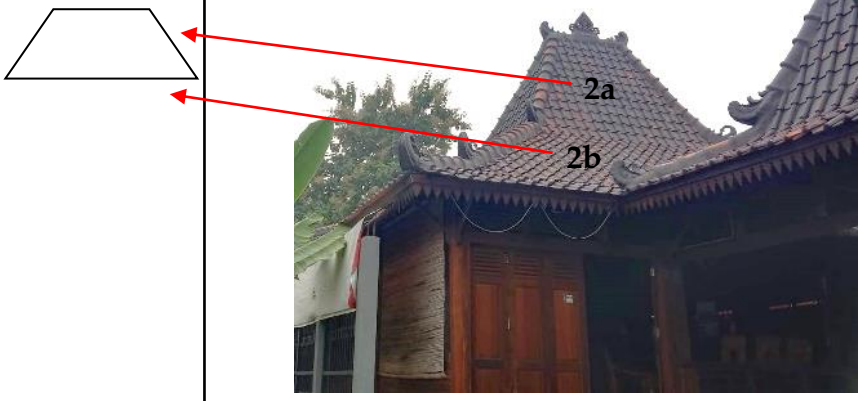

Figure 2. The Roof of the Middle Outer Joglo House

In Figure 1 shown in 1a the roof shape of the house and 1b the roof ornament helps to create a flat shape that has 3 sides and 3 corners. The shape formed is an isosceles triangle. An isosceles triangle is a triangle that has 2 pairs of sides that are equal in

length, as a result of which the 2 facing angles have the same magnitude. This makes a big contribution to the concept of flat buildings, such as finding the length of a side, the size of an angle, the circumference of triangle with formula 1, and the area of a triangle with formula 2.

Circumference of a triangle = Sum of the three sides of the triangle (1)

Triangle area = $\frac{1}{2} \times base \times height$ (2)

In Figure 1 shown in 1b and Figure 2 which consists of 2a and 2b form a two-dimensional flat shape formed from 4 ribs, two of which are parallel to each other but not equal in length. The flat shape in question is an isosceles trapezoid. The math concept that can be taken is to be able to find the circumference of the roof of the house using the trapezoid in formula 3, meanwhile the area of the roof of the house using the trapezoid ini formula 4.

Circumference of a trapezoid = Sum of the four sides of the trapezoid (3)

Area of a trapezoid = $\frac{1}{2} \times number\ of\ parallel\ sides \times height$ (4)

In Figure 2 which consists of 2a and 2b shows the concept of congruence where each angle has the same magnitude and the lengths of the sides of the angle have the same ratio. The notation symbol ≈ is usually used to denote congruence.

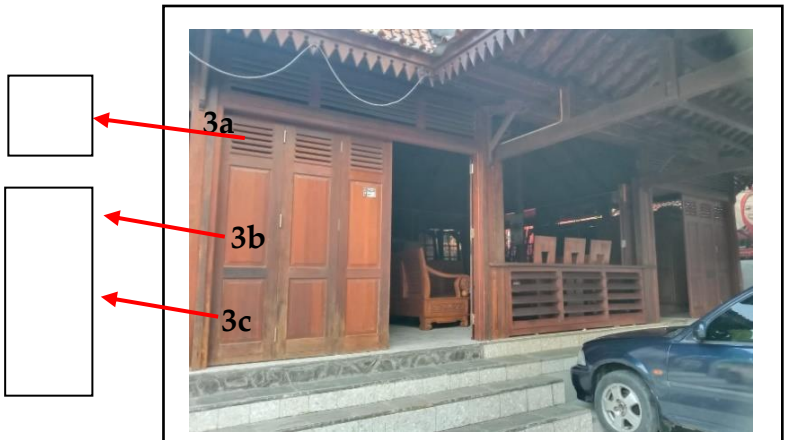

Figure 3. Main Door

The installation of the main door of the Joglo house is usually divided into two sides, located on the right and left. The choice of door position in the Joglo traditional house has a special meaning. The location of the door in the Joglo traditional house symbolizes a butterfly that continues to fly, grow and fight for a large family. In addition, the position of the door in the middle is also a symbol of openness and

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p-ISSN 2477-409X, e-ISSN: 2549-9084

intimacy between homeowners. The main door of the Banyumas Joglo contains mathematical elements, namely square and rectangular flat shapes.

In Figure 3 shown in 3a shows a two-dimensional flat shape formed by four equal-length ribs and has four angles, all of which are right angles. The flat shape in question is a square. The mathematical contribution to the main door vent in the concept of a square flat shape is to find the circumference using formula 5 and area of the door vent using formula 6.

Circumference of a square = Sum of the four sides of a square (5)
Area of a square = $s \times s$ (6)

In Figure 3 which consists of 3b and 3c shows a two-dimensional flat shape with two pairs of equal-length parallel sides and four right angles. The flat shape in question is a rectangle which is a derivative of a square. The contribution of mathematics to the main door ornament in the concept of rectangular flat shapes is to find the circumference using formula 7 and area using formula 8.

Circumference of a rectangular = Sum of the four sides of the rectangle (7)
Area of a rectangular = $length \times width$ (8)

Inside the Joglo house there are four main poles. The number of four poles means that the influence of strength comes from the four winds, namely east, west, south and north. *Saka guru* functions to support the roof of the Joglo house and is located in the center of the Joglo house.

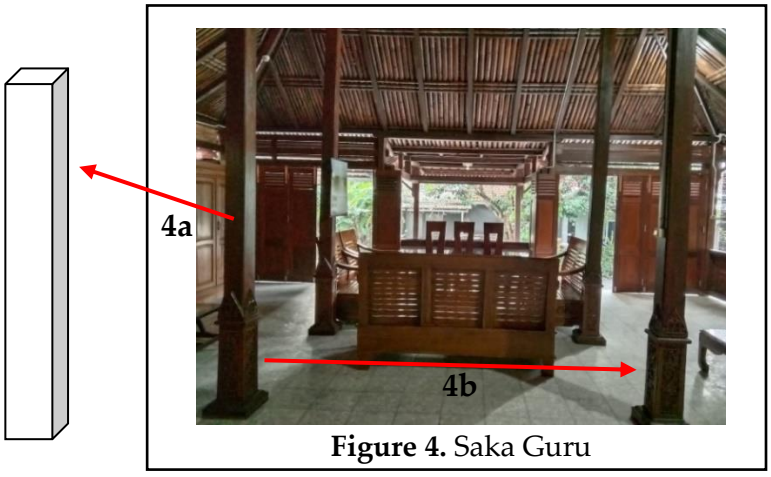

Figure 4. Saka Guru

In Figure 4 shown in 4a, there is a three-dimensional space bounded by three pairs of parallel sides that are square or rectangular with at least one pair of parallel sides that have different sizes. The building space in question is a beam which has the

characteristics of 6 sides, the opposite side has the same shape and size, has 8 corner points, has 12 ribs. The contribution of mathematics to the teacher's *saka* in the concept of building space is to find the volume using formula 9 and surface area of the *saka* using formula 10.

$$\text{Volume of a beam} = length \times width \times height \quad (9)$$

$$\text{Surface area of the beam} = 2 \times \big((p \times l) + (p \times t) + (l \times t)\big) \quad (10)$$

Saka guru consists of 4 *saka* where the shape and size of the same *saka* are placed in different places as in figure 4 shown in 4b, then this is called the concept of geomerti transformation in the form of translation or displacement. In mathematical language the position of the *saka guru* can be expressed as a coordinate point (x,y) is translated or shifted to (a,b) so that point A′ (x′, y′) is its shadow coordinate. The translation or shift formula in formula 11.

$$A(x,y) \xrightarrow{T=\binom{a}{b}} A'(x',y') \quad (11)$$

$$\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} a \\ b \end{pmatrix} + \begin{pmatrix} x \\ y \end{pmatrix}$$

$$\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} a+x \\ b+y \end{pmatrix}$$

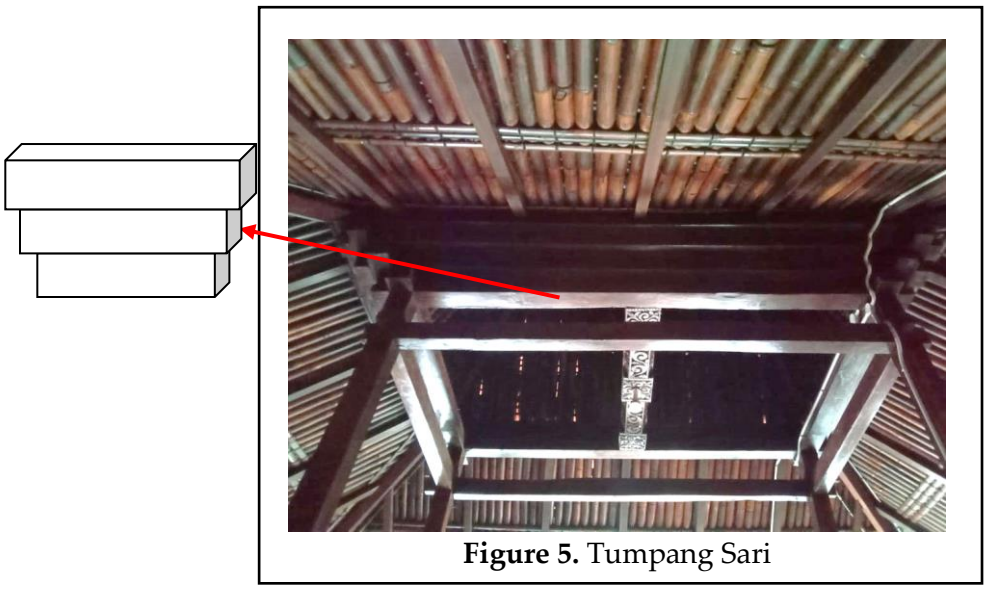

Figure 5. Tumpang Sari

At the top of the *saka guru* there is a *tumpang sari* which functions as a structural support for the Joglo roof shown in Figure 5. The *tumpang sari* is also part of the main ceiling of the rongrongan structure *(umpak-saka guru-sunduk-blandar)*. This structure consists of two types of roof trusses: the *brunjung* roof truss, which has an inverted pyramid shape that widens upwards and the *uleg* roof truss, which has a pyramid

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shape arranged in layers above the four *saka guru* poles on the inside. *Tumpang sari* indicates the social status of the Joglo owner. The more *tumpang sari* means that the owner of the Joglo house has a high social status or has an above-average economy. In Joglo buildings, the *tumpang sari* or beam arrangement is multilevel and must be an odd number ranging from 3, 5, 9 to 11.

In the overlap, the concept of geometry that exists is the concept of transformation geometry in the form of dilation because the arrangement of wooden blocks in the overlap is getting longer. This different size is considered as the concept of dilation. The dilation factor shows the magnitude of the result of dilation in a geometric shape. In mathematical language, the position of the intercrop can be expressed as a coordinate point (x,y) enlarged with a scale k so that point A′ (x′, y′) is its shadow coordinate. The formula of dilatation is in formula 12.

$$A(x,y) \xrightarrow{D(P(p,q),k)} A'(x',y') \qquad (12)$$
$$\begin{pmatrix} x' \\ y' \end{pmatrix} = k \begin{pmatrix} x-p \\ y-p \end{pmatrix} + \begin{pmatrix} p \\ q \end{pmatrix}$$

Conclusion

It can be concluded that many mathematical concepts are found in Banyumasan Joglo houses. Banyumas people have unwittingly embedded mathematical concepts in the shapes and ornaments of their traditional houses. This shows that the Banyumas Joglo house has ethnomathematics in the form of geometry concepts. The existing mathematical concepts are the concept of flat shapes such as triangles and trapezoids on the roof of the Joglo house and squares and rectangles on the main door of the Joglo house, as well as the concept of geomerti transformation, namely translation on the *saka guru* and dilation found in the overlapping part. The mathematical concept of the Banyumas Joglo house can be used as a source of learning mathematics on geometry material. On the other hand, this research can be used by teachers to make students aware that the surrounding culture has a close relationship with mathematics. This research can be a guideline for other studies to examine other cultures and can be further developed for the application of mathematics and culture in learning. However, this research still has many shortcomings, especially in the discussion part which is not revealed in detail due to the lack of reference material for the Banyumas Joglo traditional house. Therefore, further research needs to be done to achieve maximum results.

Acknowledgement

The researcher would like to Mr. Narto as the owner of the Banyumas Joglo house, Mr. Adi and Prof. Dr. Sugeng Priyadi, M.Hum., who have provided information about the

Banyumas Joglo traditional house. The researcher also thanked the Department of Mathematics Education, Universitas Muhammadiyah Purwokerto for supporting this research.

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