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The Geometry of Ijo Temple: Bridging Cultural Heritage and Mathematical Learning through Ethnomathematics

Olly Orva Peggy Kim Carla[1], Naufal Ishartono[1,*], Rizky Oktaviana Eko Putri[2]
[1]Department of Mathematics Education, Universitas Muhammadiyah Surakarta, Indonesia
[2]Department of Mathematics and Science Education, University of Malaya, Malaysia
*Corresponding author's email: ni160@ums.ac.id

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ABSTRACT

This study explores the geometric concepts within the architecture of Ijo Temple, a significant cultural heritage site in Yogyakarta, Indonesia, through the ethnomathematics framework. Previous research has examined mathematical elements in various temples, but Ijo Temple's geometric aspects remain underexplored. Addressing this gap, the study employs an ethnographic approach to identify and analyze the temple's geometric principles, aiming to enhance mathematics education through culturally contextualized learning. Using qualitative methods, including observation, interviews, and documentation, the data were analyzed through reduction, presentation, and conclusion drawing, with findings validated by expert triangulation. The study identifies geometric sub-concepts such as planar geometry (triangles, rectangles, squares, trapezoids, circles), spatial geometry (cubes, rectangular prisms, cylinders), geometric transformations (translation, reflection, dilation), and congruence principles. The research underscores the potential of integrating cultural heritage into mathematical learning, promoting deeper engagement and understanding of mathematical concepts through the cultural context of Ijo Temple. This approach not only enriches mathematics education but also contributes to the preservation and appreciation of cultural heritage.

Keywords: Ethnography, Ethnomathematics, Education, Mathematics, Culture

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INTRODUCTION

Temples are one of Indonesia's cultural heritage that has various specific meanings and ideologies. The originality and beauty of artworks in each location have characteristics (Ishartono & Ningtyas, 2021). The temple was used as a place of worship with its construction filled with the religious philosophy that prevailed at that time (Barkah & Agustina, 2020). Each temple has a different building shape and has its meaning. Therefore, preservation and maintenance efforts need to be carried out to maintain its sustainability, this is also done at Ijo Temple.

Ijo Temple

One of the historical relics is also categorized as a cultural tourism destination that is an attraction for tourists with special interests. In Indonesia, the Special Region Province of Yogyakarta is famous as one of the tourist attractions that has many cultural heritages such as temples (Repiyan et al.,

2023). Ijo Temple is in Groyokan Hamlet, Sambirejo Village, Prambanan District, Sleman Regency, Special Region of Yogyakarta, and is located 4 km southeast of Ratu Boko Temple or 18 km east of Yogyakarta city. The Ijo Temple has an interesting charm because of its location in a hilly area. Ijo Temple is located in the highest area geographically when compared to other temples in the Yogyakarta area. One attraction of Ijo Temple is that tourists can see the beauty of the sunset and watch flight activities from Yogyakarta's Adisucipto International Airport from a distance (Hadi & Widyaningsih, 2021). In addition, if the weather is sunny, visitors can also see the view of Mount Merapi to the north.

According to the findings of an interview with Mrs. Septi Indrawati Kusumaningsih on June 28, 2024, Ijo Temple is conceptually situated at an elevation of 395 meters above sea level in Yogyakarta. Ijo Temple is thought to have been built between the 10th and 11th centuries during the Medang kingdom's Mataram period. The temple was built with terraces, taking advantage of the hill's curves to put the structures. The structure's location follows a philosophical pattern in which the higher up you go, the closer you get to perfection.

On the top terrace, there is the main temple and three Perwara temples. The main temple and the three Perwara temples were built using andesite stone. Andesite stone is a rock that originates from volcanoes and immediately hardens, which is more compacted. In the western part of the main temple, there are those made of white stone (volcanic ash that settles and solidifies). The white stone was found in temples on the hill in an intact state and then treated to become the foundation of the temple and its constituent materials. Some of the stones are arranged as soil retainers. Inside the main temple, there is a large yoni phallus and below it, there are the shapes of snakes and turtles. The phallus is made from a single stone that is intact and then arranged. The Lingga is likened to the symbol of the Trimurti (Lord Shiva, Lord Vishnu, and Lord Brahma) or as a symbol of men, while the yoni is likened to Dewi Parvati, the wife of Lord Shiva. If interpreted in world life, it means living in pairs.

When Ijo Temple was found, the position of the temple was not as intact as it is now which can be used as tourism but is in a state of collapse. Then by conducting a study on the rescue of objects and looking for the distribution of findings, only 11 terraces were found, but not all terraces had findings and were only obtained to the extent of contours and then used. But if it is important then the land is freed and bought by the government, if it is still difficult to buy it it will be rented, usually within a certain period.

Under the Ijo Temple, there is a temple that is still in the process of excavation, the temple is in the form of a stupa (Buddha). In carrying out excavations, if many stone components are found, a feasibility study will be carried out aimed at preparing for the restoration and renovation of the temple. The process of restoring the temple has several concepts, including some added brick, some are only composed of stones found, and some are completely restored.

The restoration carried out at Ijo Temple is by arranging the original stones first which are prioritized, then followed by the lost stones replaced with new stones. The hooks between the stones use a lock system and a peg system. After the restoration is completed, then the maintenance process is carried out. As is the case if there is moss or mold, it is cleaned by brushing the part where there is moss or mold, but if there is scale, then there must be a special chemical applied, observed, and rubbed.

Figure 1. Ijo Temple (Main Temple and Three Perwara Temple)

The Ijo Temple Complex consists of several groups of main temples, Perwara temples, and flanking temples. The main temple faces west, in front of the main temple there are 3 temples lined up facing the main temple. Above the entrance of the temple, there is a kala with a double-headed motif wearing attributes (Hadi & Widyaningsih, 2021). Ijo Temple is currently used as a tourist attraction and cultural heritage visited by various tourists with the motivation to learn and enjoy its natural panorama.

Efforts to Preserve Ijo Temple

From 1996 to 2017, Ijo Temple was gradually renovated from the main temple to the fence of the VIII terrace, with physical conservation performed as part of routine maintenance. Ijo Temple's distinctiveness stems from its location and content, as each temple is different. Ijo Temple requires maintenance and preservation due of its distinctiveness. One of them is introducing it to the younger generation and incorporating it into educational materials, particularly mathematics education. In this situation, mathematics education experts play an essential role in exploring the concept of geometry included in Ijo Temple. The principles learned can be utilized as material to quickly present Ijo Temple and make maths.

Ethnomathematics

The term ethnomathematics was introduced by D'Ambrosio, a Brazilian mathematician in 1977. Linguistically, the prefix "ethno" is interpreted as something very broad that refers to a socio-cultural context, including language, jargon, behavioral codes, myths, and symbols. The root word "mathema" tends to mean explaining, knowing, understanding, and performing activities such as coding, measuring, clarifying, inferring, and modeling. The suffix "thic" comes from the word techne or technique (Ascher & D'Ambrosio, 1994). Ethnomathematics is a program that can help students understand, articulate,

processing, and solve everyday problems by utilizing mathematical ideas, concepts, and practices. Ethnomathematics is the basis of mathematics in local culture, including pattern creation, calculation, and prediction (Budiarto et al., 2019).

Ethnomathematics aims to recognize that there are other variations to introduce mathematics by considering academic mathematical knowledge developed by various sectors of society and by considering different modes according to their culture, where different cultures negotiate their mathematical practices (how to group, count, measure, design buildings or tools, play and others) (Ascher, 1991). Ethnomathematics is a culture or habit in people's lives that contains mathematical concepts or elements (Djannah et al., 2024). The provision of ethnomathematics-based study materials is expected to make it easier for students to get to know more about culture and understand mathematical knowledge (Vitoria et al., 2021). Ethnomathematics is divided into six fundamental activities found in several cultural groups (Ishartono & Ningtyas, 2021). The six activities are calculating, determining location, measuring, designing, playing, and explaining. The object of ethnomathematics itself is the object of a culture that contains mathematical concepts (Maryati & Prahmana, 2019). Based on these definitions, it can be concluded that ethnomathematics is a study that connects mathematics with culture and seeks to help understand culture through linguistic diversity.

From previous research, there have been many studies that examine the concept of temple geometry. Some of them are research conducted by (1) (Risdiyanti & Indra Prahmana, 2017) who studied the exploration of geometry at Bajang Ratu Temple, (2) (Irsyad et al., 2020) studied ethnomathematical exploration at Asu Temple, (3) (Ishartono & Ningtyas, 2021) studied the exploration of mathematical concepts in Batik Sidoluhur Solo, (4) (Jayanti & Puspasari, 2020) studied the exploration of ethnomathematics at Sanggrahan Tulungagung Temple, (5) (Hardiarti, 2017) who studied the ethnomathematics of the application of quadrilateral flat building at Muaro Jambi Temple. However, from previous studies that examined the concept of geometry in temples, there have been no studies that examine the concept of geometry in Ijo Temple.

In this study, the ethnomathematical context is used as an effort to explore, explore, and uncover the concept of geometry in Ijo Temple. This concept is used as material to introduce Ijo Temple as a cultural-historical relic, while in the context of mathematics, it can be studied contextually, and then it can be more familiar with the exploration of geometric concepts in culture.

METHOD

This study examines ethnomathematics, using ethnographic methods. Where there are four questions to be answered, namely "Where do I look?", "how do I find?", "how do I recognize that I have found something significant?", and "How do I understand it?" (Prahmana & Ubiratan, 2020). The research design based on the four questions can be seen in Table 1

Table 1. Research Steps

Principal Questions	Initial Answer	Specific Point	Specific Activity
Where do I start looking?	Observation begins by analyzing the place where there is Ijo Temple	Culture	Conducting interviews with people who know Ijo Temple
How do I find it?	Observation Ijo Temple directly	Alternative thinking	Analyzing Ijo Temple in terms of geometry Determining the concept of geometry contained in Ijo Temple
How do I recognize that it has found something significant?	Evidence (result) of alternative thinking from the previous process	Philosophy of mathematics	Identify the concept of geometry contained in Ijo Temple There is a concept of geometry contained in Ijo Temple
How to understand what it is?	Rated important for culture and mathematics	Anthropology	Explain the relationship that occurs between two knowledge systems (culture and mathematics) Describe cultural and mathematical concepts in Ijo Temple

This data collection process was carried out from November 2023 to July 2024 in various places such as Ijo Temple tourist attractions, universities, and libraries of the Preservation Center. The object of this study is the concept of geometry found in Ijo Temple. The geometric concepts studied in this study are plane geometry, spatial geometry, geometric transformation, and congruence. The subject of the study is Ijo Temple.

The type of data in this study is qualitative data consisting of observation data, interview data, and documentation data. Observation data collection techniques by observing the form or concept contained in Ijo Temple, semi-structured interview techniques to strengthen observation data that have been carried out, and documentation techniques to document the observation and interview process related to forms or concepts in Ijo Temple.

In addition to the researcher as the main research instrument, other assessment instruments are also used to obtain the desired data, namely a semi-structured interview design consisting of two points, namely, (1) the existence of mathematical concepts in Ijo Temple and (2) whether the mathematical concepts contained in Ijo Temple have met cultural elements that include geometric aspects and are suitable for use.

The data obtained will be processed through three stages, namely data reduction, data presentation, and conclusion drawing (Sutama., 2019). Then the data was analyzed based on mathematics and knowledge of Temple Ijo by the author to see the existence of geometry concepts. Furthermore, the geometry expert confirmed the results of the analysis as a form of data validity test (triangulation of data sources.)

RESULTS & DISCUSSION

Where do I look from?

The research began by finding out where the existence of Ijo Temple is located. Ijo Temple is in Groyokan Hamlet, Sambirejo Village, Prambanan District, Sleman Regency, Special Region of Yogyakarta. Furthermore, the author interviewed a cultural leader at the Regional X Cultural Preservation Center named Septi Indrawati Kusumaningsih, S.S, M.A., who has knowledge of the history and philosophy of Ijo Temple which has been described in the introduction of this article.

Figure 2. The interview process with Mrs. Septi Indrawati Kusumaningsih, S.S., M.A.

Based on the results of interviews about the history and philosophy of the Ijo Temple that will be studied in this study, research on the Ijo Temple was chosen. Ijo Temple on the upper terrace (Pictures 3 and 4).

Figure 3. Main Temple

Figure 4. Three Perwara Temple

How do I find it?

Based on the results of the observations that have been made, the author began to make observations related to the concept of geometry contained in Ijo Temple. Then the author analyzes the relationship between Ijo Temple and the concept of geometry that has been determined. A summary of the author's observations can be seen in Table 2.

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Table 2. Mathematics Concepts Exploration Process

Concept	Concept Existence	Sub-Concept	Topic
Geometry	Yes	Plane Geometry	Triangle Rectangle Trapezoidal Circle
		Space Geometry	Cube Beam Cylindrical
		Geometry Transformasi	Dilation Reflection Translation
		Congruence	

How do I recognize that I have found a significant one?

Based on the results of the initial analysis conducted by the author in Table 2, the concept of geometry is found. From the concept of geometry, the author obtained four sub-concepts, namely spatial geometry, plane geometry, geometric transformation, and congruence.

In the concept of geometry, plane geometry includes several sub-concepts including triangles, rectangles, squares, trapezoids, and circles. A triangle is a geometric figure made from three sides in the form of a straight line and three angles with a total of 180^0 angles (Delman & Galperin, 2003). A rectangle is a two-dimensional flat figure formed by two pairs of ribs, each of which is equal in length and parallel to its counterpart and has four right angles (Arsyad, 2014). A square is a two-dimensional flat figure formed by four ribs of equal length and has four right angles. The trapezium is a flat build that has four line segments connected by four points (Martin, 1982). A circle is a set of points on a flat plane that are equal to a certain point (Wardhani & Rumiati, 2011). The geometry of the plane in Ijo Temple can be found in the kala decoration (see Figure 5.), the pasted paper carving decoration on the wall (see Figure 6.), and the Padma (see Figure 7.).

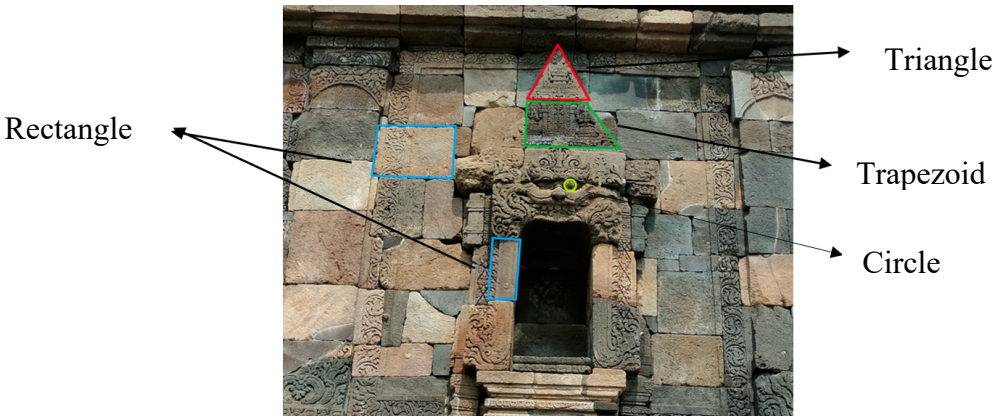

Figure 5. Plane Geometry on the decoration of the kala and walls

Figure 6. Plane geometry on Paste Paper Engraving

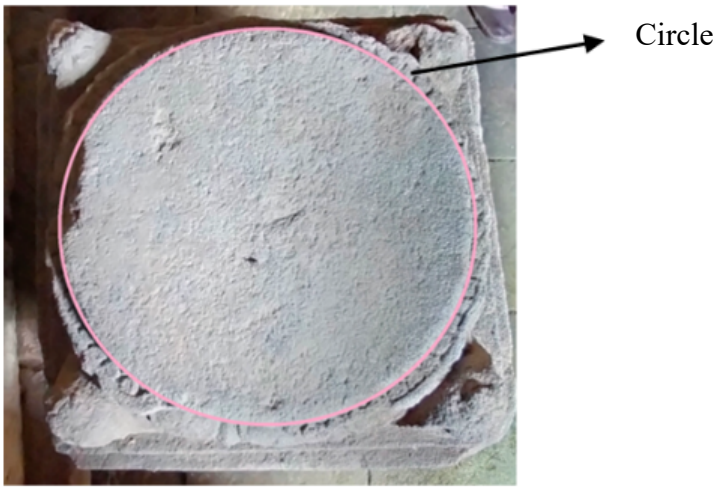

Figure 7. Plane geometry on Padma

Figure 5 shows that there are several plane geometries formed in it, such as in the plane given a red line, the shape resembles a triangle. The triangular shape is the crown of the kala, kala is a mythical or supernatural animal whose shape is a combination of elephants, dragons, and fish). While at the bottom is given a green line in the shape of a trapezoid. On the kala, eyes are given a yellow line in the form of a circle. Finally, the temple wall and door pillar as the place where the god enters, where it is given a blue line that forms a rectangle. Figure 6, the shape of the pasted paper carving on one of the walls of the Perwara temple which is given a red line forming a square. Figure 7, the plane gave a pink line in the shape of a Padma or lotus flower resembles a circle.

Space geometry is one of the sub-concepts of geometry consisting of cubes, blocks, and cylinders. A cube is a space formed by six sides that border each other, each side is a square of the same size (Witanto, 2019). A beam is a geometric shape that has three pairs of rectangular and three-dimensional sides, the two opposite sides have the same shape and size (Masruroh, 2019). Finally, a cylinder is a construction of space bounded by two congruent and parallel sides in the shape of a circle and a curved side, a base plane and an upper plane of a circle with equal radi (Vitoria & Monawati,

2020). The concept of spatial geometry can be found in one of the Perwara temples (see Figure 8). Then on the batur or floor (see Figure 9) and phallus (see Figure 10).

Figure 8. Cubes shape on temple

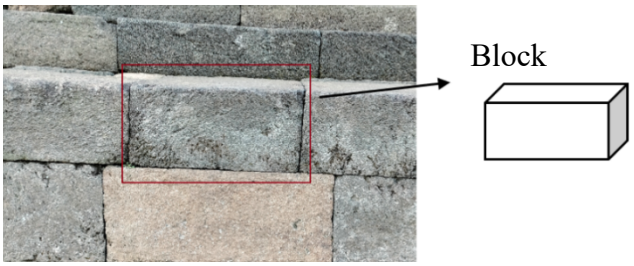

Figure 9. The shape of the blocks on Batur

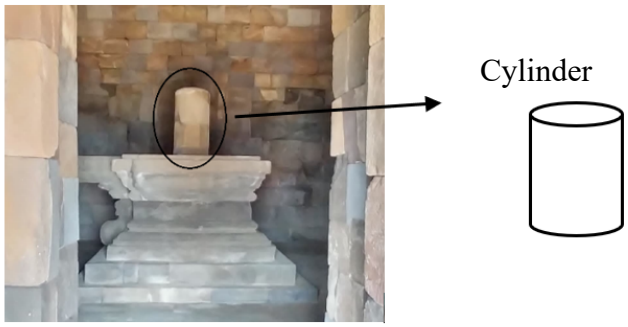

Figure 10. Cylindrical shape of Lingga

The cube shape on the temple as shown in Figure 8, is one of the perwara temples. Figure 9, the shape of the beam found on the batur. Batur is a term used to describe the lower part of a hall building built of stone or brick, usually with a rectangular plan, low, and flat surface. Finally, there is a cylindrical shape found on the phallus. The phallus is a symbol of Lord Shiva in Hinduism because it is in the shape of a man's genitals.

The next concept of geometry is geometric transformation which consists of translation, reflection, and dilatation. Translation or shift is a transformation that maps a point to another point as its shadow (Anh & Hung, 2020). The definition of reflection is a transformation that moves a plane to another plane in the same position using the properties of a mirror (Gjurchinovski & Skeparovski, 2008). Finally, dilation is a geometric transformation in the form of enlarging or shrinking a geometric plane (Ebbers-Baumann et al., 2007). Geometric transformations can be found in temple buildings and carvings.

Figure 11, translation on the decoration on the outer wall of Perwara Temple in the middle of which there is a Padma (lotus plant that is stretching). Figure 12, reflection on the antefix at the top of the temple, is usually found on temple buildings in the form of a tapered triangle. Finally, in Figure 13, dilatation on the roof of the inner temple.

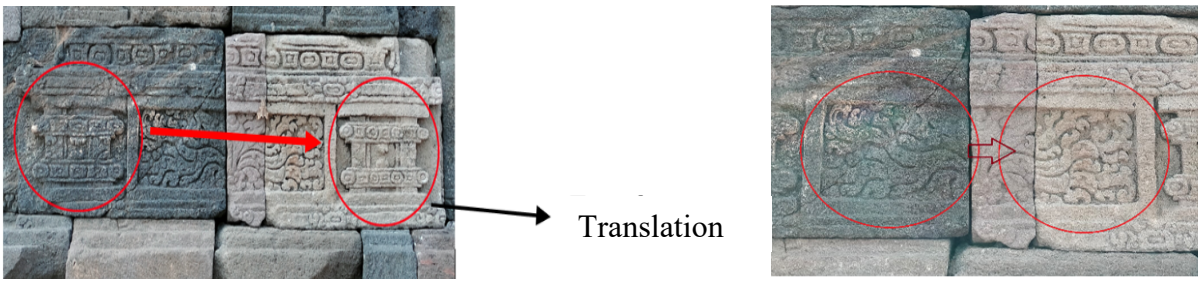

Figure 11. Translation on Wall Carving

Figure 12. Reflection on *antefiks*

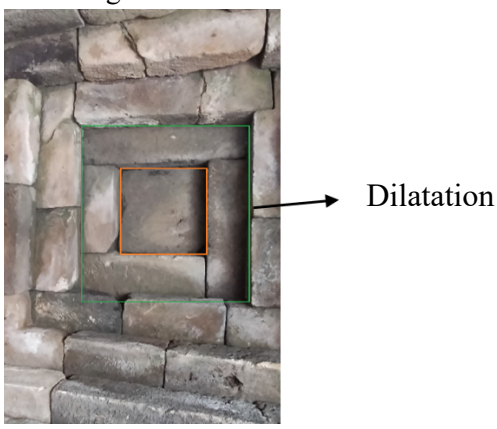

Figure 13. Dilation on *sungkup*

One of the last geometric concepts is congruence. Consolidation is the concept of two or more geometric shapes that are equal and identical to each other (Kwinta & Gniadek, 2017). Triangle congruence is that there is a relationship between the correspondence of line segments and the correspondence of angles (Alexander F. Mironychev, 2018). The form of congruence is found in the antefix and the carved ornament (see Figure 14).

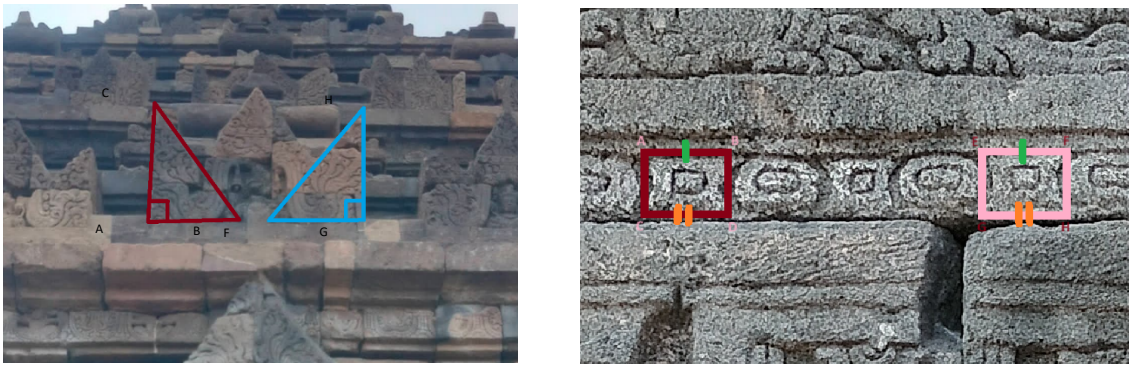

Figure 14. Forms of congruence in the antefix

How to understand this?

The process to validate the data and the process of triangulation of data sources has been carried out by comparing the author's assumptions related to the concept of geometry in Ijo Temple as shown in table 2 with the perspective of a geometry expert. The data triangulation process was carried out by the walkthrough interview method, where the author communicated directly with experts in the field of

geometry to compare with what the author found from the perspective of a geometry expert (Mulbasari et al., 2024). Two questions must be asked to experts related to (1) their views on the concept of geometry in the Ijo Temple (this point is used to confirm whether they found the same geometric concept as the author's), and (2) whether the context of the Ijo Temple can be used in mathematics learning.

The first concept to be confirmed was a geometric concept that was asked directly by a geometry expert. In response to the first concept, experts found similarities in the sub concepts as found by the author, namely plane geometry, spatial geometry, geometric transformation, and revival. Furthermore, the second concept, the geometry expert argues that the concept of geometry in Ijo Temple can be used as one of the important contexts to teach mathematics comprehensively. Teachers can use GeoGebra (a dynamic and interactive application of geometry, algebra, and calculus, aimed at teachers and students (Majerek, 2014). During the learning process, teachers can make sketches of the Ijo Temple in GeoGebra.

In the results of this study, there are still many aspects that need to be considered, such as the relationship between mathematics learning and Ijo Temple, as well as the effectiveness of mathematics learning. So that the benefits of this research can have an impact on students to improve their understanding of mathematics and make efforts to preserve Ijo Temple.

CONCLUSION

This study explores the relationship between mathematical concepts and cultural heritage, using the geometry of Ijo Temple as a focal point. By employing an ethnographic approach, the researchers answered four key questions— “Where do I look?”, “How do I find?”, “How do I recognize significance?”, and “How do I understand it?”—to guide their examination of geometric elements within the temple. The process involved observation, analysis, and triangulation through expert consultation, revealing various geometric sub-concepts, including plane geometry (triangles, rectangles, squares, trapezoids, circles), spatial geometry (cubes, blocks, cylinders), geometric transformations (translation, reflection, dilation), and congruence. This research not only uncovers the geometric foundations within Ijo Temple but also aims to promote the temple’s cultural value through mathematics education, thereby supporting cultural preservation efforts. Furthermore, the findings hold potential for enhancing student understanding by incorporating Ijo Temple-based geometry learning, which could be further evaluated for educational effectiveness.

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