Ethnomathematics: geometric analysis of historical buildings
ngawen temple in Magelang

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Abstract. The analysis of historical buildings Ngawen Temple has a purpose of knowing the history and knowing the approach to the geometry. This type of research is descriptive research with a qualitative approach. The data collection techniques used in this research are interviews and documentation (observation) directly. The interview was done with the temple officers who were around the building, and the documentation was taken directly. The data analysis technique is done by analyzing the buildings related to the geometry, such as the shape of the building on the Ngawen temple. The results of this study were obtained namely, Ngawen Temple set in Buddhism. The Ngawen temple complex consists of five temples that line the parallel from north to south. Temple building facing the east. From the south of Ngawen Temple I, II, III, IV, and V, with each temple to plan the square. One of the uniqueness of Ngawen temple is the existence of 4 lion statues in every corner of temple II and temple IV. The shape of the Ngawen temple resembles the geometry of the cuboid, the rectangular pyramidal frustum, and the rectangular pyramid.

1. Introduction

The building is a work of art in the field of architecture. Architectural work is a tangible result of the imagination and copyright of experts to make life more enjoyable and more perfect than before. Architecture has a strong bond with geometry because of its need for regularity and efficiency of construction and a desire to create aesthetically satisfying structures. Geometric shapes will be processed into beautiful works, doors, and windows show the character of geometric shapes.

Other within the last ten years, there has been an increasing move to make mathematics accessible to all learners; there has been an increasing questioning of the relevance of ex-colonial models of education in developing countries, and in countries with indigenous "minorities"; the social dimension has come into greater prominence in research in mathematics education; and the cultural nature of mathematical knowledge has become clearer to many mathematics educators [1]. People at the time also used mathematical concepts seen in buildings and geometric ornaments or ethnomathematics [2].

Ethnomathematics is a research program that focuses on the relationships between mathematics and culture [3]. Furthermore, D’Ambrosio states that, on the other hand, there is a reasonable amount of literature on this by anthropologists [4]. Making a bridge between anthropologists and historians of culture and mathematicians is an important step towards recognizing that different modes of thought may lead to different forms of mathematics; this is the field that we may call ethnomathematics. That is, making a bridge between culture and mathematics is an important step to recognize various ways of thinking that can lead to various forms of mathematics; This is a field called ethnomathematics.
Ethnomathematics research has also been carried out by many researchers, including those who suggested that the structure of the Krapyak Stage building contains mathematical elements including a cube [5], and the results of the study showed a relationship between the construction of the Van Der Wijck fortress with the flat mathematical structure [6]. In other studies, it was concluded that ethnomathematics shapes along the Great Wall of China are in the form of geometric shapes of fields, such as rectangles, triangles, squares, and circles [7].

Geometry is the science of mathematics that studies fields and space. Geometry research has also been carried out by many researchers, including which suggested that The Lawang Sewu building has a geometrical space structure, which is a cube, beam, pyramid, and octagonal prism [8]. Therefore, the knowledge of mathematics and its teachings are inseparable from the student's background, social context and worldview [9]. Based on the background, the problem is taken as a matter of how the history of Ngawen temple and the geometry approach to the building of Ngawen Temple. The purpose of this writing is to know the history of Ngawen Temple and know the geometry approach of the Ngawen temple.

2. Methods

This research is a descriptive study with a qualitative approach aimed at knowing the history of Ngawen temple and knowing the geometry approach of Ngawen temple. Research on the history and approach of building on this geometry is implemented in Ngawen Temple building, Ngawen village, Muntilan District, Magelang regency at the coordinates. The object of this study is the historical building of Ngawen Temple.

Data collection techniques used in research are interviews and documentation (observation) directly. Interviews were conducted with temple guards in the building, and documentation was taken directly. Documentation was taken in the form of a video interview about the history of the Ngawen Temple and photographs of the temple of Ngawen both from the side of the foot of the temple, the body of the temple, and the entire temple. The data analysis technique is done by analyzing the buildings associated with Geometric such as the building's shape on Ngawen temple.

3. Results and Discussion

3.1. Ngawen Temple History

In the era of Hindu-Buddhist kingdoms, many kingdoms in Indonesia. These kingdoms provide various relics such as inscriptions, temples, books, and others. Most of these kingdoms are located on Java Island. Therefore, many royal relics on the island of Java. Among the relics are many famous relics such as Borobudur Temple, Prambanan Temple, Gedong Songo temple, etc. Many small temple relics or non-intact temples are less well known by the wider public, such as Asu Temple, Wukir temple, Lumbung Semi temple, and Ngawen temple.

Ngawen temple, located in Ngawen village, Muntilan District, Magelang Regency, Central Java, is set in Buddhism. This is evidenced by the Dhyani Buddha Ratnasambhava statue's findings in Candi II and the statue of Dhyani Buddha Amitabha in Candi IV. Despite the Buddhist background, the Ngawen temple's shape is almost similar to the Hindu Temple building. This is due to the building of a tapered temple. The building is also a large temple and small temple, which is characterized by a Hindu-patterned temple. But when observed, this temple has a stupa and a terrace (Undak-Undak) that becomes a symbol in Buddhist temples. This temple was used as a place of worship.

Ngawen temple has not been known for sure when and who built it. This is because the inscription that mentions it is inevitably not found. Until today, research is still conducted by ancient experts and historians. It is estimated that the construction of this temple is a period with the construction of Borobudur temple and Gunung Wukir Temple, in the range of the 8th and 9th centuries, during the ancient Mataram kingdom.

Based on the temple officer's information, an ancient scholar De Casparis argued that the archaeological complex was constructed by mutual assistance between the king of Pikatan Dyah Siladu
of the Sanjaya dynasty and King Samaratungga of the Sailendra dynasty. The historical analysis is based on the central coral inscription in 824 M. In this inscription, King Samaratungga erected a holy building in a place that means bamboo forest. Ngawen village was thought to be one of the villages overgrown by bamboo forest, and in the north of Ngawen village, there is now a village called Gunungpring, where there is a hill that is still overgrown by bamboo groves.

The discovery of Ngawen temple began in the Dutch colonial period, namely in 1874. After the discovery, then continued with various studies, and the restoration was only performed in 1925-1927. The restoration and reconstruction were not able to produce the whole temple. Many lost stones are made possible by natural disasters such as earthquakes or volcanic eruptions, which have swept away the rocks. From that restoration only produced the legs of the temple and the body of the temple II. It is estimated that the II temple is still less than 2-3 meters. To date, there are still efforts to reconstruct the temple by the institution that has its own, namely the Central Java Cultural Reserve Preservation Hall. The last time Reconstruction was held in 2011-2012 at Temple IV.

3.2. Geometric Analysis of Ngawen Temple

The Ngawen temple complex consists of 5 (five) temples lined parallel from north to south. Temple building facing the east. From the south of Ngawen Temple I, II, III, IV, and V, each temple plans the square. The II and IV temples have the same size and shape of construction. One of Ngawen Temple's uniqueness is the existence of 4 lion statues in every corner of Temple II and Temple IV. The lion statue supports the four sides of the temple building, reconstructed from the five buildings. The carved style of the lion statue resembles the lion symbol of the country of Singapore and serves the rainwater that comes out through the mouth of the statue.

Ngawen temple complex is approximately 900 square meters. Based on the reconstruction results that produce only the body of Temple II, temples other than Temple II are only the temple's foot in the form of cuboid and variant size. In Temple III, only the legs are left, as shown in Figure 1. The remaining stones are not even enough to form a complete foot. The foot of temple III is lying quite scattered like in the picture.

As for temple IV, there are quite a lot of remaining stones to be sufficient for neater reconstruction. This is like in picture 2. The legs of Temple IV look neat and intact even though it is equipped with artificial stones. Temple IV is more extensive compared to temple III.
Figure 2. Temple Foot IV

The foot of the temple is in the form of a beam. To make it easier to review geometrically, the authors attach sketches of temple legs from various angles.

Figure 3. Sketch of the temple's foot side view, a front view, and looks up

The size of temple II is more or less like in the sketch, but for temple II and temple IV, the size is more extensive. The foot of Candi II measures 13.36 m x 12.82 m. The height of the temple is 2.32 m, and the east view is 2.42 m.

Figure 4 shows the temple II side view. At the foot of temple II, there is a hall surrounding the temple's body as wide as 1.10 m. The photo also shows that there is a gate in front of the temple. For more details, you can see in the sketch in Figure 5. The separate temple gate has a width of 4.9 m, the entrance gate is 1.05 m, and the height is 2.1 m. The lower gate is in the form of blocks, while the upper part is in a quadrilateral pyramid.

Figure 4. Temple II Side View  

Figure 5. Sketch Temple II Look Side

The temple II front view can be seen in figure 6, and the sketch front view in figure 7. From the front, the temple roof looks like a trapezoid in 2 dimensions. However, when viewed from the front and sides, this roof is in a rectangular pyramid.
Based on the results that have been described, it is clear that objects or buildings around us also contain mathematical things. Ethnomathematics moves mathematics from the institutional context of learning such as schools and universities and puts it in people's interior world, their cultures, and their day-to-day activities [10]. It also increases students' intellectual, social, emotional, and political learning by using their unique cultural reference points to convey their knowledge, skills, and attitudes [11]. Therefore, a mathematics teacher must be able to connect cultural values and mathematics. Teachers' role in the integration of ethnomathematics approaches into the teaching of geometry is of great significance [12].

3.3. Integration of Ethnomathematics into the Learning Process of Teaching Mathematics

Through ethnomathematics, learning mathematics geometry material helps students know the culture, environmental issues, provides geometry content and allows students to master geometry concepts taught in the classroom. Based on Brandt and Chernoff the ethnomathmatic approach has been effectively integrated in the classroom [10]. Rosa reports that it is important to understand the culture and relationships in mathematics learning that can be a source of knowledge for teachers who are willing to help them to customize and modify their teaching practices [13]. Teachers need to be aware of students' cultural knowledge and experience and understanding of culture and its relationship to geometry so that teachers can integrate ethnomathematika into geometry teaching [14]. Ethnomatmatics also covers all aspects of teaching and learning, consisting of curriculum and content development to improve math teaching and learning [15].

4. Conclusions

Ngawen temple complex is approximately 900 square meters. Based on the results of reconstruction that produces only the body of Temple II, temples other than Temple II are only the foot of the temple in the form of a beam and variant size. Likewise, in Temple II, because this temple is not found in the form of the stupa, this temple is also the only variant of the beam that is arranged. The footprint of Ngawen II temple measuring 13.36 m x 12.82 m. The foot of the temple is 2.32 m, and the East Side viewer 2.42 m. Above the foot of the temple is the lobby that surrounds the temple body as wide as 1.10 m. While the separate temple gate is the size, width 4.9 m, the gate section 1.05 m and height 2.1 m. Meanwhile, on the roof is the rectangular pyramidal frustum and the upper part of the arch in the form of a rectangular pyramid. It is certainly rational to integrate Ethnomathematics and the mathematics curriculum [16].

From an ethnomathematical perspective, mathematics becomes the product of all cultures, being the school mathematical experience of an academic researcher with only one form of mathematical experience [17]. Learning mathematics in meeting current challenges requires prospective teachers to effectively use learning resources that are based on context, culture, and ethnicity. The ethnomathematics approach is one of the tools needed to build an inquiry-based mathematical learning process and the development of student personalities [18]. An ethnomathematics approach is embedded in social constructivism as it recognizes the daily knowledge that the learners bring into classroom [19].
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