Ethnomathematics values in Temple of Heaven: An Imperial Sacrificial Altar in Beijing, China

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Abstract. Many studies are proving that learning mathematics with an ethnomathematical approach can improve students’ mathematical skills. Developing and using ethnomathematics concepts are important to raise history and cultural awareness of mathematics. This study aims to analyse the ethnomathematics values of the Temple of Heaven. Temple of Heaven is one of the famous heritage sites in Beijing, China, which bears many ethnomathematics concepts. The researchers applied a qualitative method in this study. The subject of this research is the Temple of Heaven building that is located in Beijing, China. Researchers identified the geometrical concept present in the exterior, interior design, and building structure of the Temple of Heaven building. This research shows the existence of mathematical concepts in the architecture of the Temple of Heaven. This research result can help teachers in making mathematical practice questions with ethnomathematics concepts.

Keywords: Ethnomathematics, geometrical design, Temple of Heaven

1. Introduction

Mathematics lessons at every level usually focus on student’s mathematical abilities such as communication [1,2], problem-solving [3,4], creative thinking [5,6], and other skills [7,8]. Other research discussed students’ mathematical higher-order thinking skills. However, only a few studies showed the relationship between mathematics and culture or history even though every heritage has a unique culture, and it is worth discussing and learning from the mathematics viewpoint. One of the examples is Pramudita and Rosnawati who explored the Javanese culture from the geometry perspective [9]. They found that Javanese culture has many mathematical elements and this is very interesting to be discussed.

Ethnomathematics itself comes from the word ethno or ethnic [10]. Accordingly, ethnomathematics means knowledge that talks about culture and mathematics. Some researchers have developed mathematics questions related to culture in the hope that when students learn mathematics, they can also know and learn about the culture [11,12]. A teaching method that uses an ethnomathematics approach would enable students to understand the outside world and culture and is proven to improve students’ mathematical ability.

When we observe papers in reliable resources, we can discover some papers about ethnomathematics in Indonesia [13,14], but there is lack of work on ethnomathematics in China. China is a huge country with a lot of interesting cultural values that are unknown to many people. There are many places and things in China that have their uniqueness and ethnomathematics value. One of the...
study done was about the ethnomathematics value of the Great Wall of China [15]. The researchers investigated the ethnomathematics of the Great Wall and found that the architecture in the Great Wall applied geometrical concepts such as circles, slice theorem, rectangles and so on. The researchers also found that some parts of the Great Wall are in shapes such as beams, cubes and tubes. This indicates that ethnomathematics is certainly worth studying.

Temple of Heaven is located in Beijing, China. It was built in 1420 [16]. The Temple of Heaven is one of the religious buildings built in the Ming dynasty when the Emperors of the Ming ruled in 1368-1644. At first, this place was originally named as Sacrificial palace. In 1998, UNESCO officially inaugurated the Temple of Heaven as a world heritage [17]. The Temple of Heaven measures 2.73 km² and was built according to the Chinese philosophical requirements [18]. The temple hall is circular with a squared foundation that means “heaven is round and earth is square”. The base of the hall of prayer was constructed with three layers that were made from marble. The Temple of Heaven is a familiar landmark in Beijing.

This present study explains the existence of ethnomathematics concept of the Temple of Heaven, Beijing, China. Researchers see that China has a lot of ethnomathematics values that are not discussed by other researchers.

2. **Method**

This study was done in December 2020. The researchers went to a few historical places in Beijing to study ethnomathematics. The object of this study is the Temple of Heaven. This is an exploratory study in which researchers investigate things or places that contain ethnomathematics then discuss them using a qualitative method. This enables readers to see and understand the ethnomathematics present in the Temple of Heaven, China. The data collected were based on observation data, documentation, and literature review.

Firstly, researchers interviewed locals on the culture of the Temple of Heaven and conduct literature survey works from various sources [17,19–22]. From the interview result and literature study, researchers tried to relate the history and ethnomathematics of the Temple of Heaven. Lastly, the researcher visited the Temple of Heaven, Beijing, China to observe and collect the data.

3. **Results and Discussion**

Based on the religious activity in the Temple of Heaven, Beijing, China, researchers can see that it has much culture and ethnomathematics values that can be discussed and learned by students. Teachers can also use an ethnomathematics approach to teach their students. In this study, the ethnomathematics analysis was divided into two areas of Temple of Heaven which are the outside of the hall of prayer and the inside of the hall of prayer. When we observed the Temple of Heaven, we can see from afar that the construction uses many geometry concepts.

3.1. **Temple of Heaven in geometry perspective.**

Figure 1 shows the view of Temple of Heaven from outside of the building. It is symmetric, with a round foundation, and the building pattern is square and rectangle with three main floors, roughly cylindrical. Based on the analysis, the magnificent classical architecture can be regarded as composed of basic three-dimensional geometric figures that show the atmosphere. The abstract geometry of each part can be seen in Figure 2. The main part of each floor of the building is abstracted into a cylinder, the eaves between each floor are abstracted into a round table, and the top of the building is abstracted into a cone. Figure 3 indicates the vertical straight line as the axis of symmetry of the whole building.
Figure 1. The overall image of the Temple of Heaven

Figure 2. The geometrical shapes of each part of the Temple of Heaven
Figure 3. The symmetrical appearance of the building

From the perspective of internal design, the interior still maintains its symmetrical feature. Such a large building is supported by 28 wooden pillars and possesses high artistic value in architectural modeling. As shown in figure 4, the wooden pillars are all cylinders, which are substantial.

Figure 4. The interior design of the building

From the architectural structure, the temple built for prayer is beautiful and charming. The tour guide explained the history and specific materials for the construction of the temple. There is a lot of mathematical culture in architectural design. Each floor has nine steps. This is based on a Chinese tradition. The odd number is a "yang number", and the number 9 is the largest odd number within ten, so the number of stones on the altar is a multiple of nines. This building was first renovated in 1545 and was renamed "Pray for Wealth and Peace". The building has three main colors: yellow represents the emperor, blue represents the connection between humankind and heaven, and red represents luck and prosperity. In August 1889, the Temple of Heaven was destroyed by fire and was rebuilt again, and it
was completed in 1896, 6 years later. During the reconstruction process, there are no additional or reduction of materials being used, and everything is the same as the original building.

3.2. Ethnomathematics on the building structure of Temple of Heaven

Figure 5 summarizes the ethnomathematics concept of the building. The roof of the Temple of Heaven is blue and round. 28 wooden doors form a circle at the same distance [17]. From this, we can see that the arrangement of pillars requires a deep understanding of mathematics. The foundation of the temple is round, which means that heaven is round and endless.

There are four golden pillars, measuring 19.2 meters high and 1.2 meters high. These four pillars represent the four seasons of China: spring, summer, autumn, and winter. There are 12 pillars in the middle which means there are 12 months in a year, so people should pray every month. There are 12 pillars outside, representing 12 hours. According to records, in ancient China, 2 hours was considered as 1 hour, so there were 12 hours in a day.

The 12 pillars in the middle and the 12 outer pillars plus 24 are also metaphors for the sun. According to ancient Chinese sayings, human beings and heaven are one. It can be concluded that the number of pillars in the temple is mostly 4 and 12. According to ancient Chinese records, 28 pillars represent 28 astrological constellations in the sky. At the top of the roof, there is a golden ball, representing a world leader.

![Figure 5. Building structure of Temple of Heaven](image)

After we know the mathematics concept present in the Temple of Heaven, researchers can then make ethnomathematics-based questions and introduce an ethnomathematics concept in class that can improve students’ mathematical ability. There are many studies in Indonesia that tried to use ethnomathematics concepts in class and receive positive response from students [23, 24]. In other words, ethnomathematics study can be developed to improve students’ mathematical abilities.

4. Conclusion

Temple of Heaven is a world heritage site that UNESCO has officially inaugurated. The Temple of Heaven building has many cultural features that are closely related to mathematical concepts. These concepts are related to the Chinese belief in 1420. This study shows that the exterior, interior, and building structures are closely related to complex mathematics concepts. This study contributes to knowledge about the ethnomathematics values of the Temple of Heaven. Future research can be done on the use of the Temple of Heaven in practice questions for students. There are still many things or
buildings in China that contain ethnomathematics and have never been discussed. Hopefully, this study can serve as a beginning for future ethnomathematics studies.

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