Ethnomathematics exploration at the Chinese Wall and its relation to the concept of geometry

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Abstract. The purpose of the research was to explore forms of ethnomathematics on the Chinese wall and analyze their relationship with geometrical concepts. The study was conducted in 4-13 Mei 2018. The research location was the Chinese wall. Data collection was done by observation. Data were analyzed descriptively. The results showed that various forms of building geometry in the Chinese wall could identify various geometrical structures: flat, like squares, rectangles or circles, as well as various forms of building space, such as beams and cubes, and building spaces such as tubes.

1. Introduction
The Great Wall of China was one of the wonders of the world, which was certified by Unesco in 1987. The Great Wall of China was built during the reign of the Qin Dynasty, followed by the Han Dynasty, and was completed by the Ming Dynasty. In 220 BC, the Emperor Qin Shi Huang's government connected the previous walls as a line of defense. Development takes 9 years. In 127 BC, when Emperor Han Wudi was in power (140 BC-87 BC), the renovation project and construction of old parts of the wall were carried out for 20 years adding to the overall wall length to 1000 km. During the Ming Dynasty (1368-1644), the construction of the Chinese wall was perfected, reaching a length of 5,650 km. At this time, the Great Wall of China was divided into 9 military districts equipped with defenses and gates; the easternmost gate is called Shanhaiguan and the westernmost gate is called Jiayuguan.

The Great Wall of China architecture could be classified into 3 (three), namely flare towers, gates, and walls. The flare tower building contains: round, oval and square. The gate is built with a maximum length of 10 meters, while the height of the walls averages 23-26 feet (7.01-7.92 meters).

Length and height are units of measurement, as well as round, oval, and square are geometric shapes (flat and space), which have area and volume. Thus, mathematical concepts have actually been integrated in the construction of the Great Wall of China. The Great Wall of China is a cultural product because it is realized as a combination of feeling, initiative, and creativity. Cultural products that are full of meaning with mathematical concepts are ethnomatics studies.

[1] wrote that ethnomatematics is defined as cultural anthropology of mathematics from mathematics and mathematics education. [2] wrote that ethnomatatics is a relation between mathematics (and mathematics education) and socio-cultural reality. According to [3], the relationship between mathematical concepts (and various mathematical procedures) with cultural artifacts can be formulated in the form of measurements, calculations, games, predictions, navigation, astronomy, and modeling.
D'Ambrosio in [4] emphasizes that ethnomathematics is the application of mathematical skills, ideas, procedures, and practices by a group of people in the past, and is still preserved until now. [5-8] stated that ethnomathematics in the mathematics learning process can be seen as an approach to motivate students to learn mathematics by linking mathematical material taught with existing local culture, or by practice - existing cultural practices, or existing ones. [9] argued that ethnomatematics is a learning approach that is carried out by teaching mathematics by linking mathematics to the work of the nation's own culture and also involving the needs and lives of the people.

If mathematical learning is given to students through an ethnomathematics approach, it is hoped that a love for the country will grow, proud, and love of its own culture. Various research results, [10] and [11] shown, mathematical ideas and practices, such as geometric principles, are born from handicraft activities, architectural concepts, and artifacts from many native, and local languages.

The problems of this research were focused on the exploration of ethnomathematics at the Great Wall of China and its relation to the concept of geometry. Geometry is a branch of mathematics that is built from three elements that are not defined, namely points, lines, and fields. These three undefined elements are used to define a variety of flat and built up spaces. Various types of flat building and building space into building structures that are on the Great Wall of China.

2. Methods
Survey research was chosen as this research design. This research was conducted at the Great Wall of China on May 4th -13th, 2018. The location and research subjects were determined purposively. The use of survey methods takes the following stages: literature study, field study or data collection, and description and analysis of the field findings. The literature study was taken by examining various documents related to the Great Wall of China, such as the history of the Great Wall and the architecture of the Great Wall of China. The results of the literature study were used to determine the various forms of buildings in the Great Wall of China, to be further observed. Observation results were documented, as material for analysis [12].

In other words, data collection uses observation techniques, and documentation, in addition to the literature review. In general, the three techniques were used simultaneously and complement each other. Data were analyzed descriptively qualitatively [13].

3. Results and Discussion
The following is the results of the exploration of ethnomathematics at the Great Wall of China in the form of examples of findings that were products of Chinese culture in the past at the Great Wall of China and beyond. The first, the Great Wall of China architecture was limited by 2 (two) gates, namely Shanhaiguan (easternmost gate) and Jiayuguan (westernmost gate), as shown in Figures 1.a and 1.b.

![Shanhaiguan](image1.jpg) ![Jiayuguan](image2.jpg)

**Figure 1.** a. Shanhaiguan b. Jiayuguan

The second, the result of ethnomathematics exploration along the road on the Great Wall of China were found in the form of ethnomathematic objects involving concepts: (1) plane geometry, such as
rectangles and circles (Figures 2.a and 2.b) and (2) space geometry, such as cube and tubes (Figures 3.a and 3.b).

Along the road of the Great Wall of China, between the gates of Shanhaiguan and Jiayuguan there were many forms of ethnomathematics that could be correlated with geometric concepts, both plane geometry and space geometry. The following were presented various forms of ethnomathematics which could be related to geometry subject matter.

Case 1

A tourist (Figure 2a) observes these rectangular stairs. The tourist remembered the table surface in her square-shaped house. If the rectangular stairs has a length of 205 cm and a width of 26 cm, while the surface of a rectangular table has a side that is twice the width of the stairs in the form of a rectangle, then calculate the wide difference between the stairs in the house.

Solutions

Given: The stairs are rectangular and the table surface is square. Rectangular, has a length of 205 cm and a width of 26 cm. Square, with sides twice the width of a rectangular stairs. Asked: The difference between the stairs area in the form of a rectangle with the table surface area. Solution:
Information:  $p = \text{length}, \ l = \text{width}, \ s = \text{side}, \ s = 2l$

Calculate the Rectangular area:

Rectangular area = $p \times l$

= $205 \times 26$

= $5,330 \ cm^2$

Calculate the Square area:

Square Area = $s \times s$

= $2l \times 2l$

= $2(26) \times 2(26)$

= $52 \times 52$

= $2,704 \ cm^2$

Determine the difference:

Difference = Rectangular area – Square area

= $5,330 – 2,704$

= $2,626 \ cm^2$

So, the difference between the area of the staircase in the form of a square with a table surface area is $2,626 \ cm^2$.

Case 2

One of the spaces that was built as a large barrier of the Great Wall of China, in the form of a combination of squares and rectangles squeezed on one side (Figure 3a). After being drawn on a smaller scale, Figure 6 is obtained.

Calculate the combined volume.

Conclusion: Given: Side length of the cube = 10 cm.

Cuboid height = $(10 + 7) \ cm = 17 \ cm$.

Cuboid length = 14 cm.
Cuboid width = 10 cm.

Asked: The combined volume of the two shapes.

Solution:
Calculate the cube volume:
Cube Volume = s × s × s
= 10 × 10 × 10
= 1.000 cm³

Calculate the cuboid volume:
Cuboid volume = p × l × t
= 14 × 10 × 17
= 2.380 cm³

Calculate the combined volume:
Combined volume = Cube volume + Cuboid volume
= 1.000 + 2.380
= 3.380 cm³

So, the combined volume of the building is 3,380 cm³.

Figures 2b and 3b are also ethnomathematical object forms that can be played to improve students' abilities in geometry subject matter. Figure 2b is a product of ancient Chinese culture in the past, in the form of a table made of carved stone. This stone chair and table is in the great wall area of China. Mebelair can be used by government officials to meet or relax. The object of ethnomathematics is very clean and authenticity.

As a cultural product, the edge of a table describes a circle. These cultural products can be utilized in ethnomathematics activities as semi-concrete props to show the shape of a circle, which can be calculated around the circumference and surface area of the table. Through the process of learning mathematics with an ethnomathematics approach, students are inculcated with a sense of preserving the cultural heritage of the past [14].

4. Conclusion
Based on the description above, conclusions can be drawn: (1) ethnomathematics forms along the Great Wall of China in the form of stones of plane geometry, such as rectangles, triangles, squares, circles, and various geometric spaces. (2) Ethnomathematics in the Great Wall of China can be related to geometric concepts, both plane geometry and space geometry.

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