ETHNOMATHEMATICS EXPLORATION AT GUA SUNYARAGI CULTURAL HERITAGE IN CIREBON

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Abstract - Gua Sunyaragi Water Park comes from Sanskrit, namely the word “sunya” which means quiet and “ragi” means body. This park was made as a resting place for the family of the Cirebon sultanate king. In addition, this place is used by the king to meditate closer to God. The area of this water park is around 15 hectares. There are several types of buildings around the area, namely Pasanggrahan building, Gua Pengawal, Gua Pande Kemasan, Gua Simanyan, Jinem ward, Mande Beling, Gua Peteng, Gua Langse, Kaputren room, Panembahan ward, Chinese Princess statue room, puncup, Bale Kambang, Gua Arga Jumut, Gua Padang Ati, Gua Kelanggengan, Gua Lawa, Gua Pawon, courtyard square, Mei Man Chia Tin monument. Gua Sunyaragi Water Park is a mixture of Javanese, Arabic and Chinese architecture. Gua Sunyaragi Water Park consists of stone, coral, brick, water and garden-like elements in China. Sacred atmosphere created with the use of Wadasan. Wadasan has an architectural function as a building envelope, a circulation barrier and sclupture. Wadasan has several functions such as a temperature controller combined with water to reduce the temperature around the room. The stone used as Wadasan has a variety of types but has the same character. The purpose of this study is to determine the contribution of the mathematical aspects of Gua Sunyaragi Water Park, its history, and the process of mathematical thinking in how it is created. The results of this study are presented in a qualitative form to describe the history of the Gua Sunyaragi Water Park. The building shape is described as a pyramid and trapezoid-like building which is a part of mathematical aspects of geometrical material. In addition, other aspects discussed are fractal dimensions in the shape of the building by looking at several scales starting at 1, ½ and ¼. This scale can determine the level of roughness of the building forms of Gua Sunyaragi Water Park. It is expected that the results of this study can be used as teaching materials at the secondary school level or references for other studies in the field of ethnomatematics.

Keywords - Cultural Heritage of Gua Sunyaragi Water Park, Ethnomatematics, Exploration.

I. INTRODUCTION

Gua Sunyaragi Water Park is a park that forms a cave and is located in the Cirebon city. This water park is shape-like temple called the Gua Sunyaragi, or the Sunyaragi Water Park, or Tamansari Sunyaragi. The name "Sunyaragi" comes from the Sanskrit word "sunya" which means lonely and "ragi" which means body. The main purpose of the construction is as a place of rest and meditation for the royal family (sultanate) Cirebon. The history of Gua Sunyaragi has two versions. First, the history of its establishment was passed down through generations by Cirebon nobles or the royal palace descendants verbally. This version is better known as the version of “kandha carub”. Another one is the version of the caruban nagari, which is based on a book entitled "Purwaka Caruban Nagari" comes from the handwriting of Prince Kararangen (Prince Arya Carbon) in 1720 AD. [1]

The version of caruban nagari is used as a reference for Gua Sunyaragi tour guides to date. According to this version, Gua Sunyaragi was founded in 1703 AD by Prince Kararangen, great-grandson of Sunan Gunung Jati Cirebon. According to caruban kandha and some notes from the kasepuhan keraton, tamansari was built because the Giri Nur Sapta Rengga pesanggrahan turned into a burial place for the kings of Cirebon, now known as Astana Gunung Jati. So that the record can be related to the expansion of the Pakungwati keraton (now the Cirebon of Kasepuhan keraton) which took place in 1529 AD with the construction of the surrounding wall of the palace, Siti Inggil, etc. As a comparative data, Siti Inggil was built and marked with Candrasengkala Benteng Tinataan Bata, which was founded in 1529 AD. There is a Candrasengkala garden called "Taman Bujengin Obahing Bumi" at Tamansari Gua Sunyaragi. There are also similarities in these two places, namely the Bentar temple which has the same shape and cultivation. In the same year, Prince Kararangen only built the Arga Jumut cave and Mande Kemasan.

Gua Sunyaragi Water Park has similarities with other attractions in Indonesia. Tamansari is a palace park with water and trees as a place to rest and playground for the royal family. Gua Sunyaragi Water Park is unique to compare to other attractions in Indonesia, an area consisting of caves makes it a special attraction for the Gua Sunyaragi Water Park. This water park is often dubbed the "Coral Palace".The term is supported by building architecture in the form of arranged coral rocks to form mountains and road paths so that the whole building is shaped like a beautiful coral complex.The use of coral is what distinguishes Gua Sunyaragi Water Park with other water parks in Indonesia. [1] The following is given a picture of the atmosphere at the Gua Sunyaragi Water Park area.



Fig. 1 Gua Sunyaragi Water Park Area

Gua Sunyaragi Water Park is an ancient water park in Indonesia. This water park has the original name of Kaputren Panyepi Ing Raga Park. It is part of the Cirebon Kasepuhan Keraton and is registered as the land belonging to the Cirebon City administration. Gua Sunyaragi Water Park is a national level cultural heritage site under the management of the Serang Cultural Heritage Preservation Hall. This water park is registered in the cultural heritage site with the number RNCB.19980616.04.000709. The following is given a mockup image of the cave plan of the Sunyaragi water park complex.



Fig. 2 Buldings in Gua Sunyaragi Water Park Area (Source: Paramarini)



(a) Segaran



(b) Gua Raja Jumut



(c) Bentar Temple



(d) Bale Kambang



(e) Gua Padang Ati



(f) Elephant Statue



(g) Mei Man Chia Tin Monument



(h) Jinem Ward



(i) The Snake wrapped around Garuda statue

Gua Sunyaragi water park has the shape of a hollow building and has winding, dark alleyways resembling a cave, so this site is known as the Gua Sunyaragi. This site is a Kelangenan park or a pleasure park (water park) which the main function is for hospitalization or solitude. Gua Sunyaragi Water Park Site has undergone repairs or renovations from the time of Sultan Sepuh IX, colonial until now. This water park functions as a tourist attraction.

II. LITERATURE REVIEW

A. Ethnomathematics Definition

The term ethnomathematics was introduced by D'Ambrosio, a Brazilian mathematician in 1977. The term ethnomatematics is defined as: "The mathematics which is practiced among identifiable cultural groups such as national-tribe societies, labour groups, children of certain age brackets and professional classes". Meaning: [2] Mathematics is practiced among identified cultural groups such as tribal national communities, labor groups, children of certain age groups and professional classes. The term is then refined to become: [3] I have been using the word ethnomathematics as modes, styles, and techniques (tics) of explanation, of understanding, and of coping with the natural and cultural environment (mathema) in distinct cultural systems (ethnos). Meaning: [4] I have used the word Etnomatematics as fashion, style, and technique (tics) to explain, understand, and deal with natural and cultural environments (mathema) in different cultural systems (ethnos).

Until this time, mathematics is seen as something far from the activities of human life, and not related to culture at all. Urbiratan D'Ambrosio is a mathematical education expert who rejects this. Mathematics is not something free of culture and value. Mathematics has been united, practiced and has become a tradition in all aspects of cultural life. Existing research in mathematics education is generally more focused on

classrooms. However, there are new findings that show a lot of mathematical knowledge can also be obtained outside of school, one of which is the finding of ethnomatematics.

B. Gua Sunyaragi Architecture

[1] Seen from the style or pattern and variety of makeup patterns that appear as well as diverse building patterns, it can be concluded that the architectural style of Gua Sunyaragi is the result of acculturation of classical Indonesian or Hindu style, Chinese or ancient Chinese style, Middle Eastern or Islamic style and European style. Classic or Hindu Indonesian style can be seen in some joglo-shaped buildings. For example, in the Bale Kambang building, Mande Beling and the pesanggrahan building, the shape of the gate and several statues such as elephant statues and eagle-headed human statues wrapped around by snakes. The whole building ornaments show a strong cultural syncretsime originating from various parts of the world. However, it is generally influenced by classical Indonesian or Hindu architectural styles. Chinese style is seen in flower carvings such as peach blossoms, sunflowers and lotus flowers. In some places, Gua Sunyaragi was once decorated with various porcelain ornaments (ceramics) originating from China on the outside. The porcelain has long been lost or damaged so there are no known motifs or patterns. The porcelain installation on the surface of Mande Beling as well as the mega mendungmotif as in Gua Arga Jumut shows that Gua Sunyaragi has the influence of Chinese architectural style. In addition, there is also a Chinese tomb, which is not a grave of a person of Chinese descent but a type of monument that serves as a place of prayer for the descendants of escorts and guards of the Chinese Princess named Ong Tien Nio or queen Rara Sumanding who is the wife of Sunan Gunung Jati. As a heritage of the palace led by a Muslim sultan, Gua Sunyaragi is also carved with architectural patterns in the style of Islam or the Middle East, for example, niches on the walls of several buildings, Qibla signs for each prayer center or prayer room, the presence of several parades or ablution places and the shape of the Jinem Ward that resemble the shape of the Kaaba when viewed from the back of Jinem Ward. This explains that the architectural style of Gua Sunyaragi was also influenced by the Middle East or Islam. [1] Furthermore the elements of the Gua Sunyaragi Water Park area consist of:

1) Wadasan

Wadasan and mega mendung patterns dominate most of the Gua Sunyaragi Water Park area. A pair of rocks and buoyancy representing the shape of the wadasan are arranged in such a way as to form the wadasan and mega mendung patterns. In some parts of the Gua Sunyaragi Water Park area, it is equipped with floral motifs in the form of vines, either in the form of pataran or simbaran.

2) Water

The presence of water is inseparable from the Chinese landscape that uses water as a mandatory element in the park. The water in front of the Gua Peteng area is used by the sons and daughters of the palace to play. In this case, the water in Gua Sunyaragi Water Park has functions as :

a) Security

The area in the middle of the lake serves to maintain security so that people cannot enter it carelessly. With the limitation in the form of water, a raft is needed to enter the area, especially at the royal guest gate.

b) Air Conditioner

Water flowing from Segara Amparan Jati is cooling the room inside the area. The flowing water serves to keep the temperature cool by absorbing hot air in the room. The cooling function is because the average temperature of the city of Cirebon is at point 27.40C which tends to be hot so that the Gua Sunyaragi Water Park area is cooler and supports to carry out sport activities.

c) Ablution Water

The establishment of Gua Sunyaragi Water Park is a period of the spread of Islam in Cirebon, so that the activities of tourism are inseparable from the teachings of Islam. In carrying out these activities, the sultan family continued to perform prayer services so that they needed water for ablution. Lake water in Islamic teachings is clean water for ablution. With the water flowing inside the Gua Sunyaragi Water Park area, the sultan family does not need to go far. At this time, the presence of water began to disappear because access to the entry of water from Segara Amparan Jati was closed and water began to dry out especially during the dry season.

3) Brick

Another prominent element in Gua Sunyaragi Water Park area is the use of red bricks. Red brick is used in the Bentar temple at the entrance, retaining walls on hills, waterways, and in caves. The red brick serves as a place for attaching wadasan stones to Gua Sunyaragi Water Park area.

4) Wood

Gua Sunyaragi Water Park area is inseparable from wood elements. The wood in the area is in joglo buildings, namely in the mande beling, bale kambang and cungkup puncit.

Gua Sunyaragi Water Park was founded in the Dutch colonial era so that Dutch or European architectural styles also influenced its architectural style. It can be seen in the shape of the window located in the

kaputren building, the shape of the rotating staircase in the Gua Arga Jumut and the shape of the rest house. Visually, the buildings in the Gua Sunyaragi area are more sacred. The sacred impression can be seen by the retreat place such as Gua Padang Ati and Gua Kelangenan, the prayer and pawudon place or the place to take ablution water, the hall leading to Arabia and China which is located in Gua Arga Jumut area; and the hall leading to Gunung Jati in Gua Peteng area. In front of the entrance to the Gua Peteng, there is a virgin statue of Sunti. According to the legend of the local community, if a girl holds the statue then it will be difficult to get a mate. The sacred impression also appears in the form of jinem ward buildings that resemble the shape of the Kaaba when viewed from the back side. In addition, there is also a Balela Hajj statue that resembles a statue of Lord Vishnu. The following is given a sketch of Gua Sunyaragi Water Park.



Fig. 3 Sketch of Tamansari Gua Sunyaragi (Source: Supriyanto, R)

In 1997 the management of Gua Sunyaragi was handed over by the government to the Kasepuhan palace. This greatly affected the physical condition of Gua Sunyaragi. The lack of maintenance costs caused the tourist location of Gua Sunyaragi to gradually be abandoned.

C. History and Construction Stages of Gua Sunyaragi Water Park

Based on the records of Candrasangkala, which read "Gajah Derum Tirta Linuwih" became evidence of the establishment of Gua Sunyaragi Water Park for the first time. The meaning of "Gajah Derum Tirta Linuwih" represents the number of the elephant (8) derum (5) tirta (4) linuwih (1). The notes of Candrasangkala show numbers 8541 when read from back to 1458. Note Candrasangkala uses a Javanese year where it has a difference between 78 years and years when it is read in the year of the year to 1536. Gua Sunyaragi Water Park is part of the Cirebon palace of Kasepuhan. This park was first established by the Sultan of Cirebon I. The architect of the Gua Sunyaragi Water Park is Raden Sepat from Demak and Prince Losari from Cirebon assisted by architects from China who, at that time, were in Cirebon.

In the 1500s, the resthouse was located on the west side of the Amparan Jati hill named Nur Giri Sapta Rengga, which became known as Sembung mountain. This resthouse is used as a place to study Islamic religion and physical training for the people's army. This area turned into a funeral after Princess Ong Tien Nio who was the wife of Sunan Gunung Jati was buried in the area followed by Sunan Gunung Jati and her descendants were buried in the same funeral. With the funeral, Taman Sari turned into a funeral area and was no longer suitable for physical training.

Golden Prince Zainul Arifin, a great-grandson of Sunan Gunung Jati took the initiative to build a new resthouse replacing Nur Giri Sapta Rengga. The idea was negotiated with Raden Sepat from Demak and Prince Losari. Gua Sunyaragi Water Park is called Gua Sunyaragi because it has a building with the shape of caves. [1] The following is a diagram of the period of construction of Gua Sunyaragi Water Park.

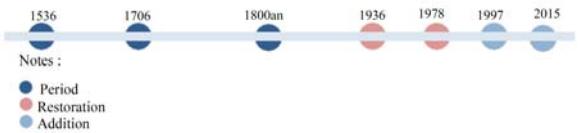

Fig. 4 Construction Period of Gua Sunyaragi Water Park

1) 1st Period

In this period, the buildings that were erected were (1) Gua Guards, (2) Gua Pawon, (3) Gua Lawa, (4) Gua Peteng Area, (5) Gua Padang Ati, and (6) Gua Kelanggengan. The function of the building in this period is a place of training or imprisonment and training of soldiers.

2) 2nd Period

(1) Cave of Arga Jumut, Bale Kambang, and Mande Beling are established in this period.

3) 3rd Period

During this period there was an addition of caves, namely (1) Gua Pande Packaging, (2) Gua Simanyang, and (3) Jinem Ward. In the construction, Prince Matanghaji received help from Chinese Architects. The function of Gua Sunyaragi area is a place to compile the strength to fight the Dutch and a place of recreation for the sons and daughters of the palace.

4) Dutch Attack

During this time, Gua Sunyaragi Water Park area was attacked and destroyed. Based on historical records, several building areas were destroyed by the attacks including Gua Arga Jumut and Mande Beling. Until now, the mande area was shattered with debris due to the Dutch attack at that time and could not be returned to its original form.

5) Restoration

The restoration period was first carried out in 1936 by strengthening and replacing existing structures. Strengthening is carried out by giving additional columns to the graves of the village that were hit by the Dutch attack in the 1800s.

6) 4th Period

In 1997, Cirebon hosted the 2nd Indonesian Palace Festival. Supporting this activity, Gua Sunyaragi Water Park area added buildings in the form of a venue for the performing arts and other supporting buildings such as an executive office.

D. Functions and Spaces of Gua Sunyaragi Water Park

Gua Sunyaragi Water Park is an area of ancient buildings or ancient water parks with the main characteristics of having winding and dark aisles and hollow exterior walls. The aisle is winding like a natural cave so this area is referred to as Gua Sunyaragi. Buildings in the area of Gua Sunyaragi Water Park have their respective functions and meanings.

Buildings	Function
Pasanggarahan Building	(1) Secretariat or the management office of Gua Sunyaragi Water Park, (2) Tourist reception, (3) Museum, dan (4) Warehouse.
Gua Pengawal	The gathering place and rest of the sultan's companions in Gua Sunyaragi Water Park.
Gua Pande Kemasan	The place for forging sharp weapons such as kris, spears, swords, and handicrafts. This cave was founded during the establishment of the 3rd period in the 1800s at the initiative of Sultan Sepuh Kasepuhan V namely prince Amir Sidik.
Gua Simanyang	Guard post
Jinem Ward	A place for the royal family to see dance performances and security training held in the square. Besides that, it functions as a place for the sultan to give direction and prayers for soldiers who will carry out training or attractions in war dexterity and self-defense in Sunyaragi Square.
Mande Beling	Resting place for the sultanate family, including the sultan himself when giving advice and wisdom to courtiers and the community.
Gua Peteng	Used secret passage.
Gua Langse	A place of worship and one room used for relaxing.
Kaputren Room	A place to rest, also used for the daughters of the palace to recite as a form of galvanizing.
Panembahan Jinem	Men's room to galvanize themselves.
Chinnese Princess Sculpture Room	Place of the Chinese Princess Statue made of sandalwood which gives off a pleasant aroma that fills the room.
Cungkup Puncit	Watchtower.
Bale Kambang	A place to relax and also connector the front and rear. Bale Kambang, at a certain time, is used to sound the gamelan.
Gua Arga Jumut	A gathering place for important people of the palace after boating in Segaran Jati lake.
Gua Padang Ati	A seclusion or meditation place to get vision or inspiration as a heart to achieve the ideals.
Gua Kelanggengan	A seclusion place for the royal family who wants permanence in his life.
Gua Lawa	Cave trap so that the members of the kingdom are not disturbed while making a seclusion.
Gua Pawon	Supplies store.
Courtyard Square	Cultural venue and war training. 2 lotus ponds in the west of the square overgrown with white lotus.
Mei Man Chia Tin Monument	The monument to commemorate that the early stages of Taman Sari Sunyaragi construction involving Chinese architects and archaeologists who were at that time in Cirebon.

Table I. The function of the caves in Gua Sunyaragi Water Park Area

E. Box-Counting Method (Grid Method)

The Box-Counting Method is an estimation procedure for calculating fractal dimensions of complex objects. This method is used if you cannot determine the length of the segment or the slope of objects that are unique in shape. For example, [5] counting the dimensions of dust, waves of the sea and clouds. The following formula is given from Box-Counting Method.

$$D = \frac{\ln n(a) - \ln n(b)}{\ln {}^{1}/_{S_a} - \ln {}^{1}/_{S_b}}$$

With: n : number of squares / grid covered by curves. ${}^{1}/_{S}$: grid scale

The following is an example of calculating the dimensions of the Koch curve

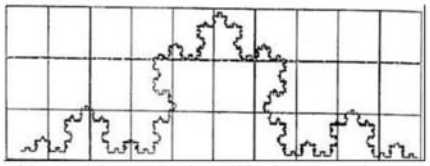

Fig. 5 Koch Curve with a scale size of 1 grid and a grid covered by 18

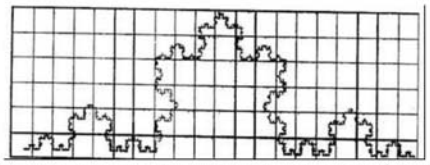

Fig. 6 Koch Curve with a scale size of 1/2 grid and a grid covered by 41

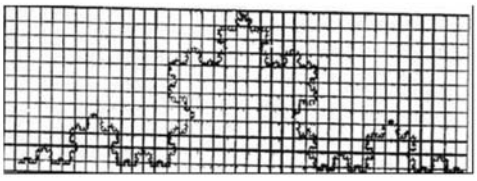

Fig. 7 Koch Curve with a scale size of 1/4 grid and a grid covered by 105

The dimensions of the Koch Curve can be calculated as follows:

$$D = \frac{\ln n(a) - \ln n(b)}{\ln {}^{1}/_{S_a} - \ln {}^{1}/_{S_b}}$$

$$D_{grid\,{}^{1}/_{2},1} = \frac{\ln 41 - \ln 18}{\ln 2 - 0} \approx 1{,}19$$

$$D_{grid\,{}^{1}/_{4},1} = \frac{\ln 105 - \ln 18}{\ln 4 - 0} \approx 1{,}27$$

$$D_{grid\,{}^{1}/_{4},{}^{1}/_{2}} = \frac{\ln 105 - \ln 41}{\ln 4 - \ln 2} \approx 1{,}36$$

From the dimensions of the Koch Curve above, it can be concluded as a statement of the level of roughness of the geometry of an object or object. The greater the value of the Kooch Curve dimension, the lower the roughness level.

F. Ethnomathematics-Based Mathematics Learning at School

Mathematical ideas are abstract forms of everyday human life activities that should be easy to learn and understand. However, there are many students who still have difficulties in learning mathematics. [6] This is because mathematics taught in schools is sometimes different from the mathematical problems found in everyday life.

[7] As stated by Teguh & Dwiyanti that there is a difference between mathematical knowledge obtained academically and informally. The incompatibility of mathematical problems found in school with mathematics found in everyday life makes it difficult for students to connect formal mathematical concepts to problems in the real world. Therefore, many students are able to operate mathematical calculations in the classroom but it is difficult to solve mathematical problems found in everyday life. On the other side, there are children who are able to solve everyday problems even though they are not formally educated. Teaching mathematics for students should be adapted to their culture.

[8] Beside the diversity of cultures in Indonesia, it is difficult for students to understand the mathematics acquired in school and the difficulties students have in connecting with real life making it a major factor in the importance of integrating cultural based learning into learning. For this reason, we need a connection between mathematics outside of school and mathematics in school. One of them is by utilizing the ethnomatematics approach.

By applying ethnomatematics in learning mathematics, students are expected to be able to understand mathematics and culture better and teachers are easier to instill cultural values themselves in students. With ethnomatematics based learning, in addition to being able to learn mathematics contextually, students can also understand culture and can grow character values.

III. METHODOLOGY

This research was conducted to provide a qualitative description of the exploration of ethnomatematics in Gua Sunyaragi Cirebon. As for what is being explored is a form of building arrangement in the Gua Sunyaragi Water Park area that can be viewed from the aspect of geometry. Then, fractal geometry elements can be explored more deeply to find out the real fractal dimensions of Gua Sunyaragi.

The methods used in this study are qualitative, comparative, and descriptive methods. Qualitative methods are in the form of searching literature studies, active observation, passivity, and retrieving documentation data in the form of photos and images.

A. Research Framework

This research framework can be presented in full in the diagram below.

ETHNOMATHEMATICS EXPLORATION IN GUA SUNYARAGI CULTURAL RESERVATION AT CIREBON

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Research Questions
1. What is the result of exploration of ethnomatematics in the Sunyaragi cave in Cirebon city?
2. What mathematical aspects can be found from the results of exploration of ethnomatematics in the Sunyaragi cave in Cirebon city?
3. What is the result of fractal dimension analysis related to the shape of the building in Gua Sunyaragi Area Cirebon?

Literary Studies		Observation	Interviews
Ethnomatematics, Euclid Geometry and Fractal Geometry Assessment		Research Objects	Experts
1. Understanding etnomatematics, history and development of ethnomatematics in West Java. 2. The definition of Euclid's geometry, the properties and position of each field and side. 3. Definition of fractal geometry, Mandelbrot method in analyzing fractal dimensions.	The object of this research focused on the buildings of Gua Sunyaragi Water Park.	1. Guidance with ethnomatematics to strengthen qualitative methods. 2. Cirebon culture expert can explain the philosophical meaning of Gua Sunyaragi Water Park.	1. Guard of Gua Sunyaragi Water Park to find out the history of the object of research. 2. Sultan of Cirebon to find out the development of Gua Sunyaragi Water Park today.

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Conclusions and Recommendations

Fig. 8 Research Framework (Source: Private Document)

B. Theoretical Framework

In analyzing ethnomatematics in Gua Sunyaragi Water Park, qualitative methods are used with mathematical concept approaches. The character of Gua Sunyaragi created by the existence of Wadasan was analyzed using the character theory approach. Whereas the semiotic theory is used to describe the philosophical meaning of the construction of Gua Sunyaragi Water Park area. The following diagram is related to the theoretical framework of this research.

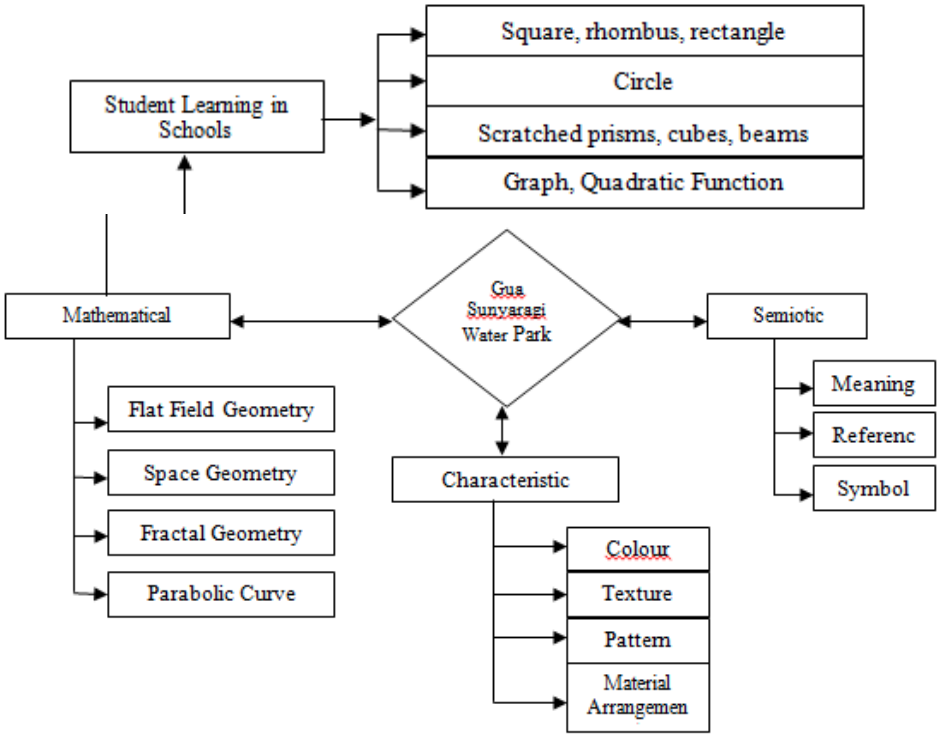


Fig. 9 Theoretical Framework

IV. RESULTS AND DISCUSSION

A. Etnomatematics in Gua Sunyaragi Water Park

Communities in the Cirebon city are well acquainted with the Sunyaragi Cave Water Park area, because it is an ancient building that was used as a cultural heritage by the local tourism agency. In addition to the building's unique and mystical design because it has a winding and dark passage, Gua Sunyaragi has more than one distinctive features and philosophical stories from each building. The buildings in Gua Sunyaragi area are as follows: Pasanggrahan Building, Gua Pengawal, Gua Pande Kemasan, Gua Simanyan, Jinem Ward, Mande Beling, Gua Peteng, Gua Langse, Kaputren Room, Panembahan Ward, Chinese Princess Sculpture Room, Puncit Cupola, Bale Kambang, Gua Arga Jumut, Gua Padang Ati, Gua Kelanggengan, Gua Lawa, Gua Pawon, Courtyard Square, Mei Man Chia Tin Monument.

Based on the building structure, Gua Sunyaragi Water Park has distinctive characteristics from each other architecturally, culturally, and mathematically. These mathematical concepts and theories emerge from several building forms that have similarities with simple geometric concepts up to the complex. The followings are pictures of the building around Gua Sunyaragi Water Park area.

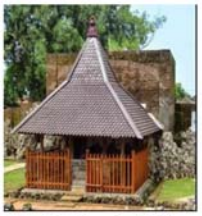


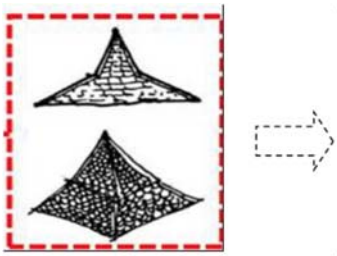
Fig. 10 Mande Beling



Fig. 11 Mande Beling Roof Shaped Limas

From the pictures above, it is a form of building named Mande Beling which is used as a family resting place for the sultanate, including the sultan himself when giving advice and wisdom to courtiers and the surrounding community. The building has a unique roof shaped rectangular pyramid on the top and a rectangular trapezoid at the bottom.

The roof has a triangular pyramid shape with a length of 70 cm ribs and a height of 90 cm. Then, if we are looking for the surface area of the pyramid, the following mathematical concepts are obtained.



$$\text{Base area} = sisi \times sisi = 70 \times 70 = 4900 \text{ cm}^2$$

$$\text{Tall} = \sqrt{35^2 + 90^2} = 96{,}5 \text{ cm}$$

$$\text{Triangle area} = \frac{b \times t}{2} = \frac{70 \times 96.5}{2} = 3.377{,}5 \text{ cm}^2$$

$$L_p = 4900 + 4(3.377{,}5) = 18.410 \text{ cm}^2.$$

Fig. 12 Mande Beling Roof Sketch

At the bottom, the Mande Beling roof has a trapezoidal rectangular shape with 300 cm long bottom ribs, 70 cm upper rib length, and 250 cm height of the building. The surface area is obtained with the following details.

$$t = \sqrt{250^2 + \left(\frac{300-70}{2}\right)^2} = 2{,}75 \text{ cm},$$

$$Base\ area_{bigger} = 90.000 \text{ cm}^2,$$

$$Base\ area_{smaller} = 4900 \text{ cm}^2,$$

$$Trapezoidal\ area = \left(\frac{a+b}{2}\right),$$

$$t = \left(\frac{370}{2}\right) 275 = 50.875 \text{ cm}$$

$$L_p = 90.000 + 4900 + 4(50.875) = 298.400 \text{ cm}^2$$

It can be concluded that the shape of the Mande Beling building that is inside Gua Sunyaragi area is 298.400 cm^2.

Furthermore, in the other buildings discussed are the Puncit Cupola, which is a tower in Gua Sumyaragi Water Park area used to monitor the enemy with similar building forms such as Mande Beling, only with different sizes. The followings are pictures of the Puncit Cupola around Gua Sunyaragi Water Park area.



Fig. 13 Cungkup Puncit



Fig. 14 Cungkup Puncit Closer Look

Based on the results of measurements with local officials, the roof of the lower Cungkup Puncit with the upper rib length of 35 cm was obtained, the lower was 150 cm, and the height was 80 cm. In more detail, the surface area of the Puncit Cupola building is obtained as follows.

$$\text{Tall} = \sqrt{80^2 + \left(\frac{150-35}{2}\right)^2} = 260 \text{ cm}$$

$$\text{Base area} = 150 \times 150 = 22.500 \text{ cm}^2$$

$$\text{Trapezoidal area} = \left(\frac{150+35}{2}\right) 260 = 24.050 \text{ cm}^2$$

$$L_P = 22.500 + 4(24.050) = 118.700 \text{ cm}^2$$

The middle part of the trapezoid-shaped Cungkup Puncit has a height of 18 cm, the top is 30 cm, and the bottom is 50 cm. Thus, the surface area of the center of the Cungkup Puncit is obtained as follows.

Next, it is the building from Arga Jumut which is a gathering place for important officials of the palace after boating around the Segaran Jati lake. To be clearer, the followings are pictures of Arga Jumut that appears from the front and side.

$$\text{Base area} = 50 \times 50 = 2500 \text{ cm}^2$$

$$\text{Trapezoidal area} = \left(\frac{30+50}{2}\right) 18 = 720 \text{ cm}^2$$

$$L_p = 2500 + 4(720) = 5.380 \text{ cm}^2$$

Then, the top has a height of 40 cm and a base of 30 cm.

Base area	$= sisi \times sisi = 30 \times 30 = 900\ cm^2$
t	$= \sqrt{40^2 + 15^2} = 42{,}7\ cm$
Triangle area	$= \frac{a \times t}{2} = \frac{30 \times 42{,}7}{2} = 640{,}5\ cm^2$
L_p	$= 900 + 4(640{,}5) = 3462\ cm^2$

So, the surface area of the Cungkup Puncit is 3462cm^2.



Fig. 15 Front Look of Gua Arga Jumut



Fig. 16 Gua Arga Jumut Entrance Side Look

The shape of Gua Arga Jumut entrance has similarities to the parabolic curve that opens down like the picture below.



Fig. 17 Sketch of Gua Arga Jumut Entrance

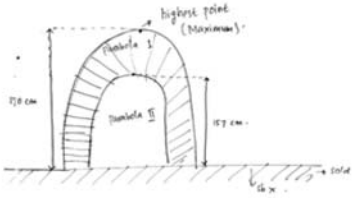


Fig.18 Size of Gua Arga Jumut Entrance

From the sketches above, we can find the general form of parabolic equations as follows.

The first parabolic curve is a function curve that opens down. The general form of the equation is as follows.

$$y = a(x - x_1)(x - x_2) \quad \text{.....(1)}$$

Then, the shape of the second parabolic curve has the position just below the first curve. So, the general form of the equation is as follows.

$$y = a(x - x_1)(x - x_2) \quad \text{.....(2)}$$

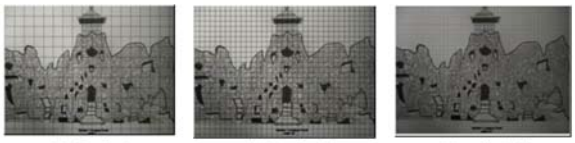
The parabolic curve can be approached with the broad concept of the area of the integral

$$\int_a^b L_1 - L_2\, dx.$$

B. Fractal Dimension Analysis of Gua Sunyaragi Water Park

Fractal dimension analysis aims to determine the fractal dimensions found in the shape of buildings in Gua Sunyaragi Water Park area and shows the basic form and repetition patterns that are formed on the visible plan. This fractal analysis uses the Counting Box method. In this analysis, it can be seen that the fractal level of a building of visual analysis is limited to the visible object and the plan seen in two dimensions, so the results of the dimensions obtained in this analysis cannot be more than two dimensions.

The following is the picture designs for Gua Sunyaragi Water Park with several scales, namely 1, ½ and ¼ with the building is a Cungkup Puncit.



(a) Scale 1 (b) Scale ½ (c) scale 1/4

Fig. 18 Fractal Dimension of Cungkup Puncit

The following is the fractal dimension calculation of the Koch Curve with the Box-Counting method.

$$D = \frac{\ln n(a) - \ln n(b)}{\ln {}^1/_{s_a} - \ln {}^1/_{s_b}}$$

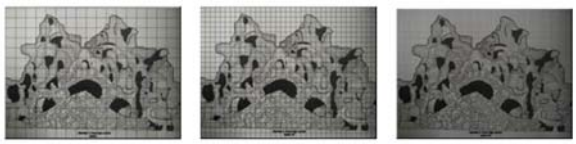
$$D_{grid\,{}^1/_2 1} = \frac{\ln 560 - \ln 146}{\ln 2 - 0} \approx 1{,}93$$

$$D_{grid\,{}^1/_4 1} = \frac{\ln 2150 - \ln 146}{\ln 4 - 0} \approx 1{,}94$$

$$D_{grid\,{}^1/_4 {}^1/_2} = \frac{\ln 2150 - \ln 560}{\ln 4 - \ln 2} \approx 1{,}94$$

From the calculation above, it can be seen that the Popup Cup has a depth (fractal dimension) D approaching 1.94. It shows the level of roughness and detail in the geometry of the building is high.

While the image design for Gua Arga Jumut, inside Gua Sunyaragi Water Park area, can be seen in the picture below with a scale of 1, ½ and ¼.



(a) Scale 1 (b) Scale ½ (c) scale 1/4

Fig. 19 Fractal Dimension of Arga Jumut

The following is the fractal dimension calculation of the Koch curve with the Box-Counting method.

$$D = \frac{\ln n(a) - \ln n(b)}{\ln {}^1/_{s_a} - \ln {}^1/_{s_b}}$$

$$D_{grid\,{}^1/_2 1} = \frac{\ln 315 - \ln 115}{\ln 2 - 0} \approx 1{,}45$$

$$D_{grid\,{}^1/_4 1} = \frac{\ln 1195 - \ln 115}{\ln 4 - 0} \approx 1{,}68$$

$$D_{grid\,{}^1/_4 {}^1/_2} = \frac{\ln 1195 - \ln 315}{\ln 4 - \ln 2} \approx 1{,}92$$

From the calculation above, it can be seen that Cungkup Puncit has a depth (fractal dimension) D approaching 1.92. [9] It shows the level of roughness and detail in the building geometry is high.

C. Ethnomatematics Associated with Mathematics Learning in Schools

[10] The idea of implementing ethnomatematics in the school curriculum is not new. By incorporating ethnomatematics into the curriculum, the school will provide a new nuance in teaching mathematics with the consideration that the Indonesian consists of a variety of tribes and cultures, and each tribe has its own way of solving problems, such as Cultural Reservation of Gua Sunyaragi Water Park in Cirebon.

Another consideration is that the mathematics obtained at school does not fit the way of life of the local community, so that mathematics is difficult for students to understand because there are two schemes obtained, namely the scheme obtained in the surrounding environment and the scheme obtained at school. [11] These two things are thought to be the cause of the difficulty of students learning mathematics. Therefore, in the modern mathematics curriculum, there are two ways to teach mathematics. First, informal mathematics is taught from kindergarten to elementary school grade 3. Mathematics contains mathematics that students often find in their environment that is applied by the local community. This mathematics can be said as mathematics which contains local content. Second, formal mathematics is taught from grade 4 to elementary school and above. [12] This type of mathematics contains mathematics that does not emphasize local content, but leads to advanced mathematics.

Mathematics is not a universal domain of formal knowledge, but is a collection of symbolically constructed symbols and procedures in certain groups of people. As student thinks developly, they combine representations and procedures into their cognitive systems. [13] A process has occurred in the context of socially constructed activities.

[14] Mathematical skills learned by students in schools are not constructed logically and are based on abstract cognitive structures, but as a combination of knowledge and skills that have been previously obtained as well as new (cultural) input where activities involving numbers, geometric patterns, counts and so it is considered an application of mathematical knowledge. The following is an ethnomatematic diagram that can be associated with mathematics learning at school.

From the chart above, it can be explained that the ethnomatematics concept can be implemented into learning in various levels ranging from Junior High School, Senior High School to College Student. Mathematical concepts found from the Cultural Reservation of Gua Sunyaragi Water Park are the activities of the ancient community who designed and made different buildings inside the water park area. The philosophy meaning that emerges is adapted to the beliefs held by the Cirebon sultan that Gua Sunyaragi Water Park was created to draw closer to God by making a refuge and cleansing of body and soul. The shape of the building has been studied in a mathematical concept more likely towards the geometrical concepts of both eculid and non-euclid. Non-euclid geometry is a natural form derived from the composition of rocks (wadasan), the majority of which are in this area.

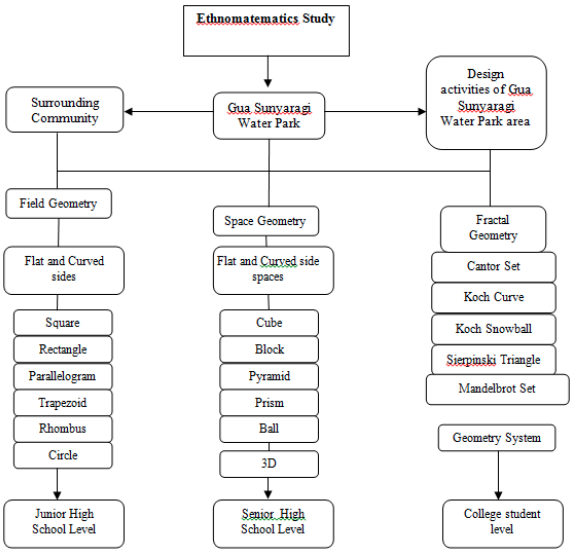


Fig. 20 Chart of Mathematical Concepts of Ethnomatematics Associated with Mathematics Learning in Schools

V. CONCLUSIONS AND RECOMMENDATIONS

From the explanation previously, it can be concluded that Gua Sunyaragi Water Park was founded in 1703 AD, which is now 316 years old and has an area of around 15 hectares. This water park is used as a means of playing and resting for the royal family. In addition, various types of caves around the area have their respective functions. One of them is as a place to get closer to the Almighty God by cleansing the soul and body in a quiet or lonely place.

The building structures around the park are made of stone river material, known as 'wadasan'. The sacred atmosphere is very thick in this water park because it is supported by lighting and the effects of using 'wadasan' stones that can absorb the sun's heat. Several mathematical concepts were found in the form of buildings around the Gua Sunyaragi Water Park area.

Whether we realize it or not, the community, including the royal family and government officials, built Gua Sunyaragi Water Park using mathematical principles. This can be seen from several buildings such as Mande Beling and Cungkup Puncit which were further analyzed using geometric concepts in building the roof. The entrance to Gua Arga Jumut also uses

mathematical concepts, namely the parabolic function curve. From this entrance, it can be known the peak point by using the quadratic function rules.

Broadly speaking, the caves around the water park area can be analyzed for depth or fractal dimensions. By using the Counting-Box method, the fractal dimensions of the building shape can be known with certainty, for example the Puncit Cupola has fractal dimensions of 1.94 which means the level of roughness and detail in the building geometry is high. Same is the case with Gua Arga Jumut.

Ethnomatematics studies found can be linked to mathematics learning in schools with various levels. Not only to understand the mathematical concepts learned in accordance with the curriculum, but students can also understand and get to know the culture around the environment in which they live through ethnomatematics - based teaching and learning activities.

Based on the conclusions described above, recommendations made in this study, is it needs to be explored further in relation to the mathematical concepts obtained from Gua Sunyaragi Water Park area. Like the concept of row and number series patterns, integral concepts, fractal geometry concepts are traced from the wadasan stone arrangement patterns that exist on the surface Gua Sunyaragi.

In addition, the relationship with mathematics learning in schools is recommended to begin cultural-based curriculum planning up to the design of textbooks as the teacher and student's hand when teaching and learning activities are taking place in the classroom.

ACKNOWLEDGMENTS

The author conveys acknowledgments to Swadaya Gunung Jati University (UGJ) which has so provided internal research grants that this scientific article can be completed. In addition, the author also so expresses his or her gratitude to the involved parties that the research and writing of this article could be carried out smoothly.

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