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Unveiling Mathematics Concepts on Panggung Krapyak and Rotiban Activities: An Ethnomathematics Study in Yogyakarta

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Abstract. The utilization of cultural context in mathematics learning can be an alternative of effective learning approach to bridge students to master the abstract dimension of mathematics through the real context in students' lives. However, cultural integration in mathematics learning must begin with the identification of mathematical concepts contained in cultural objects that are relevant to school mathematics. This study aims to identify mathematical concepts contained in the Panggung Krapyak and Rotiban activities at one of the Islamic boarding schools in Yogyakarta, Indonesia. This study is an exploratory study with a qualitative approach. Data were collected through observations of the Panggung Krapyak and Rotiban activities, in-depth interviews with figures, documentation, and literature reviews. The results of the study indicate that Panggung Krapyak displays various mathematical concepts such as reflection, similarity, and congruence in the shape of the building. In addition, the Rotiban activity contains the concept of multiples of numbers in its schedule and cyclic permutation in the cycle pattern of participants sitting. These findings indicate that the existence of mathematical concepts contained in local culture is in line with school mathematics so it can be integrated into mathematics learning to be more contextual and easier for students understanding.

Keywords: Ethnomathematics; Explorative Study; Panggung Krapyak; Rotiban Activities

Abstrak. Pemanfaatan konteks budaya dalam pembelajaran matematika dapat menjadi alternatif pendekatan pembelajaran yang efektif untuk menjembatani siswa menguasai dimensi abstrak matematika melalui konteks nyata dalam kehidupan siswa. Namun demikian, integrasi budaya dalam pembelajaran matematika harus diawali dengan identifikasi konsep-konsep matematika yang terkandung dalam objek-objek budaya yang relevan dengan matematika sekolah. Penelitian ini bertujuan untuk mengidentifikasi konsep-konsep matematika yang terkandung dalam Panggung Krapyak dan kegiatan Rotiban di salah satu pondok pesantren di Yogyakarta, Indonesia. Penelitian ini merupakan penelitian eksploratif dengan pendekatan kualitatif. Data dikumpulkan melalui observasi Panggung Krapyak dan kegiatan Rotiban, wawancara mendalam dengan tokoh, dokumentasi, dan kajian pustaka. Hasil penelitian menunjukkan bahwa Panggung Krapyak menampilkan berbagai konsep matematika seperti refleksi, kesebangunan, dan kongruensi pada bentuk bangunan. Selain itu, kegiatan Rotiban memuat konsep kelipatan bilangan pada jadwal pelaksanaannya dan permutasi siklik pada pola lingkaran tempat duduk peserta. Temuan ini menunjukkan bahwa keberadaan konsep-konsep matematika yang terdapat dalam budaya lokal sejalan dengan matematika sekolah sehingga dapat diintegrasikan ke dalam pembelajaran matematika agar lebih kontekstual dan lebih mudah dipahami siswa.

Kata kunci: Etnomatematika; Kegiatan Rotiban; Panggung Krapyak; Studi Exploratif

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INTRODUCTION

Mathematics has a very important role in human life. Mathematics is a science that cannot be separated from everyday life (Ashabulabib & Suparni, 2022). According to Siagian (2016), mathematics is one of the branches of science that has an important role in the development of science and technology, both as a tool and the development of mathematics. The importance of mathematics in life makes it something that needs to be learned through mathematics education. Mathematics education is one of several subjects that can foster students' talents and creativity (Cahyono, 2017). Through mathematics education, students will follow the learning process to obtain information and things that are not yet known, both in the social environment and in the academic scope (Amri, 2018). In learning mathematics itself, there are several problems that become obstacles in the learning process. These problems include the lack of student interest in mathematics lessons, the inappropriate use of learning methods by educators in delivering material, and in problem solving, students make several mistakes in problem solving (Jayanti et al., 2022).

The use of inappropriate learning methods is one of the problems in learning. Educators must be able to bridge the abstract dimension in mathematics and realize it. To overcome these problems, an approach or context is needed that can bridge the abstract dimension in mathematics. One of the contexts that can be used in learning mathematics is culture or often called ethnomathematics. Ethnomathematics is a learning method that links cultural elements in mathematics learning (Fauzi & Lu'luilmaknun, 2019). Ethnomathematics comes from the word "*ethnomathematics*" which consists of three syllables, namely *ethno* means related to culture, *mathema* related to mathematical activities and *tics* which means art or technique. So if assembled, ethnomathematics means a science that studies the art of mathematics in various human cultural activities (Nur et al., 2019). Mathematics is often seen as a tool for solving practical problems in science alone, thus ignoring that mathematics is used in everyday life and culture (Fatmahanik, 2019). The use of culture in learning mathematics will make activities more contextual. Contextual learning is a concept in learning that helps educators to link the material taught in class with real-world situations (Muhartini et al., 2023). Contextual learning like this encourages students to make connections between the knowledge they have and its application in their daily lives. Contextual learning like this is expected to bridge the abstract dimension in mathematics. One of the socio-cultural contexts that can be used is Islamic boarding school.

Islamic boarding school is one of the oldest Islamic educational institutions in Indonesia (Syafe'i, 2015). Pesantren according to the term (etymology) is derived from the word *santri* (people or student who seek Islamic religious knowledge) by getting the prefix *pe-* and the suffix *-an* so that it changes the meaning to be a place to study religious knowledge sourced from yellow books, memorization of the Al-Quran and Al- Hadith or Islamic religious education (Irawati, 2018). As a

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social institution, Islamic boarding schools are involved in dealing with social problems faced by the community (Gumilang & Nurcholis, 2018). Social problems can be minimized through the cultivation of character values in social and cultural activities.

Social activities are things that we cannot avoid in life as social beings. Many social activities are carried out in boarding schools to develop the potential of students not only in knowledge of Islamic religion, but also character education. The values that can be in these activities include politeness, kinship, and discipline. Such values will be instilled into the students and give birth to a culture, both tangible and intangible, that is in accordance with the character of an Islamic boarding school.

Krapyak Islamic Boarding School is one of the Islamic boarding schools in Yogyakarta. The name "Krapyak" is taken from the area where this boarding school is located. Many activities are carried out in the boarding school to develop the potential of students such as diba', rotib, mujahadah, sholawat, and so on. The icon of the Krapyak area itself is an ancient building where the king hunts which we often refer to as "Panggung Krapyak". The many activities and cultures that exist in Krapyak Islamic Boarding School make researchers to explore the potential of ethnomathematics on Panggung Krapyak and rotiban activities at Krapyak Yogyakarta Islamic Boarding School which can help students in appreciating cultural diversity and developing tolerance attitudes towards cultural differences.

The research conducted by Fauzi & Lu'luimaknun (2019) concluded that with the dengkleq game children can play while learning math. Other research founds the elements of the plane figure in the Al-Mashun Great Mosque like triangles, quadrilaterals, octagons, polygons, and circles (Hasibuan & Hasanah, 2022). While the research conducted Hasanah (2021) concluded that the use of ethnomathematics-based learning modules can increase student learning motivation. Based on some of these research results, we can see that the surrounding culture has elements of ethnomathematics. The use of ethnomathematics-based learning methods is also able to develop the competencies of students. In addition, learning with the use of ethnomathematics learning media can help improve student achievement in terms of student learning outcomes (Husna, 2024).

The novelty in this research includes the exploration of new aspects in Panggung Krapyak and *rotiban* activities that have not been widely researched in understanding the relationship between mathematics and culture. The purpose of this research is to identify mathematical concepts in a local culture. By learning mathematics through a cultural context, learners are expected to develop their analytical skills as well as their problem-solving abilities. This approach also contributes to the development of a more inclusive and diverse curriculum, reflecting different cultural values and experiences.

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METHOD

The research method used in this research is exploratory research with an ethnographic approach. Exploratory research is preliminary research that tries to explore new information or problems (Stebbins, 2001). The purpose of conducting exploratory research is to explore and get ideas about the problems found. Ethnography is known as a scientific theory that seeks to describe a culture (Risjord, 2006). This research was conducted by exploring information or problems of a culture that exists in the Krapyak Islamic Boarding School Yogyakarta.

Data collection techniques used in this research are observation, interview, documentation, and literature review. The subjects of this research are Panggung Krapyak and *rotiban* activities. The observation stage was used to obtain qualitative data related to Panggung Krapyak and *rotiban* activities. At this stage, researchers made direct observations of the location of the research subject. The result of this observation is qualitative data about the mathematical potential found.

Interviews were conducted in order to obtain in-depth information and complete information with the sources, namely a teacher and a *santri* (student) at Krapyak Islamic Boarding School. The selection of sources was carried out using purposive sampling technique or sampling based on certain considerations. The consideration of the selection of samples of sources in this study is community leaders who are considered to understand the Panggung Krapyak and students who participate in *rotiban* activities. Documentation was used to obtain several documents about Panggung Krapyak and *rotiban* activities that have mathematical potential. Documentation taken from this research is in the form of photos of Panggung Krapyak, photos of *rotiban* activities, and documentation of interview results. Data analysis used in this research is triangulation, namely data reduction, presentation and conclusion drawing.

RESULTS AND DISCUSSION

Panggung Krapyak is one of the historical buildings in Yogyakarta. Panggung Krapyak is located in the south of Ngayogyakarta Hadiningrat Palace, precisely Krapyak village, Panggungharjo village, Kapanewon Sewon, Bantul regency, Yogyakarta. This site is one of the points of the philosophical axis of Yogyakarta, namely Mount Merapi, Jogja Monument, the Palace, Panggung Krapyak, and the South Coast. The building, which was once the king's hunting ground, was built during the reign of the 1st Sri Sultan Hamengkubuono around 1760. Panggung Krapyak still stands firmly today amidst the rapidly growing Islamic boarding schools in Krapyak area.

The development of boarding school in Krapyak area was pioneered by KH Munawwir bin Abdullah Rosyad who was an expert in the field of Quran. He established a boarding school named Krapyak Islamic Boarding School. The name of this boarding school is taken from the place where

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the boarding school is located, namely "Krapyak". Many activities are conducted in this boarding school to increase the potential of the students. One of the activities carried out to increase the potential of the students is *rotiban*. *Rotiban* comes from the word *ratib* and is suffixed with *-an*. *Ratib* is a set of systematically organized prayers and *dhikr*. *Ratiban* can be defined as an activity carried out together to recite *ratib*. In its implementation, *rotiban* is led by an elder or *kyai*. One type of *ratib* read in Krapyak Islamic Boarding School is Ratib Al-Kubra by Habib Thaha bin Hasan bin Yahya Ba'Alawy. This activity is carried out once every 35 days, precisely on the night of Friday Legi.

Observation Result

The observation on Panggung Krapyak gives the result that Panggung Krapyak is shaped like a cube or parallelogram. Panggung Krapyak has 4 doors in each cardinal direction. On the right and left side of the door there is a window so that the number of windows on Panggung Krapyak is 8 pieces. Panggung Krapyak is currently very well maintained as one of the philosophical axes in Yogyakarta. The building of Panggung Krapyak is shown in Figure 1.

Figure 1. Panggung Krapyak

Observations on *rotiban* activities held in one of the Krapyak Islamic Boarding School complexes in Yogyakarta showed that this activity was attended by all students of the complex. In its implementation, they sit around a kyai who leads the activity. The activity runs very harmoniously until the end of the activity. *Rotiban* activities can be seen in Figure 2.

Figure 2. Rotiban Activities

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Interview Result

The results of the interview with informant 1 about Panggung Krapyak provided very in-depth results. According to Interviewee 1, Panggung Krapyak is a building inspired by the *ka'bah* in Mecca. This is indicated by several evidences, among others, that 1st Sri Sultan Hamengkubuono is a devout follower of Islam with the title Senopati Ing Alaga Sayyidin Panatagama Ngabdurakhman Khalifatullah and the existence of a palace heirloom named Kyai Tunggul Wulung in the form of Kaaba *kiswah*. The building that resembles the Kaaba makes Panggung Krapyak resemble a parallelogram with a size of 17 m × 15 m and 10 m high.

The results of the interview with informant 2 about *rotiban* activities produced more information. According to informant 2, this activity is held every 35 days or 5 weeks, namely on the night of Friday Legi. This activity has been running for many years led by a *kyai* in the pesantren.

Panggung Krapyak

Reflection

The concept of reflection can be seen in the structure of Panggung Krapyak building, which has the same proportions and elements (see Figure 3).

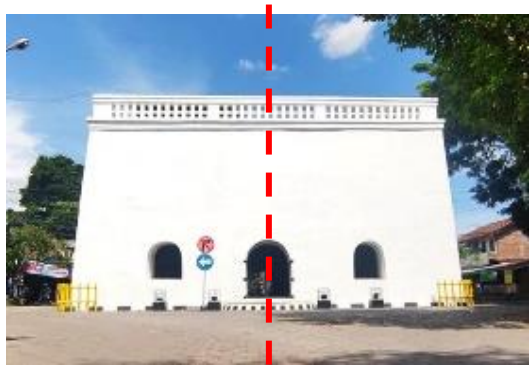

Figure 3. Reflection in Panggung Krapyak Building

The shape of Panggung Krapyak building is align with the concept of reflection, namely:

- The object and its reflection are have same measure.
- The distance of each point in the object to the reflection axis is exactly as same as the distance of each point in the reflection to the reflection axis.
- The height of object reflection is as same as the original height of the object.
- The line connecting each point on the object to the point in the shadow will always be perpendicular to the reflection axis.

These concepts can also be an introduction to reflection material on Cartesian diagram. Here is the general formula for reflection of a point (x, y) on a Cartesian diagram.

- Reflection on the axis x will become $(x, -y)$

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- Reflection on the axis y will become $(-x, y)$
- Reflection of lines $y = x$ will become (y, x)
- Reflection of lines $y = -x$ will become $(-y, -x)$
- Reflection of the origin O (0,0) will become $(-x, -y)$
- Reflection of lines $x = h$ will become $(2h - x, y)$
- Mirroring of lines $y = h$ will become $(x, 2h - y)$

Cuboid

The cuboid concept can be seen from the shape of the Panggung Krapyak which resembles a cube (see Figure 4). This is in accordance with the definition and elements of the cuboid it self.

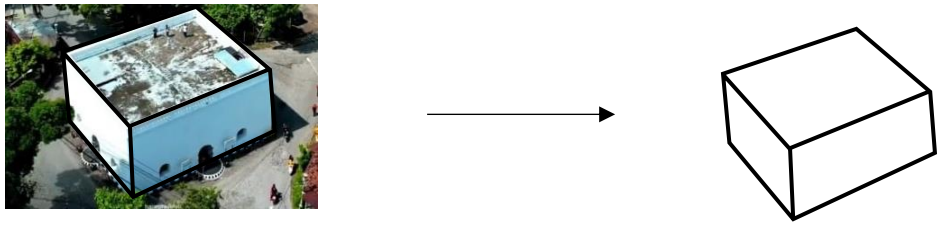

Figure 4. Cuboid in Shape of Panggung Krapyak

A cuboid is a space formed from 3 pairs of sides that are square or rectangular, facing each other and congruent. A cuboid has 6 elements, namely 6 sides or faces, 12 edges or ribs, 8 vertices or vertex points, 12 side or plane diagonals, and 4 space or body diagonals.

Formulas for web length, area, and volume of parallelogram or cuboid are (p = length of cuboid, l = wide of cuboid, and t = high of cuboid):

- Skeleton length $= 4(p + l + \times t)$
- Surface area $= 2((p \times l) + (p \times t) + (l \times t)$
- Volume $= p \times l \times t$

Similarity and Congruence

The concept of congruence can be seen in Figure 5. In Figure 5, it can be seen that Panggung Krapyak has pillars that are shaped like doors.

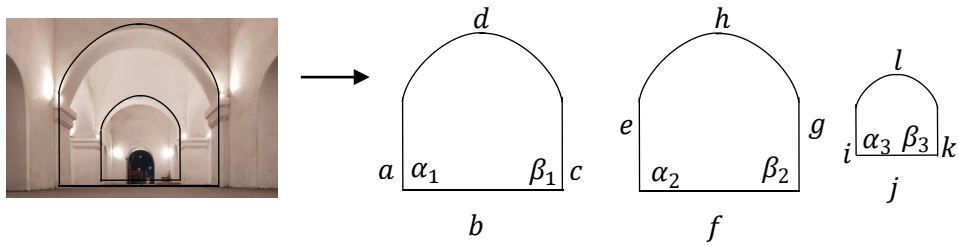

Figure 5. Similarity and Congruence inside of Panggung Krapyak

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When brought into 2-dimensions, the poles will shrink with the same shape. This is in accordance with the definition of similarity, namely two flat shapes are said to be congruent if the two flat shapes have the same shape. Based on the two buildings, it will apply:

- The proportion is equal:

$$\frac{a}{i} = \frac{b}{j} = \frac{c}{k} = \frac{d}{l}$$

- The corresponding angles are equal:

$$\alpha_1 = \alpha_3 \text{ and : } \beta_1 = \beta_3$$

The concept of congruence can also be seen from this site. If we look at Panggung Krapyak directly, we will see that the pillars that resemble this door have the same shape and size. This is in accordance with the concept of congruence, which is that two shapes are said to be congruent if they have the same shape and size. Based on these two figures, then applies:

- Side lengths are equal:

$$a = e\ ,\ b = f,\ c = g, \text{ and } d = h$$

- The corresponding angles are equal:

$$\alpha_1 = \alpha_2 \text{ and : } \beta_1 = \beta_2$$

Ethnomathematics-based Problem

One of the potentials that can be developed from the results of observations on the Panggung Krapyak is ethnomathematics-based problems.

Example. *Panggung Krapyak is one of the cultural heritage in Yogyakarta. Panggung Krapyak has a size of 17m × 15m × 10m. One day, an artist will make a miniature of Panggung Krapyak. The artist will make a miniature of Panggung Krapyak with the same proportion as the original size. What are the length, width, and height of the miniature if the scale used is 1:50?*

Rotiban Activity

Lowest Common Multiple (LCM)

The concept of LCM that can be seen in this *rotiban* activity is the determination of the implementation of the event. This event is held on every night of Friday Legi, which is 35 days or 5 weeks. To calculate it, we can use the concept of multiples.

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Figure 6. Calender

In Figure 6, we can see that this *rotiban* activity was held on March 15th, 2024. To find out when the activity will be held in the following month, we can calculate it in the following way.

The date of the next rotiban = the held date + 35 days - number of the day of previous month.

The date of the next rotiban = 15 + 35 – 31

The date of the next rotiban = 50 - 31

The date of the next rotiban = 19

So it can be concluded that the rotiban activity will be held again on April 19, 2024.

If we want to find when the previous *rotiban* will be held, we can calculate it with the same formula.

The date of the next rotiban = the held date + 35 days - number of the day of previous month.

The date of the next rotiban = 19 + 35 – 30

The date of the next rotiban = 54 - 30

The date of the next rotiban = 24

So it can be concluded that the rotiban activity will be held again on May 24, 2024.

Cyclical Permutation

Cyclical permutations can be seen from the position of the rotiban participants sitting in a circle (see Figure 7).

Figure 7. The Students' Sitting Position Forms a Circle

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To find out the number of ways to arrange, we can use the concept of cyclical permutations. A cyclical permutation is the number of ways to arrange an object in a circular position. Mathematically, cyclical permutations are formulated as follows.

$$P_{cyclical} = (n-1)!$$

Figure 7 shows that in the first row, there are 8 people lined up in a circle. To know the number of ways to arrange, we can use the cyclical permutation formula as follows.

$$\begin{aligned} P_{syclical} &= (n-1)! \\ &= (8-1)! \\ &= (7)! \\ &= 7 \times 6 \times 5 \times 4 \times 3 \times 2 \times 1 \\ &= 5040 \end{aligned}$$

So the number of ways of arrangement in the first row is 5040.

To calculate the number of ways of arrangement in the second row of 12 people, we can also use the same formula as follows.

$$\begin{aligned} P_{syclical} &= (n-1)! \\ &= (12-1)! \\ &= (11)! \\ &= 11 \times 10 \times 9 \times 8 \times 7 \times 6 \times 5 \times 4 \times 3 \times 2 \times 1 \\ &= 39916800 \end{aligned}$$

So the number of ways to arrange the second row is 39916800 ways.

Ethnomathematics-based Problem

One of the potentials that can be developed from the observation of the implementation of this *rotiban* activity is ethnomathematics-based questions.

Example. *The rotiban activity is an activity that is routinely carried out for 35 days. To prepare for the event, a santri was given the task of boiling beans and cassava for consumption. On March 15, the student bought 4 kg of beans and 3 kg of cassava for a total price of IDR 53,000. On April 19, the student bought 6 kg of beans and 2 kg of cassava for a total of IDR 62,000. What is the price of 1 kg of beans and cassava each?*

DISCUSSION

Panggung Krapyak cultural object has some mathematical potential. The mathematical potential that can be seen includes the concept of mirroring (reflection), cuboids, similarity, congruence, and ethnomathematics-based mathematical problems. The concept of mirroring (reflection) can be seen

from the symmetrical side of the building between the right and left parts. The concept of parallelograms can be seen from the cuboid-shaped building. The concept of similarity can be seen from the shape of the building pillars that are congruent between one pillar and another. In addition, we can use Pangung Krapyak as a material to create ethnomathematics-based problems.

Rotiban activities also have some mathematical potential that can be used. Mathematical potentials that can be seen include arithmetics, cyclic permutations, and ethnomathematics-based mathematics problems. The concept of arithmetics can be seen from the implementation of *rotiban* activities, which is every 35 days or 5 weeks. The concept of permutation can be seen from the circular position of rotiban participants. In addition, *rotiban* activities like this can also be used as material for creating ethnomathematics-based mathematics problems.

The results of the observation of the mathematical potential of Panggung Krapyak and *rotiban* activities at Krapyak Islamic Boarding School are very relevant to the mathematics material in school. At the elementary school level, students can learn about the concept of reflection of a 2D shape, multiples of numbers, and know the kinds of flat-sided spaces. At the junior high school level, learners can learn about the reflection of a point on a reference point, flat and composite spaces, and the similarity and congruence of flat shapes. At the senior high school level, students can learn about the concept of mirroring in cartesian diagrams, 3-dimension, and permutations.

The mathematical potential found in Panggung Krapyak and *rotiban* activities can be utilised as learning media to make mathematics learning more contextual based on ethnomathematics. The use of culture in learning mathematics will make it easier for students to understand the topic (Fonataba et al., 2023). By combining ethnomathematics with learning models and materials, students' abilities will increase (Bakhrodin et al., 2019). In addition, learning using ethnomathematics will instil character values in students and can foster a love for local culture (Kuswidi et al., 2021).

CONCLUSION

This ethnographic reseach that conducted at Panggung Krapyak and Krapyak Islamic Boarding School Yogyakarta, was found that these two subjects have various mathematical potentials that are relevant to learning materials in schools. Panggung Krapyak shows mathematical concepts such as mirroring, cuboids, congruence, while *rotiban* activities show the concepts of arithmetics and permutations. These findings can be utilised as a contextual learning media based on ethnomathematics, which not only facilitates students in understanding mathematics material, but also instils character values and a sense of love for local culture.

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