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Ethnomathematics in Heritage: Exploration from Sonobudoyo Museum Yogyakarta

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Abstract

Yogyakarta is known as a cultural city with rich traditions and local values. Integrating local culture into mathematics education can make the material more relevant and engaging for students. However, educators in Yogyakarta have yet to widely recognize this culture as a context that can be used in teaching mathematics. One museum that houses much of this culture is the Sonobudoyo Museum. Thus, this study aims to explore the ethnomathematics in the Sonobudoyo Museum, which can be used as a starting point in mathematics education. This research employs a qualitative method with an ethnographic approach. The instrument in this research is the human instrument, where the researcher directly engages with the study and acts as the data collector through library research, observation, and documentation. Data analysis techniques include data reduction, data presentation, data analysis, and data exposition. The results of this study indicate that the mathematical concepts found in the Sonobudoyo Museum include geometry, sets, relations, and functions. These mathematical concepts can be utilized to introduce and understand mathematics through local culture.

Keywords: Ethnography, Ethnomathematics, Geometry, Museum Sonobudoyo, Relation,Set

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Introduction

Mathematics developed in the Mediterranean region and was primarily organized in the past by the Greeks. As a community, culture, and civilization, society was organized according to models of urban, economic, and social relationships that emerged in Europe after the feudal period, from the late Middle Ages to the Renaissance (D'Ambrosio, 2007). Yohanes (2020) states that mathematics is a science that discusses patterns and levels. Mathematics can be considered a structured science because its concepts are arranged hierarchically, logically, and systematically, from the simplest to the most complex concepts. Mathematics also plays a vital role in bringing new dimensions to students in the relationship between individuals, society, and culture, potentially helping to address social, economic, and cultural issues (Cobb & Hodge, 2002; Morgan, 2014; Mendes, 2022; Özcan & Bahadır, 2023).

However, most students need help learning mathematics (Tall & Razali, 1993; Gersten & Flojo, 2005; Nelson & Powell, 2018; Lumbantoruan, 2023). The factors causing difficulties in learning mathematics are both internal and external (Sariningtias et al., 2020; Setiawan & Hendriana, 2021). Internal factors include students' negative attitudes during mathematics lessons, low interest in learning, weak motivation, and inadequate sensory abilities. External factors include unengaged teachers, limited learning tools, unsupportive family environments, and noisy community environments with generally low

education levels.

Based on these issues, actions are needed to improve students' learning outcomes. Considering the importance of mathematics, it should not only act as a 'filter' but should be utilized effectively to ensure our students can compete with those from other nations (Povidaichyk & Shtymak, 2022). Creating an engaging, relevant, and interactive learning environment by connecting mathematical concepts with real-life situations is essential (Anhalt et al., 2018; Raisinghani, 2021). D'Ambrosio and Domite (2007) propose interactive learning innovations that link mathematics with the surrounding culture, known as Ethnomathematics.

Linguistically, the prefix "ethnic" refers to something broad related to socio-cultural contexts, including language, jargon, behavior codes, myths, and symbols. The root word "mathema" means explaining, knowing, understanding, and performing activities such as coding, measuring, classifying, inferring, and modeling. The suffix "tics" derives from techne, meaning technique. Terminologically, ethnomathematics is defined as: "The mathematics which is practiced among identifiable cultural groups such as national tribes, labor groups, children of certain age brackets, and professional classes" (D'Ambrosio, 1985). Ethnomathematics is a field that merges culture and education, studying mathematical ideas from illiterate people and focusing on the cultural context and expressions surrounding them (Ascher & Ascher, 1986; Salsabilah et al., 2022). Ethnomathematics is a study of mathematics based on cultural manifestations (ideas, activities, or cultural objects) unique to a particular community group (Rosa et al., 2016), and it is conducted by someone with knowledge/expertise in mathematics (Soebagyo et al., 2021).

Indonesia's cultural heritage is rich in stories and philosophies. Many artifacts are preserved, and their cultures are maintained in museums. Almost every region in Indonesia has a museum to immortalize the cultural history of its area, each with unique characteristics. One interesting source of learning from the perspective of ethnomathematics is the Sonobudoyo Museum in Yogyakarta. This museum has various cultural collections essential for preserving Indonesia's cultural heritage.

Several researchers have studied the use of museums as learning sources from an ethnomathematics perspective. Setiana et al. (2021) explored the Yogyakarta Palace carriage museum, finding concepts such as plane figures' area, solid figures' volume, symmetry, and tiling. At the map museum in Bogor, Mufidatunnisa, and Hidayati (2022) found ethnomathematics concepts such as quadrilateral, triangle, and curved surface figures. Similar geometric concepts were found in explorations by Irfansyah & Siregar (2023) at the Deli Serdang Museum and Litik & Argarini (2023) at the Sumba Cultural House Museum. The Sonobudoyo Museum has also been studied by Putri et al. (2023) to explore the Jlamprang batik motifs from Pekalongan, resulting in the concept of geometric transformations. However, many cultural aspects and mathematical concepts are still to be explored at the Sonobudoyo

Museum. Therefore, this study aims to explore ethnomathematics at the Sonobudoyo Museum for use in mathematics education.

Methods

This study employs a qualitative research approach. Qualitative research is a process aimed at understanding human or social phenomena in a complex and comprehensive manner, presented through words (Wilson & Hutchinson, 1991; Walidin & Tabrani, 2015). Qualitative research includes approaches such as Grounded Theory, ethnography, biography, narrative, and phenomenology (Habermann-Little, 1991; Begum, 2009). This research uses the ethnographic approach. The ethnographic approach describes, explains, and analyzes the cultural elements of a society or ethnic group (Caughey, 1982; Chock, 1986).

The data for this study were collected through field observations, documentation, and literature review. Field observations and documentation were conducted from June to July at the Sonobudoyo Museum in Yogyakarta, located at Jl. Pangurakan No.6, Ngupasan, Kec. Gondomanan, Kota Yogyakarta, Daerah Istimewa Yogyakarta. A literature review was also conducted, examining various books, journal articles, and other relevant sources related to batik and traditional ceremonies in Javanese society.

Results and Discussions

This study explores the collections at the Sonobudoyo Museum in Yogyakarta. The Sonobudoyo Museum houses numerous cultural artifacts from various regions worldwide, particularly from Indonesia. To clarify, the results of the ethnomathematical exploration at the Sonobudoyo Museum are as follows:

Geometry Concepts at the Sonobudoyo Museum

Geometry is a field of mathematics that studies points, lines, planes, and space and their properties, measurements, and interrelationships (Nur'aini et al., 2017). Geometry can also encompass aspects of various domains such as art, architecture, vehicles, and machinery, and nearly everything humans create contains geometric elements (Budiarto & Artiono, 2019). The ethnomathematical findings related to geometry at the Sonobudoyo Museum are detailed in Table 1.

Table 1. Geometry Concepts at the Sonobudoyo Museum

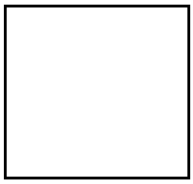
Findings	Mathematical Concept	Implementation
 **Figure 1**. Wall Decorations The wall decoration in the picture is one of the decorations in a traditional Javanese house.	Concept of Square 	The wall decoration and ornament on the kori frame in the picture can be used to introduce the concept of a square. A square is a flat shape bounded by four sides of equal length, parallel sides, and four right angles.
 **Figure 2.** Ornamen Kusen Kori The picture shows an ornament on the kori frame. Kori is the door leaf and frame, with left and right panels. The decoration pattern includes geometric designs, foliage, flowers, and the Bambara lion.		

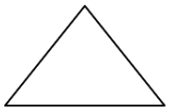
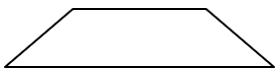
 **Figure 3**. tebeng Tebeng, also known as boven in the picture, is part of a Javanese house that functions as an air circulation channel.	Concept of Rectangle 	The tubing in the picture can be used to introduce the concept of a rectangle. A rectangle is a flat shape with longer and shorter sides, with opposite sides of equal length.
 **Figure 4**. Mianiature of Sunan Bayat The miniature Sunan Bayat tomb is a replica of the Sunan Bayat tomb, functioning as a tomb protector. It is located at the top of the Tembayat cemetery complex on Jabalkat Hill, Central Java.	Concept of Triangle 	The top roof of the miniature Sunan Bayat tomb in the picture can be used to introduce the concept of a triangle. A triangle is a flat shape bounded by three straight sides and has three angles, with the sum of the angles being 180 degrees.
	Concept of Trapezoid 	The middle and lower roofs of the miniature Sunan Bayat tomb in the picture can be used to introduce the concept of a trapezoid. A trapezoid is a four-sided flat shape with one pair of parallel sides.

Figure 5. Kas Craft

Kas's handicrafts are the works of Kunstanbachtschool students stored in the Sonobudoyo Museum.

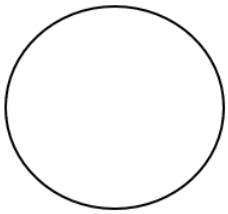
Figure 6. Talam

A tray is a place to put offerings, pasek-pasek, or other ceremonial tools.

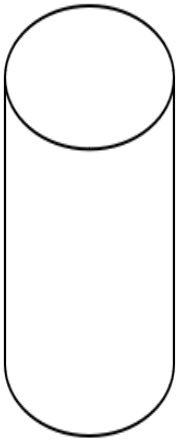
Figure 7. Nekara

Nekara, a bronze drum, is a percussion instrument played during certain events or rituals. Additionally, Ankara serves as a burial

Concept of Circle



The kas handicrafts, tray, and nekara in the picture can be used to introduce the concept of a circle. A circle is a collection of points equidistant from a specific point called the circle's center.

provision, dowry, heirloom, and valuable trade item.		
 **Figure 8**. Kentongan	Concept of Cylinder 	The kentongan in the picture can be used to introduce the concept of the cylinder. A cylinder is a three-dimensional shape with a circular base and top of the same size, having three surfaces: base, top, and lateral surface, and no vertices.

The Concept of Geometric Transformation at the Sonobudoyo Museum

Geometric transformation is a part of mathematical geometry. Geometric transformations include translation (shifting), reflection (mirroring), rotation, and dilation. The ethnomathematical findings at the Sonobudoyo Museum are presented in Table 2.

Table 2. The Concept of Geometric Transformation at the Sonobudoyo Museum

Findings	Mathematical Concept and Implementation
 **Figure 9**. Kembang Mayang Cabinet The kembang mayang cabinet is a twin wedding cabinet.	The kembang mayang cabinet, the kancil puppet mountain, the kori, and the tebeng in the picture can be used to introduce the concept of geometric transformation, precisely reflection (mirroring). Reflection (mirroring) is a type of transformation that moves every point in a plane or geometric shape by using the properties of objects and their images on a flat mirror.

Figure 10. Gunungan Wayang kancil

The kancil puppet mountain is one form of the kancil puppet. The kancil puppet at the Sonobudoyo Museum was created by Ki Ledjar in 1994.

Figure 11. Kori

Kori is a door and frame with left-right panels. It features geometric patterns, floral motifs, and singa Bambara (mythical lions).

Figure 12. Tebeng

Tebeng, also called boven in the picture, is part of a Javanese house that functions as an air circulation channel.	

The Concept of Sets in the Life Cycle of Javanese Society

Humans' life process changes, which are referred to as the life cycle. The life cycle is a series of processes experienced by living beings, starting from the initial moment of life on earth, growing and developing into adult living beings, and reproducing to sustain their species (Firmansyah et al., 2022). The life cycle process concludes with death.

As a country with diverse cultures, Indonesia has different interpretations of the life cycle. In Bugis society, Massolo refers to celebrating achievements in the life cycle, such as pregnancy, birth, and marriage (Syukur, 2020). In Javanese society, life cycle events can be categorized into three stages: the period before and after birth until childhood, adolescence to adulthood, and death.

Javanese society highly values the culture passed down by their ancestors, and this appreciation is expressed through various ceremonies within the life cycle, which have historical and philosophical significance. One form of strengthening historical and philosophical expressions in Javanese life cycle ceremonies is represented in batik. Batik is an art form that can convey the meaning of traditions, beliefs, and aspects that develop in society (Handayani & Emilda, 2018).

Here are the results of explorations at the Sonobudoyo Museum in Yogyakarta regarding batik used in Javanese life cycle ceremonies:

A. Prenatal and Birth

Before the birth of a child, Javanese society has a tradition called Mitoni. Mitoni is a ceremony to commemorate a mother's pregnancy reaching seven months. This ceremony is performed as a form of prayer so that the child can be born safely and healthily and receive blessings and mercy.

Figure 13. Batik Collection Used in Mitoni

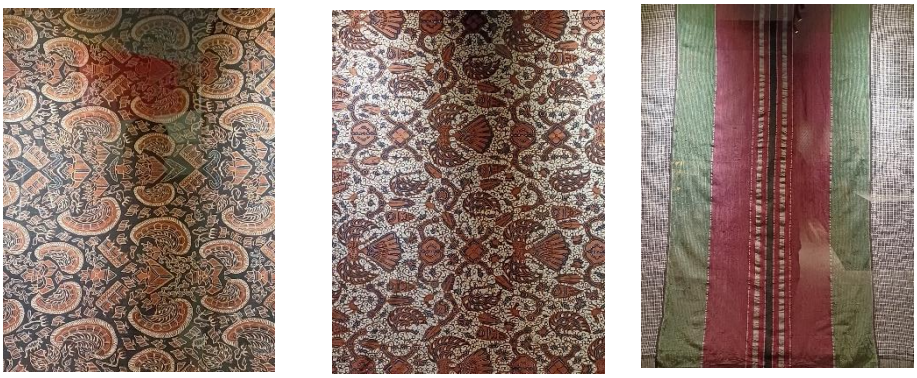


Figure 14. Images of Batik Semen Rama, Sida Mukti, and Lurik Lasem

Next, when the child is born, Javanese society recognizes the term Kopohan. Kopohan is a ceremony of wrapping a newborn baby in batik cloth. The batik used is typically owned by the baby's grandmother and has a good motif. This is done with the hope that the baby will have a long, happy life. The following batik can be used in the Kopohan ceremony:

Figure 15. batik Semen Cuwuri, and Gringsing Buron Toya

Furthermore, when children grow older, Javanese society has a tradition called Supitan. Supitan is the circumcision or khitan ceremony for boys. The following batik can be used in the Supitan ceremony:

Figure 16. batik Parang Baron Nagaraja and Kohinur

Meanwhile, circumcision for girls is called Tetesan (Nurcahyo, 2020). The following batik can be used in the Tetesan ceremony.

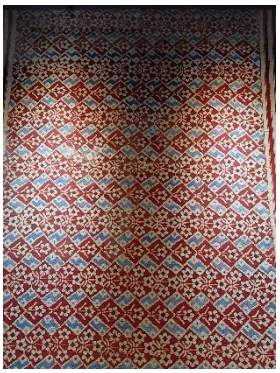


Figure 17. Batik cinde patola

B. Growth and marriage

When a child reaches adolescence and adulthood, Javanese society has a tradition called Lamaran. Lamaran is the tradition of proposing to the bride-to-be. The following batik can be used in the Lamaran ceremony:

Figure 18. Batik Satriya and Semen Kudha Rante

In addition to Lamaran, the prospective bride and groom will participate in the Siraman tradition. Siraman is the tradition of bathing the bride and groom with water from seven springs. This tradition signifies cleansing both physically and spiritually (Nurcahyo, 2020). The following batik can be used in the Siraman ceremony:

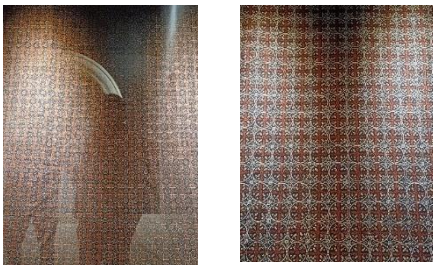


Figure 19. batik Grompol and Nitik

Midodareni is a tradition that must be undertaken by the bride-to-be the night before the wedding. Midodareni is performed by the bride on the night before the wedding to invite heavenly angels to descend

to earth and bless her, making her even more beautiful. The following batik can be used in the Midodareni ceremony:

Figure 20. Batik Truntum

After several pre-wedding rituals, the bride and groom will participate in the Panggih tradition. Panggih is the tradition where the bride and groom meet for the first time after being officially declared married. In this tradition, the bride and groom sit together, witnessed by family and guests (Meidinata & Raharso, 2022). The following batik can be used in the Panggih ceremony:

Figure 21. Batik Semen gunung

Finally, there is the tradition known as Tumbuk Ageng or Congkokan. This tradition is observed by someone upon reaching the age of 64. It is a form of gratitude for the blessing of long life. The following batik can be used in the Tumbuk Ageng or Congkokan ceremony:

Figure 22. Batik Sida Luhur

C. Death

The end of the human life cycle is death. Here, the long series of life processes comes to an end. The following batik can be used in the Death ceremony:

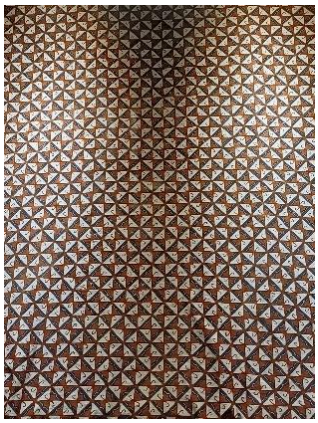


Figure 23. Batik Slobog

Mathematical Model Creation

From the explanation regarding batik and its use in the traditional life cycle of the Javanese people, the series of explanations can be expressed in a set as follows:

A. Batik Motifs

A collection of batik motifs used in the traditional life cycle celebrations of the Javanese people can be represented as the set of batik motifs (M), written as follows: M = {Brangtamangu, Peksi Kurung, Putri Piningit, Semen Sida Asih, Semen Rama, Sida Mukti, Lurik Lasem, Semen Cuwuri, Gringsing Buron Toya, Parang Barong Nagaraja, Kohinur, Cinde Patola, Satriya Manah, Semen Kudha Rante, Grompol, Nitik, Truntum, Semen Gunung, Sida Luhur, Batik Slobog} Mathematically, it can be written as:

$$M = \{X \mid X \text{ a batik motif used in the traditional life cycle celebrations of the Javanese people}\}$$

Figure 24. Illustration of Batik Motif Sets in the Javanese Life Cycle Tradition

B. Traditions

A collection of traditions performed in the life cycle celebrations of the Javanese people can be represented as the set of traditions (T), written as follows: T = {Mitoni, Kopohan, Sunatan, Tetesan, Lamaran, Siraman, Midodareni, Panggih, Congkokan, Kematian} Mathematically, it can be written as:

T = {X | X is a tradition in the life cycle celebrations of the Javanese people}

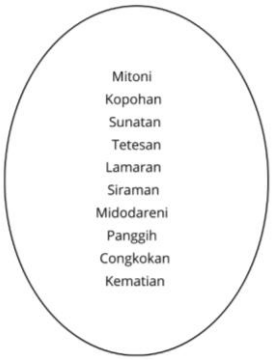


Figure 25. Illustration of Tradition Sets in Javanese Life Cycle Celebrations

C. Life Cycle

The components of the life cycle of the Javanese people can be represented as the set of life cycle stages (D), written as follows: D= { Prenatal dan kelahiran, pertumbuhan dan perkawinan, kematian} Mathematically, it can be written as:

T = {X | X is a part of the life cycle of the Javanese people}

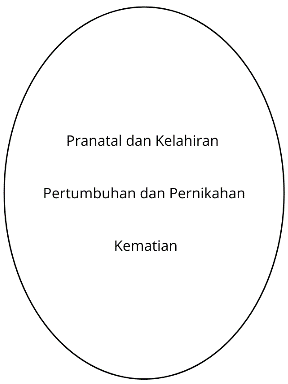


Figure 26. Illustration of Life Cycle Stages in Javanese Society

Forming these groups into a set is justified as they meet the criteria to be considered a set. In mathematics, a set is a collection of clearly defined elements or objects based on specific rules (Fatqurrahman, 2021). The elements are clearly defined in the set of batik names based on the batik patterns presented at the Sonobudoyo Museum. The elements of the set of traditions are clearly defined based on the variety of traditions at the Sonobudoyo Museum. The life cycle stages are clearly defined

based on the rules at the Sonobudoyo Museum. Thus, these three classifications constitute a set. The three sets are interrelated with each other. The nature of these relationships can be expressed as follows:

A. Batik Motifs and Traditions

The diverse batik motifs are used in accordance with the traditions being performed. The relation that can be established between the set of batik motifs and traditions is "Used in." This can be expressed mathematically as follows:

R1 = used in

R1: M → T = {(Brangtamangu, Mitoni), (Peksi Kurung, Mitoni), (Putri Piningit, Mitoni), (Semen Sida Asih, Mitoni), (Semen Rama, Mitoni), (Sida Mukti, Mitoni), (Lurik Lasem, Mitoni), (Semen Cuwuri, Kopohan), (Gringsing Buron Toya, Kopohan), (Parang Barong Nagaraja, Sunatan), (Kohinur, Sunatan) (Cinde Patola, Tetesan), (Satriya Manah, Lamaran), (Semen Kudha Rante, Lamaran), (Grompol, Siraman), (Nitik, Lamaran), (Truntum, Midodareni), (Semen Gunung, Panggih), Sida Luhur, Congkokan), (Batik Slobog, Kematian)}

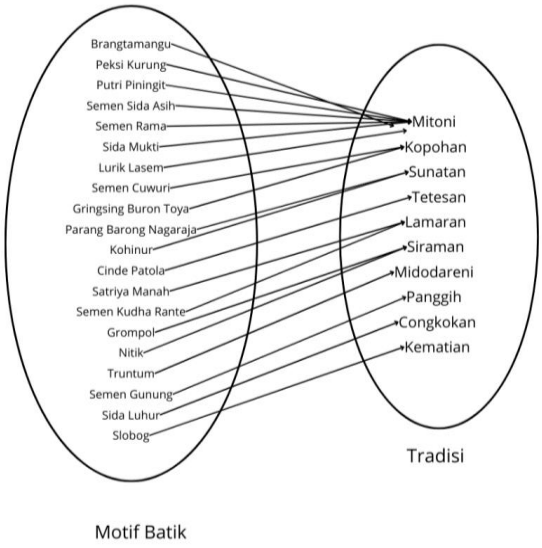


Figure 27. Illustration of the Relationship Between Batik Motifs and Traditions

From this relation, we can observe that each batik motif is used in precisely one tradition. This corresponds with the mathematical definition of a function, a relation that connects each element of one set to exactly one element of another set. Therefore, the relation R1 connecting the set of batik motifs and the set of traditions is a function.

B. Traditions and Life Cycle

Various traditions accompany each stage of the Javanese life cycle. The relation that can be established between the set of traditions and the set of life cycle stages is "Part of." This can be expressed mathematically as follows:

R2 = Part of

r: U → D = {(Mitoni, Prenatal dan kelahiran) (Kopohan, Prenatal dan kelahiran), (Sunatan, pertumbuhan dan perkawinan) (Tetesan, pertumbuhan dan perkawinan), (Lamaran, pertumbuhan dan perkawinan), (Siraman, pertumbuhan dan perkawinan), (Midodareni, pertumbuhan dan perkawinan), (Panggih, pertumbuhan dan perkawinan), (Congkokan, pertumbuhan dan perkawinan), (Kematian, Kematian)

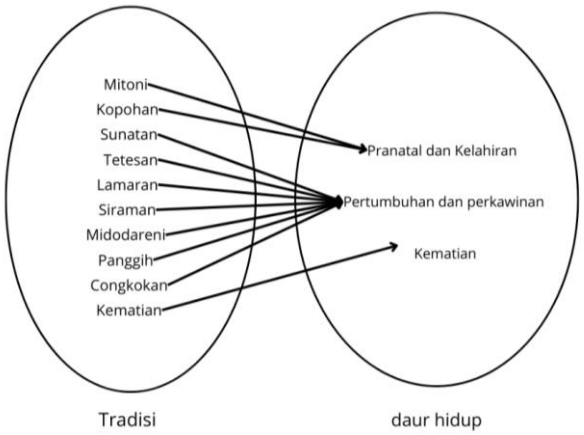


Figure 28. Illustration of the Relationship Between Batik Motifs and Javanese Life Cycle Traditions

From this relation, we can observe that each tradition is part of one specific phase in the life cycle stages. This corresponds with the mathematical definition of a function, a relation that connects each element of one set to exactly one element of another. Therefore, the relation R2 connecting the set of traditions and the set of life cycle stages is a function.

Conclusion

This study has revealed that the Sonobudoyo Museum can serve as an alternative for teaching mathematics by introducing geometric concepts such as flat and solid shapes and geometric transformations derived from the objects and replicas displayed in the museum. In the Javanese life cycle section, concepts of sets, relations, and functions can be derived from batik motifs, traditions, and life cycle phases. The results of this study can be used in mathematics education to make learning more engaging by incorporating real-life elements. Furthermore, the findings of this study have significant implications for mathematics education, particularly in teaching sets, relations, functions, geometry, and geometric transformations. Using the local cultural context of the Sonobudoyo Museum in teaching can help students understand mathematical concepts in a more applied and contextual manner. This

approach can motivate students by relating the subject matter to familiar and valued cultural aspects, thus enhancing their understanding of how mathematics plays a role in everyday life. The study also emphasizes the importance of cultural preservation as part of cultural heritage. By understanding and valuing culture, we can better appreciate and preserve local cultural diversity. Finally, this study highlights the importance of integrating cultural knowledge with mathematics education to provide a more comprehensive insight into the cultural heritage and the application of mathematics in a broader context.

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