



Ethnomathematics: An Exploration of Mathematical Concepts in Yogyakarta's Ox Cart

Ilham Rais Arvianto^{1*}, Abi Fadila², Adi Nurcahyo³, Muhammad Luthfi Farizqi⁴

^{1,4}Universitas Teknologi Digital Indonesia, Indonesia

²Universitas Islam Negeri Raden Intan Lampung, Indonesia

³Universitas Muhammadiyah Surakarta, Indonesia

E-mail*: ir.arvianto@utdi.ac.id

Abstract

Yogyakarta's ox carts, though culturally significant and increasingly rare, have not yet been explored as sources of mathematical concepts. This study addresses the urgency of preserving and utilizing these traditional artefacts as contextual tools for mathematics education. This ethnographic research aims to identify and describe mathematical concepts—geometry, arithmetic, algebra, and statistics—embedded in various parts of the Yogyakarta ox cart. Data were collected through interviews and observations, with the subject being an ox cart craftsman and the object being the mathematical concepts found in the cart's section. Data analysis followed the Miles and Huberman model. The findings reveal four major mathematical concepts: (1) Geometry, including rectangles, trapezoids, rhombuses, triangles, reflections, translations, rotations, parallel and intersecting lines, angles, and tessellations; (2) Arithmetic, involving arithmetic sequences and division operations; (3) Algebra, in the form of variable terms; and (4) Statistics, represented by the mode topic. These findings contribute to the field of ethnomathematics by introducing a new cultural context and supporting the development of mathematical materials based on local wisdom, making learning more realistic. Integrating local heritage into mathematics instruction can foster a deeper understanding, increased student engagement, and a greater appreciation for cultural diversity, offering meaningful and realistic learning experiences.

Kata Kunci: descriptive statistics; ethnography; ox cart; tessellation; transportation



INTRODUCTION

The Special Region of Yogyakarta, or commonly referred to as Yogyakarta, is a province with a special status or special autonomy that is a legacy from before the independence of Indonesia (Santosa, 2016). In Yogyakarta, according to Prahmana and D'Ambrosio (2020a), many distinctive and unique cultural objects and practices are easy to find, explore, and need to be preserved. Because Yogyakarta's culture is also not spared from the threat of extinction (Wahyuningsih & Surbakti, 2018). Therefore, efforts to preserve Yogyakarta's cultural objects and practices need to be encouraged to avoid extinction, one of which is the Yogyakarta ox cart.

The Yogyakarta ox cart is one of the conventional means of transportation whose main source of power comes from the pull of an ox animal (Deskarina & Atiqah, 2020). Based on the results of an interview with a Yogyakarta ox cart craftsman named Gandung (50 years old) at "Karoseri Gerobak Mbah Montil", Sleman, it was found that the uniqueness of the Yogyakarta ox cart lies in the distinctive shape of each of its parts, including *kroso*, *gribik*, *tepongan*, *racuk*, and *manukan*. In addition, the combination of distinctive color patterns consisting of five basic colors, namely black, white, blue, yellow, and red, or what is commonly called *pancawarna*, is also unique to Yogyakarta ox carts.

Information from "Dinas Kebudayaan Kabupaten Sleman" (The Sleman Regency Culture Office) (2020), the Yogyakarta ox cart has been designated by the United Nations Educational, Scientific and Cultural Organization (UNESCO) since 2019 as one of Indonesia's intangible cultural heritages from the Special Region of Yogyakarta Province which is included in the domain of Traditional Craft Skills and Craftsmanship. However, from a survey conducted by Dyanningrat (2018) in Yogyakarta, it was found that 80.6% of respondents were aware of ox carts, but only 38.2% of respondents had ever seen one. From both of these, it becomes important to introduce and preserve the existence of Yogyakarta's ox carts.

Several efforts have been made to preserve Yogyakarta's ox carts. The Sultan of Ngayogyakarta Hadiningrat, as well as the governor of Yogyakarta, Sri Sultan Hamengkubuwana X, participated in supporting efforts to protect Yogyakarta's ox carts (Novitasari, 2021). Currently, the preservation of ox carts is carried out by utilizing them as a means of entertainment in various tourist attractions (Deskarina & Atiqah, 2020). Organizing regular festivals and carnivals is also one of the efforts to preserve ox carts (Novitasari, 2021). In addition, efforts to preserve ox carts are also carried out in the form of designing a book on the historical and philosophical values of Islamic Mataram on Yogyakarta ox carts (Dyanningrat, 2018). Meanwhile, potential efforts that can be made in the field of mathematics education to introduce and preserve culture, one of which is the Yogyakarta ox cart, are using ethnomathematics (Ishartono & Ningtyas, 2021), with the form of studying the mathematical concepts contained in it, so that the findings obtained can be integrated into mathematics learning (Listyowati, Adelia, & Pratini, 2024; Safitri, Latifah, & Angelani, 2022).

The term ethnomathematics was first introduced by Ubiratan D'Ambrosio, a Brazilian educator and mathematician, in 1977 in a presentation at the American Association for the Advancement of Science (Nurcahyo, Ishartono, Pratiwi, & Waluyo, 2024). Ethnomathematics can be defined as the entire knowledge system resulting from the discovery of mathematical concepts in a particular culture (Prahmana & D'Ambrosio, 2020b). Meanwhile, Ishartono and Ningtyas (2021) define ethnomathematics as the study of the reciprocity between culture and mathematics or mathematics education. Furthermore, ethnomathematics aims to make students love math, be motivated, and increase creativity in doing math through culture-based learning (Prahmana, Yuniyanto, Rosa, & Orey, 2021). Students who learn mathematics without ethnomathematics often struggle to understand abstract concepts and relate them to real-life experiences, which can hinder conceptual understanding and reduce learning motivation (Batiibwe, 2024; Rosa & Orey, 2011).

Several studies have been conducted on the exploration of ethnomathematical objects in Yogyakarta. The exploration of objects in the form of buildings, including Tugu Jogja (Febriana, Kurniasih, Setiyaningsih, & Maharani, 2022), the Great Mosque of Mataram Kotagede (Sanyoto, Setiana, & Agustito, 2021), Umbul Binangun in the Taman Sari complex (Putra, Alviyan, Arigiyati, & Kuncoro, 2021), Prambanan Temple (Fitriah et al., 2023), Sambisari Temple (Ardinata, Gulo, & Rudhito, 2024), Gebang Temple (Mahanani, Natalia, & Nugraha, 2023), and Soko Tunggal Mosque

(Putra, Wijayanto, & Widodo, 2020). There is also research on the exploration of batik motifs, including Batik Kawung (Christanti, Sari, & Pramita, 2020; Sa'id, Arfinanti, & Azka, 2021), Batik Kayu Krebet Bantul (Abdullah & Rahmawati, 2021), Batik Parang (Nugroho & Sugiman, 2024), and Yogyakarta batik patterns (Prahmana & D'Ambrosio, 2020b). In addition, there are also ethnomathematical explorations of Malioboro spinning game objects (Sintauri, Puspitasari, & Noviyanti, 2020), saron musical instruments (Cahyanti, Kurniawan, Kristanto, & Kurniawan, 2024), and traditional Ngasem Market snacks (Setiadi, 2025). Meanwhile, Setiana, Ayuningtyas, Wijayanto, and Kusumaningrum (2021) researched the ethnomathematics object of the Yogyakarta Kraton Train. However, there is no research that explores the existence of mathematical concepts in Yogyakarta's ox carts. Therefore, this research is important to consider because it contributes to introducing and preserving the existence of Yogyakarta ox carts to all students through mathematics learning. The results of the exploration of mathematical concepts are expected to help teachers convey mathematics more realistically and contextually.

Based on this description, the researcher wants to explore the mathematical concepts contained in the Yogyakarta ox cart. Therefore, this study aims to examine the process of identifying and describing the mathematical concepts—geometry, arithmetic, algebra, and statistics—embedded in various parts of the Yogyakarta ox cart. The results of this study, one of which is expected to be used by teachers as a context and medium for learning mathematics, are thus likely to make mathematics learning more realistic and contextual. In addition, contextualized math learning will help students be more familiar with Yogyakarta's ox carts, so that they can participate in preserving their existence.

METHOD

This qualitative research, which explores mathematical concepts in Yogyakarta ox carts, employs ethnographic methods. Referring to Shirly and Palhares (2016), the reason for choosing the ethnographic method is that it is based on the objectives of ethnomathematics, which examines the concepts, strategies, and techniques of a culture from the original perspective of its members (Prahmana et al., 2021).

Table 1. Research Design

General Questions	Initial Answer	Starting Point	Specific Activity
Where to start looking?	Analyze the location to obtain information about Yogyakarta's ox carts	Culture	Conducting interviews with people who know related information, namely, Yogyakarta ox cart artisans.
How to look for it?	Investigating Yogyakarta's ox carts firsthand	Alternative thinking	Observing and initial analysis of whether there are mathematical concepts embedded in the parts of the ox carts
How to ensure that what is obtained is something significant?	Evidence in a specific section of the ox carts, which embeds mathematical concepts	Mathematical philosophy	(1) Identify whether there are mathematical concepts embedded in the parts of Yogyakarta's ox carts, and (2) Find mathematical concepts embedded in the parts of Yogyakarta's ox carts.
How to understand what has been found	Mathematical significance by an expert's validation	Anthropological methods	(1) Validate the mathematical concepts found in Yogyakarta's ox carts by experts, and (2) Describe the connectedness that occurs between culture and mathematical knowledge

This research design adapts four general questions that are at the core of ethnographic research, namely “Where to start looking?”, “How to look for it?”, “How to ensure that what is obtained is something significant?”, and “How to understand what has been found?” (Prahmana & D'Ambrosio, 2020b). The four questions are then compiled into a research design that can be seen in Table 1.

This research was conducted at “Karoseri Gerobak Mbah Montil,” Yogyakarta, in March 2025. The subject of this research is an ox cart craftsman who possesses deep cultural and technical knowledge related to the construction of the Yogyakarta ox cart. Meanwhile, the object of this research is the mathematical concept embedded in various parts of the ox cart. Specifically, the exploration is limited to five typical parts of the Yogyakarta ox cart that Gandung had mentioned in the interview in the introduction: *kroso*, *gribik*, *tepongan*, *racuk*, and *manukan*. The classification of mathematical concepts in this study is based on the four main branches of mathematics, according to Rubenstein and Schwartz (1999) namely geometry, algebra, arithmetic, and statistics (Ishartono & Ningtyas, 2021). These four branches serve as the conceptual framework for grouping findings of the exploration into relevant mathematical domains identified in the Yogyakarta ox cart.

The type of data in this research is qualitative, comprising observation data, interview data, and documentary data. The data collection technique used is the observation technique, which involves observing the forms and mathematical concepts found in Yogyakarta's ox carts. Furthermore, semi-structured interview techniques were used to strengthen the observation data with the ox cart craftsmen as well as two experts. The selection of only two experts—one academic and one practitioner—was based on purposive sampling, as both individuals possess substantial experience in mathematics education and are directly relevant to the research context. In qualitative research, particularly with source triangulation, depth of insight is prioritized over quantity, and two experts are deemed sufficient to validate the findings (Creswell & Creswell, 2018; Sugiyono, 2013). Finally, documentation techniques were used to document the interview process and the observed cart parts.

The research instruments consisted of the researcher himself as the key instrument (Creswell & Creswell, 2018), two semi-structured interview guidelines, and one observation guideline. The observation guideline is presented in the form of a table, consisting of six columns: the name of the cart part, a description of the cart part, a picture of the cart part, math topics, math sub-concepts, and math concepts. The first interview guideline for the ox cart crafters consisted of four indicators: historical, cognitive, conceptual, and educational. Meanwhile, the second interview guideline for two expert resource persons consisted of two points by adapting Ishartono and Ningtyas' (2021) research instrument with adjustments to the object of research into Yogyakarta ox carts. Before use, the three draft instruments were validated by two mathematics academics with master's degrees, then tested for validity using Aiken's Value validity test (Retnawati, 2016). From the results of content validity index (CVI) testing, the average value of all items was 0.92, indicating high validity for use in this study.

The data analysis technique in this study uses the Miles and Huberman model, which consists of three stages: data reduction, data presentation, and conclusion drawing (Sugiyono, 2013). In the data reduction stage, the researchers selected and categorized relevant information obtained from interviews and observations, particularly those related to mathematical elements of the Yogyakarta ox cart. During the presentation stage, the data were organized into tables and descriptive narratives to illustrate the relationship between each part of the ox cart and the mathematical concepts identified. In the conclusion-drawing stage, the researchers interpreted patterns and regularities within the data to formulate a conclusion about the presence of geometry, arithmetic, algebra, and statistics in the structure and decoration of the ox cart. Finally, a credibility test was conducted to confirm the validity of the research findings using the source triangulation, involving two experts: one mathematics academic with a master's degree and one mathematics practitioner with a bachelor's degree.

RESULTS

Where to start looking?

This study began with the researcher seeking information on the location where the Yogyakarta ox cart can be found. From the search results, the researcher obtained information that Yogyakarta ox carts can be found in one of the pioneers of craftsmen workshops located in Ngangsiran – Madurejo Village, Prambanan District, Sleman Regency, Yogyakarta Special Region Province, called “Karoseri Gerobak Mbah Montil”. At the workshop, the researcher then interviewed with the resource person, one of the owners, as well as a cart craftsman named Gandung, as shown in Figure 1. The researcher has also obtained approval from the resource person to publish the results of this research.



Figure 1. Interview Process at Karoseri Gerobak Mbah Montil

Figure 1 shows the researcher conducting an interview with Gandung. The interview took place on-site—Karoseri Gerobak Mbah Montil, allowing the researchers to gather contextual information about the cart's construction, symbolism, and functional details. The researcher also posed questions related to the historical, cognitive, conceptual, and educational aspects of the ox cart.

During the interview, the researcher asked questions such as: “*What was the original function of the ox cart in the past?*”, “*How has the use of the ox cart changed over time?*”, and “*What efforts are made by the community to preserve its existence?*”. In response, the interviews revealed that ox carts were once the primary means of transportation for farmers to transport crops. However, due to its decreasing number, it now functions as a means of entertainment and tourism. In addition to maintaining its sustainability, the community regularly holds festivals and carnivals, involving several *bajingan* (a term for ox cart drivers) from each region. “Makarti Roso Manunggal” is one of Yogyakarta's active ox cart communities.

Based on the interviews, two unique features of Yogyakarta's ox carts were also obtained (see Figure 2). To explore this, the researcher asked questions such as: “*Are there any unique features that distinguish Yogyakarta's ox carts from others?*”. The respondent described a distinctive combination of typical color patterns called *pancawarna*, which consists of five basic colors: black, white, blue, yellow, and red. These colors are traditionally symbolic and are used consistently in the decoration of the cart.



Figure 2. Yogyakarta ox cart and its Parts (Dinas Kebudayaan Kabupaten Sleman, 2020)

The researcher further asked: “Can you explain the functions of the different parts of the ox cart?” The craftsman explained five unique structural elements, known as *kroso*, *gribik*, *tepongan*, *racuk*, and *manukan*. In Figure 2, *kroso* is located on the upper right and left sides of the ox cart body which functions as protection for the inside of the cart from rain. Below it is the *gribik*, which functions as a side support/protection (load safety). *Tepongan* functions like a *gribik* located at the back. The *racuk* extends from the front of the body to the leading edge of the cart which serves to shoulder/lift the cart and also serves as a protection for the front of the ox. Finally, the *manukan* is a slanted wooden stick positioned behind the *racuk*, serving as a protective or holding tool for the *bajingan*.

How to look for it?

After the interview, the research continued by following the procedure in Table 1, namely observing the existence of mathematical concepts in the five parts of the Yogyakarta ox cart. Then, four researchers analyzed the relationship between the five parts of a typical Yogyakarta ox cart and the four mathematical concepts that had been determined. A summary of the researcher's initial analysis and observations is presented in Table 2.

Table 2. Initial Mathematical Analysis of Concepts by Researchers

Concept	Sub-concepts	Topic
Geometry	Flat shapes	Rectangle; Trapezoid; Rhombuse; Triangle
	Transformation geometry	Reflection; Translation; Rotation
	The relationship between the two lines	Parallel; Intersecting; Angle
	Patterns and repetition	Tesellation/tiling
Arithmetic	Number patterns	Arithmetic rows
	Number operations	Division operations
Algebra	Algebraic terms	Variables
Statistics	Descriptive statistics	Mode

Based on Table 2, we can observe the initial presence of four predetermined mathematical concepts in the Yogyakarta ox cart section. Of the four predetermined mathematical concepts, all are found in the Yogyakarta ox cart section. The existence of geometry concepts in Yogyakarta's ox carts includes four sub-concepts: flat shapes covering the topics of rectangles, trapeziums, rhombuses, and triangles; transformation geometry covering the topics of mirroring, shifting, and rotation; the relationship between two lines covering the topics of alignment, intersection, and angles; and patterns and repetition with the topic of correlation. Meanwhile, the arithmetic concept encompasses two sub-concepts: number patterns, which relate to the topic of arithmetic sequences, and number operations, which involve division operations. Furthermore, the existence of algebraic concepts that consist of sub-concepts of algebraic terms with the topic of variables. Finally, the concept of statistics encompasses sub-concepts, including descriptive statistics, with a focus on the topic of mode.

The classification of mathematical topics into sub-concepts and main concepts in this study is based on the researcher's initial analysis of the mathematical characteristics identified in the cultural object. This categorization is preliminary and will be further validated through expert judgment to ensure its accuracy and relevance.

How to ensure that what is obtained is something significant?

Based on the results of the researcher's analysis in Table 2, the geometry concepts found in the Yogyakarta ox cart section include four sub-concepts: flat shapes, transformation geometry, the relationship between two lines, and tests. Furthermore, in each of these sub-concepts, related topics were also found.

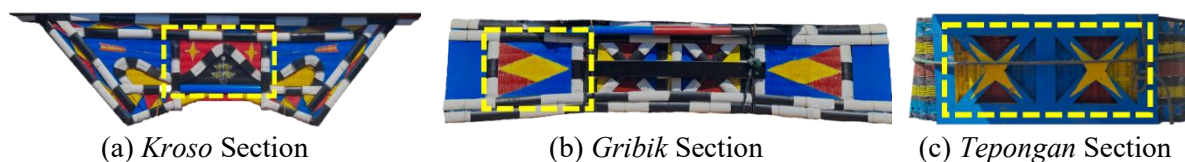


Figure 3. Illustration of Rectangle

Rectangular shapes can be identified in several sections of the Yogyakarta ox cart, namely in the *kroso*—upper side cover (see Figure 3(a)), *gribik*—lower side cover (see Figure 3(b)), and *tepongan*—back cover (see Figure 3(c)). These rectangular shapes are highlighted with yellow illustration lines. In the sub-concept of flat shapes, a rectangle is defined as a polygon with two pairs of parallel and equal-

length sides and four right angles (Sari, Fredy, & Sabono, 2023). The rectangles in the *kroso* and *gribik* sections are formed by the arrangement of bamboo wooden ornaments known as *gapit*, decorated in black and white patterns. Meanwhile, the rectangle on the *tepongan* section is formed by a distinct blue wooden frame.

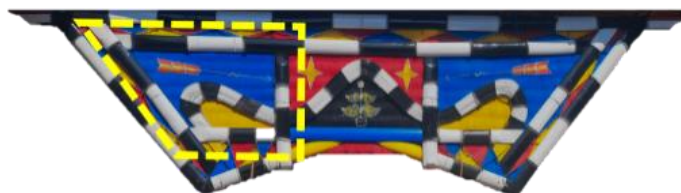


Figure 4. Illustration of Trapezoid on *Kroso* Section

Figure 4 displays the presence of trapezoidal shapes located in the *kroso* section of the Yogyakarta ox cart, highlighted with yellow illustration lines. Following the identification of rectangles in the previous components, this finding also falls under the sub-concept of four-sided flat shapes, specifically the topic of trapezoids. A trapezoid is defined as a quadrilateral that has exactly one pair of parallel sides facing each other, but with unequal lengths (Putra et al., 2020; Yuningsih, Nursupriana, & Manfaat, 2021). In the *kroso* section, the sides of the trapezoid are formed from the arrangement of *gapit*, decorative bamboo elements arranged in a slanted formation.



Figure 5. Illustration of Rhombus on *Gribik* Section

Figure 5 highlights the presence of rhombus shapes found in the *gribik* section of the Yogyakarta ox cart, indicated by yellow illustration lines. In addition to rectangles and trapezoids, this finding also belongs to the sub-concept of four-sided flat shapes, specifically the topic of a rhombus. A rhombus is defined as a quadrilateral in which all four sides are equal in length and has two pairs of opposite, non-right angles (Putra et al., 2020; Yuningsih et al., 2021). Furthermore, according to Putra et al. (Putra et al., 2020), the diagonals of a rhombus intersect perpendicularly. The rhombus shape in the *gribik* section is formed through a decorative motif in yellow, contributing to both the aesthetic and structural elements of the cart.



Figure 6. Illustration of Triangle

Triangular shapes can be found in the *gribik* (see Figure 6(a)) and *tepongan* (see Figure 6(b)) sections of the Yogyakarta ox cart, highlighted with yellow illustration lines. Continuing the exploration of flat shapes, the topic of triangles—a polygon with three straight sides whose ends meet to form angles (Ishartono & Ningtyas, 2021; Putra et al., 2020)—is also identified in this traditional vehicle. In the *gribik* section, triangles appear in distinctive blue, red, or combined ornamental patterns, as well as in the structure of the *gapit*. Meanwhile, in the *tepongan* section, triangle shapes are formed by the design of the blue wooden frame. These findings further emphasize the integration of geometric principles in the artistic and structural design of the ox cart.

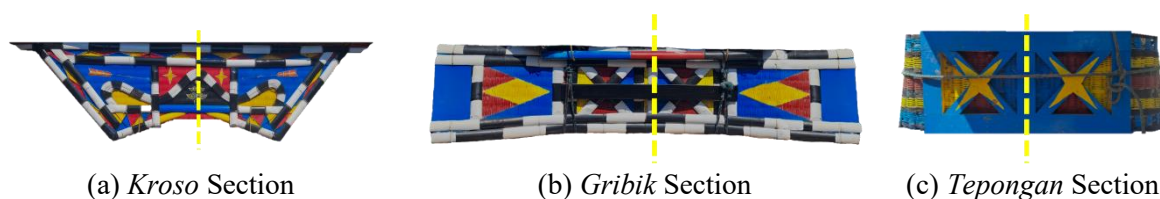


Figure 7. Illustration of Reflection

The topic of reflection found in the *kroso* (see Figure 7(a)), *gribik* (see Figure 7(b)), and *tepongan* (see Figure 7(c)) sections of the Yogyakarta ox cart, with yellow lines illustrating the axes of symmetry. Beyond the identification of two-dimensional shapes, another sub-concept of geometry found in the ox cart is transformation geometry, particularly the topic of reflection. According to Roebyanto (2014) reflection is defined as the movement of an object such that each point and its image are equidistant from a central axis or mirror line (Hada, Maulida, Dewi, Dewanti, & Surur, 2021). If an imaginary vertical line is drawn precisely in the middle of the *kroso* (Figure 7(a)), *gribik* (Figure 7(b)), and *tepongan* (Figure 7(c)), it functions as the axis symmetry that divides each part into two equal and mirror-reflected sides. To visualize this reflection using Cartesian coordinates, we can assume the symmetry axis as the y -axis ($x = 0$), with each point (x,y) on one side reflected to the opposite point $(-x,y)$ in the other side. This symmetry is a visual representation of reflection, embedded within the traditional design structure of the ox cart.

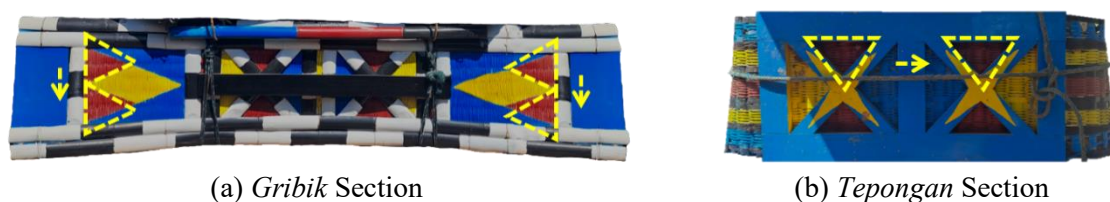


Figure 8. Illustration of Translation

The topic of translation identified in the *gribik* (see Figure 8(a)) and *tepongan* (see Figure 8(b)) sections of the Yogyakarta ox cart. The figure illustrates a shift in the position of ornamental patterns, indicated by arrows, where the size and shape of the motifs remain unchanged. Continuing the exploration of transformation geometry, this finding highlights the topic of translation, which is defined as a change in the position of an object without altering its size or shape (Hada et al., 2021). In the context of Cartesian coordinates, this transformation can be modeled by moving each point (x,y) on the motif to a new position $(x + a, y + b)$, where a and b represent the horizontal and vertical shift, respectively. In both the *gribik* and *tepongan* sections, similar decorative elements appear repeatedly in aligned directions, visually representing translational motion in the cart's design.



Figure 9. Illustration of Rotation

The topic of rotation found in the *gribik* (see Figure 9(a)) and *tepongan* (see Figure 9(b)) sections of the Yogyakarta ox cart, with directional arrows and labeled points (A and B), illustrates the centers of rotation. Building upon the previous exploration of transformation geometry, the next identified topic is rotation, which refers to a transformation resulting from turning a point around a specific center on a plane (Hada et al., 2021). In the *gribik* section (Figure 9(a)), rotation is observed in the blue triangular ornament, where the center of rotation lies at the midpoint of the *gribik* surface (point A), and the direction of rotation follows the indicated arrow. Similarly, in the *tepongan* section (Figure 9(b)), the

wooden frame on the ledge exhibits rotational symmetry, with its center point (point B) serving as the pivot, and the empty triangular space formed by the intersecting wooden frame acting as the rotating object. Mathematically, in a Cartesian coordinate system, rotation can be visualized by transforming a point (x,y) around a center (h,k) using a specific angle, producing (x',y') following the rotation matrix. This interpretation helps in clearly modeling the rotational motion observed in both ox cart sections.

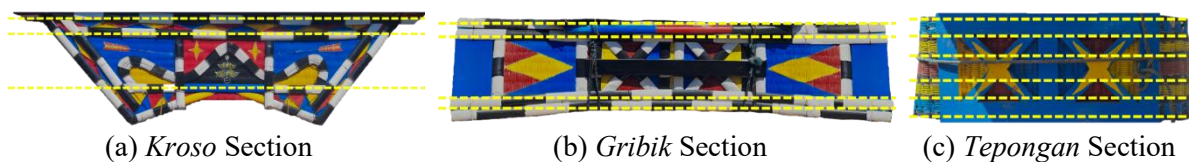


Figure 10. Illustration of Parallel Lines

The illustration of the presence of parallel lines in the Yogyakarta ox cart is shown in Figure 10(a) for the *kroso* section, Figure 10(b) for the *gribik* section, and Figure 10(c) for the *tepongan*. The yellow illustration lines highlight sets of lines that lie on the same plane and do not intersect, even when extended. Following the exploration of transformation geometry, this finding shifts to the sub-concept of the relationship between two lines, specifically the topic of parallel lines. Two lines are considered parallel if they lie in one plane and have no common point (Bili et al., 2019; Dasmasea, Urath, & Nifanngelyau, 2021). Furthermore, Ardian and Suparni (2023) explain that parallel lines do not intersect, even when extended infinitely. These lines are evident in the *gapit* ornaments of the *gribik* and *kroso* sections, as well as in the black borders of the colorful ornaments in the *tepongan* section.

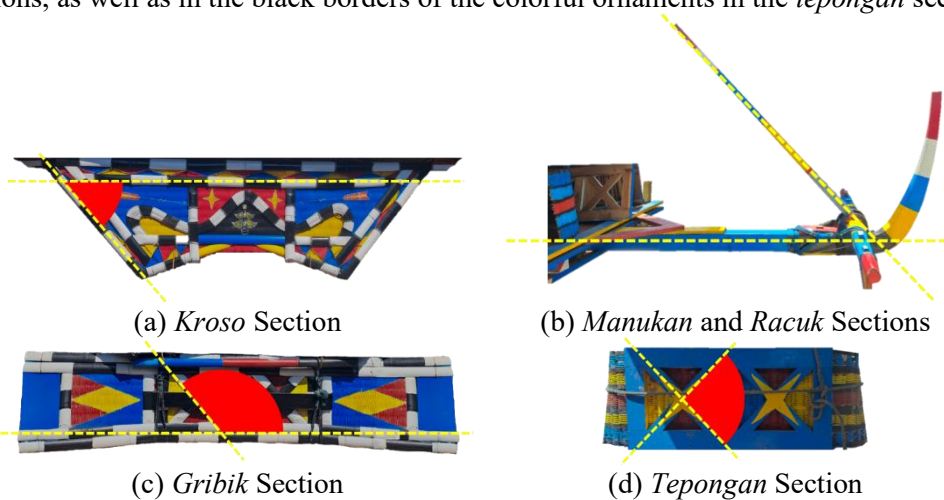


Figure 11. Illustration of Intersecting Lines and Angles

The illustration of the presence of intersecting lines in the Yogyakarta ox cart is shown in Figure 11(a) for the *kroso* section, in Figure 11(b) for the *manukan* and *racuk* sections, Figure 11(c) for the *gribik* section, and Figure 11(d) for the *tepongan* section. The intersecting points are highlighted with yellow lines to emphasize where two lines meet in a single plane. Continuing the sub-concept of the relationship between two lines, this finding focuses on the topic of intersecting lines. Two distinct lines are said to be intersecting if and only if they lie on the same plane and meet at exactly one point (Ardian & Suparni, 2023; Dasmasea et al., 2021). In the *kroso* and *gribik* sections, intersecting lines appear in the structure of the *gapit*. In the *tepongan* section, they are found at the crossing points between slats of the blue wooden frame. Similarly, the *manukan* section displays intersecting lines at the joint where it meets the *racuk*.

From the topic of two intersecting lines, the topic of angles emerged as part of the line position sub-concept. An angle is defined as the area bounded by two line segments or line rays that meet at a meeting point called an angle point (Nuraeni, Uswatun, & Nurasiah, 2020; Nurpratiwiningsih, Kurniawan, Indriyani, & Purwanti, 2021). There are three types of angles, namely acute, right, and obtuse (Fitriani, 2022). Just like the topic of intersecting lines, this angle topic is found in the *gribik*, *kroso*, *tepongan*, *manukan*, and *racuk* sections. Most of the angles found in these sections are acute and

right angles, formed through the intersections of structural or ornamental elements. However, there is no specific numerical measurement of the angles, as they are not standardized in the traditional fabrication of the ox cart. An illustration of the angular topic in this section of the ox cart can be seen in Figure 11(a), Figure 11(b), Figure 11(c), and Figure 11(d), highlighted in red between the intersecting yellow lines.

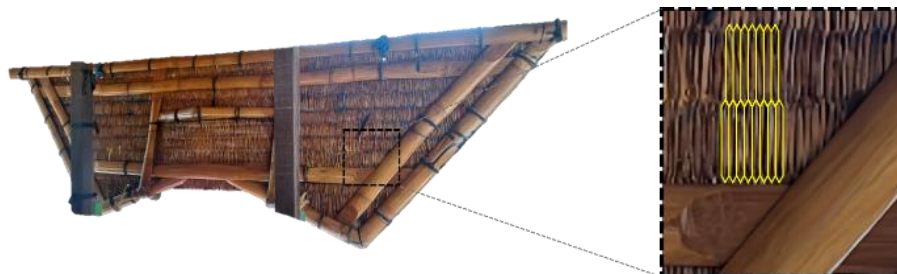


Figure 12. Illustration of Tessellation on the Inner Side of the *Kroso* Section

Figure 12 highlights the presence of tessellation patterns on the inner side of the *kroso* section of the Yogyakarta ox cart, formed by a combination of elongated hexagon shapes. These tessellations are highlighted with yellow illustration shapes. Expanding beyond geometric shapes and line relationships, this finding enters the sub-concept of pattern and repetition, specifically the topic of tessellation or tiling. Tessellation refers to a layered arrangement of polygonal shapes of the same size and form, covering a surface without gaps or overlaps (Parker, 2003). In the *kroso*, *gribik*, and *tepongan* sections, this regular and aesthetic pattern emerges from the woven bamboo used as the primary construction material. The tessellation is most clearly visible from the inner side of these parts, revealing the craftsmen's mastery in blending functionality with geometric precision.

Based on the researcher's analysis in Table 2, the mathematical concepts found in the Yogyakarta ox cart include not only geometry but also arithmetic. In the arithmetic domain, two sub-concepts were identified: number patterns, specifically arithmetic sequences, and number operations, particularly the topic of division.

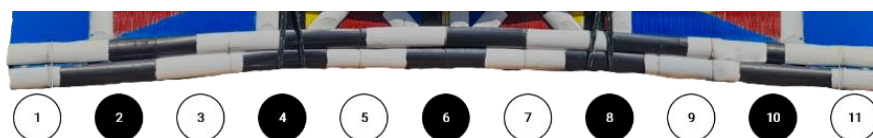


Figure 13. Illustration of an Arithmetic Sequence at *Gapit* in *Gribik* Section

Figure 13 displays the arrangement of *gapit* (black and white wooden ornaments) on the *kroso* and *gribik* sections of the Yogyakarta ox cart, which reveals a number pattern forming an arithmetic sequence. Continuing the discussion on patterns, this finding falls under the sub-concept of number patterns, specifically the topic of arithmetic sequences. An arithmetic sequence is defined as a sequence in which each term is obtained by adding a constant number to the previous term (Abidin & Tohir, 2019; Nurcahyo et al., 2024). In the visual arrangement shown, the white ornaments follow a pattern of 1, 3, 5, 7, and so on—indicating a constant difference of 2 between terms. This sequence can be modeled by the arithmetic formula $U_n = 2n + 1$, where each term increases consistently and predictably.

Figure 13 also shows that the black color in the *kroso* and *gribik* wood ornaments also has a pattern that forms an arithmetic sequence, namely 2, 4, 6, 8, and so on. The new term is obtained from adding 2 to the previous term. Therefore, if the sequence is continued, then after eight terms, there are 10 terms. From this, if an arithmetic sequence equation is formed with the difference of each term being 2, then the n th term of the sequence can be formulated as $U_n = 2n$.

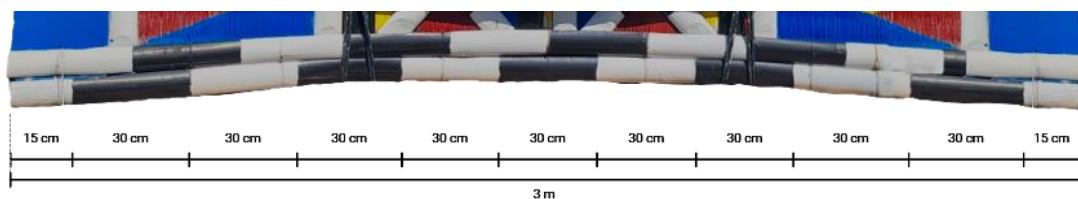


Figure 14. Illustration of Division Operation at *Gapit* in *Gribik* Section

Figure 14 illustrates the application of division in determining the size and proportion of colored segments on various parts of the Yogyakarta ox cart, particularly in the *gribik*, *kroso*, *racuk*, and *manukan* sections. Building upon the previous exploration of number patterns, this finding extends to the sub-concept of number operations, specifically focusing on the topic of division. Division is one of the four fundamental arithmetic operations, alongside addition, subtraction, and multiplication (Muyassar & Harahap, 2020). In this context, division is used to calculate the length of color segments on the *gapit* ornaments. For example, the total length of the *gribik* (3 meters) is divided into 10 equal segments, resulting in each black or white segment being 30 cm long. The segment at the end is designed to be half the length of the center segment, producing a 15 cm length. Similar principles of proportional division are also applied to more complex color arrangements found in the *racuk* and *manukan* sections.

In addition to geometry and arithmetic, the analysis in Table 2 also reveals the presence of algebraic concepts in the Yogyakarta ox cart, particularly in the topic of variables in the sub-concept of algebraic terms. It has been previously stated that there are findings on the color patterns of the *kroso* and *gribik* parts of the ox cart that form an arithmetic sequence. Furthermore, the members of the sequence are commonly referred to as tribes, and the location of the sequence is expressed in the variable n . In general, to express the n th term, it is symbolized in the form U_n (Abidin & Tohir, 2019). For example, with $n = 1$, the symbol U_1 is obtained, which represents the first term in the sequence. From this, it can be seen that algebraic terms, namely variables, are found in this study.

The final finding in this study (see Table 2) is the topic mode in the descriptive statistics sub-concept in the *gribik*, *kroso*, *racuk*, *tepongan*, and *manukan* sections. Descriptive statistics is defined as a method of collecting, describing, processing, analyzing, and interpreting numbers by giving interpretations (Arvianto & Bhikuning, 2022; Silvia, 2020). Based on Pratikno et al. (2020), mode is one of the measures of data centering in descriptive statistics besides the mean and median. Furthermore, mode is defined as the value that appears most often or has the highest frequency in a data (Pratikno et al., 2020). In the context of Yogyakarta's ox carts, mode can be used to express the most significant number of color segments in the ox cart section. For example, if the number of segments of each color in the *kroso* section is calculated, the data shows that 43 segments are white, 41 segments are black, 19 segments are blue, 18 segments are yellow, and 17 segments are red. Therefore, the mode of the data is the color white, with the most significant number of segments, which is 43.

How to understand what has been found?

Based on the results of observation and identification, it was found that there are mathematical topics and sub-concepts in the *gribik*, *kroso*, *racuk*, *tepongan*, and *manukan* parts of the Yogyakarta ox cart. Furthermore, the findings were grouped into mathematical concepts based on the four leading branches of mathematics, according to Rubenstein and Schwartz (1999) consisting of geometry, algebra, arithmetic, and statistics (Ishartono & Ningtyas, 2021). The results of the grouping of these findings can be seen in Table 2.

Based on these findings, a credibility test was conducted to confirm the results using the source triangulation method. Source triangulation for credibility testing is done by checking the data obtained through several sources (Sugiyono, 2013). Previously, experts were asked to identify the presence of geometry, arithmetic, algebraic, and statistical concepts in the Yogyakarta ox cart. Then a comparison was made of the findings of the researchers with the views of the experts, as in Table 2. If there is consistency between the researcher's findings and the expert's point of view, then it is said that the findings are valid. Furthermore, the experts were also asked to provide recommendations for suitable mathematics learning materials to be used or developed from the research findings.

In Table 2, the findings of geometry concepts are valid. The researcher, together with two expert consultants, comprising an academic and a practitioner, stated the presence of geometric concepts in the parts of the Yogyakarta ox cart. Because it has a variety of geometric shapes in its ornaments, the experts recommended the Yogyakarta ox cart as an alternative ethnomathematics object that can be integrated into learning. Furthermore, the expert stated that one form of integration involved developing teaching materials on flat building materials.

Furthermore, both experts share the researcher's view regarding the existence of arithmetic concepts in the Yogyakarta ox cart section. This indicates that the research findings on the arithmetic concept are valid. The experts also recommended the Yogyakarta ox cart as an alternative ethnomathematics object that can be integrated into mathematics learning, one of which is in the form of developing teaching materials and student worksheets on number operations or pattern materials.

The subsequent finding that was declared valid was the presence of algebraic concepts. Researchers and experts consistently stated that there is an algebraic concept in the Yogyakarta ox cart section, especially in the sub-concept of algebraic terms. In line with this, the experts recommended utilizing the ethnomathematical elements of the Yogyakarta ox cart as an alternative context for teaching mathematical topics such as relations and functions. The presence of variable concepts in the ornamentation and structure of the cart can be integrated into mathematics learning through the development of learning media, such as educational videos and student worksheets.

The last finding in the Yogyakarta ox cart section, which was declared valid, is the existence of the concept of statistics. Furthermore, the two experts also provided recommendations that the Yogyakarta ox cart as an ethnomathematics object can be used as one of the contexts for mathematics learning related to the sub-concept of descriptive statistics, taken from the data on the number of each color in each part.

DISCUSSION

This research, which explores the mathematical concepts embedded in Yogyakarta ox carts using the ethnomathematics method, has produced several findings regarding mathematical sub-concepts contained in the kroso, gibik, tepongan, racuk, and *manukan* sections. The sub-concepts are flat shapes, transformation geometry, relationship between two lines, angles, patterns and repetition, number patterns, number operations, algebraic terms, and descriptive statistics.

Before interpreting the findings, several methodological limitations arise from this research. These limitations include the relatively short duration of the study and the small number of ox cart parts explored. As a result, there may still be unidentified mathematical sub-concepts and topics from the Yogyakarta ox cart parts. However, the strength of this study lies in the uniqueness of the ethnomathematics object explored, the Yogyakarta ox cart. UNESCO has designated this ethnomathematics object as an intangible cultural heritage of Indonesia (Dinas Kebudayaan Kabupaten Sleman, 2020) and needs to be preserved because it is rarely found.

This study identified various geometric concepts embedded in the design of the Yogyakarta ox cart, including sub-concepts of flat shapes, transformation geometry, line relationships, and patterns. In the sub-concept of flat shapes, the topics of rectangles, trapezoids, rhombuses, and triangles were discovered. These findings resonate with earlier ethnomathematics studies conducted in Yogyakarta, such as in the Soko Tunggal Mosque, Tugu Jogja, Kraton Carriage Museum, Sambisari Temple, and traditional artifacts like saron instruments and Ngasem Market snacks (Ardinata et al., 2024; Febriana et al., 2022; Putra et al., 2020; Setiadi, 2025). Similarly, findings in transformation geometry, which include reflection, translation, and rotation, are also consistent with studies on Gebang Temple, bamboo weaving, Kawung batik, Prambanan Temple, and Krebet wood batik (Abdullah & Rahmawati, 2021; Christanti et al., 2020; Mahanani et al., 2023). In terms of line relationships, the presence of parallel and intersecting lines, as well as angles, in the ox cart's structure also reflects previous studies on Umbul Binangun (Taman Sari), batik motifs, and cultural processions like Arak Jodhang (Faizah & Suparni, 2023; Putra et al., 2021). Finally, the topic of tessellation, evident in the cart's woven structure, parallels the tessellation patterns identified in the Kraton Carriage Museum (Setiana et al., 2021). These similarities affirm the consistency of mathematical ideas within Javanese cultural artifacts and

emphasize the potential of integrating such findings into mathematics learning that is contextual, meaningful, and culturally grounded.

In addition to geometric concepts, this study also identified arithmetic concepts embedded in the decorative elements of the Yogyakarta ox cart. The first is the sub-concept of number patterns, specifically the topic of arithmetic sequences, which is evident in the repeating pattern of black and white ornaments (*gapit*) on the *kroso* and *gribik* sections. This finding aligns with previous ethnomathematics studies in Yogyakarta that also revealed arithmetic sequences in Kawung batik patterns (Safitri et al., 2022) and in the structure of saron musical instruments (Cahyanti et al., 2024). Furthermore, this study contributes a novel finding in the sub-concept of number operations, namely the topic of division, which is reflected in the proportional segmentation of ornaments along the ox cart body. While no prior studies in Yogyakarta have reported the presence of division operations in cultural objects, this topic has been explored in ethnomathematics studies in other regions, such as the traditional games of gobak sodor in Java (Imaniyah & Zuroida, 2020), kemprengh in East Java (Susanti, 2020), and wayang umbul cards in Madura (Hasanah, Basri, Muplihah, & Ramadhani, 2024). These findings highlight the arithmetic dimension of ethnomathematics that emerges not only in play and musical traditions but also in craftsmanship, thereby enriching the repertoire of culturally based mathematical contexts for learning.

This study also uncovered algebraic concepts embedded in the structure of the Yogyakarta ox cart, specifically in the sub-concept of algebraic terms with the topic of variables. The presence of variable concepts is illustrated through the symbolic generalization of color segment lengths and decorative patterns, which can be represented algebraically. These findings are consistent with an ethnomathematics study in Yogyakarta by Nugroho and Sugiman (2024), who explored algebraic concepts through Batik Parang motifs. Although research on algebraic representations in Yogyakarta cultural objects remains limited, similar findings outside the region have been reported, such as in the calendar system of the Baduy community (Putri & Pujiastuti, 2022) and the jenang-making process in Kudus, which involves ratio-based calculations and variable quantities (Masduki & Malasari, 2023) alignment reinforces the idea that algebraic thinking is culturally embedded and can be introduced meaningfully through local artifacts in mathematics education.

This study also revealed a statistical concept embedded in the Yogyakarta ox cart, specifically in the sub-concept of descriptive statistics through the topic of mode. The mode is evident in the frequent use of specific decorative elements—such as color patterns, shapes, or ornamental arrangements—that appear most commonly across different parts of the cart, particularly in the *gapit* ornament patterns on the *gribik* and *kroso*. These repeated elements represent the most frequently occurring values, aligning with the statistical definition of mode. A similar integration of descriptive statistics in cultural contexts was also found in the ethnomathematics study by Sintauri et al. (2020), which explored the spinning top game sold at Malioboro, Yogyakarta. Their study employed statistical analysis, calculating the mean and standard deviation from repeated trials of top spinning durations. These parallels demonstrate that statistical thinking—like other mathematical domains—can emerge naturally from cultural artifacts and traditional games, offering relevant entry points for contextualized learning in mathematics education.

In addition, the findings of this research, which comprise several sub-concepts categorized into four mathematical concepts contained in the ethnomathematics of Yogyakarta ox carts, can be utilized by teachers as a context and medium for mathematics learning. This supports prior studies, such as Wulandari, Hakim & Kasyadi (2024) and Agustino (2024) which emphasized the potential of ethnomathematics as a meaningful and culturally relevant teaching tool. Such contextual and realistic learning is expected to improve students' understanding while also fostering awareness and preservation of the cultural heritage of ox carts in Yogyakarta. All mathematical concepts identified in this study have been validated by experts, reinforcing their relevance for learning. This supports Setiana et al. (2021), who emphasized the potential of ethnomathematical findings to be integrated into instructional materials. Similar efforts have been carried out through the development of teaching materials (Ardinata et al., 2024), student activity sheets (Astuti, Jana, & Marsiyam, 2022), learning videos (Shalsabila & Loviana, 2024), and e-worksheets (Pangestuti, Sulistyaningsih, & Purnomo, 2025). In statistics learning, Listyowati et al. (2024) also used local cultural contexts. These examples demonstrate that the findings of this study could be further developed into culturally responsive mathematics teaching resources.

The findings of this study offer significant contributions to the future of mathematics education. One of the key implications is the importance of integrating local cultural contexts—such as ethnomathematical elements derived from Yogyakarta's ox carts—into mathematics instruction to foster contextual and meaningful learning. Utilizing cultural artifacts in instructional materials not only enhances students' understanding of mathematical concepts but also promotes engagement, cultural awareness, and appreciation for the real-world applications of mathematics. These results support the growing emphasis on culturally responsive mathematics education, which aligns with global efforts to develop curricula, teacher training, and educational policies that preserve local heritage while improving mathematical literacy.

Given its potential, further research is highly recommended—particularly studies that examine the classroom implementation of these findings and evaluate their effectiveness. In doing so, the integration of ethnomathematics from Yogyakarta's ox carts may contribute not only to cultural preservation but also to the advancement of mathematics education that is relevant, inclusive, and grounded in students' lived experiences.

CONCLUSION

This ethnomathematics research explored various aspects of the Yogyakarta ox cart and identified mathematical concepts across four domains: geometry (including flat shapes, transformations, line relationships, and patterns), arithmetic (number patterns and operations), algebra (algebraic terms), and statistics (descriptive statistics). These findings highlight the potential of ox carts as a cultural context for developing teaching materials that make mathematics more realistic, meaningful, and connected to students' real lives. By integrating local heritage into their learning, students not only gain a deeper understanding of mathematical concepts but also develop a sense of cultural appreciation and responsibility. In the future, this approach can support more culturally responsive mathematics education. However, this study is limited by its short duration and the number of parts explored, so further research is needed to uncover other possible mathematical ideas and evaluate how this context can be effectively implemented in the classroom.

ACKNOWLEDGMENTS

On this occasion, the author would like to thank several parties who have supported the implementation of this research, namely the Institute for Research and Community Service (LPPM), Universitas Teknologi Digital Indonesia, Karoseri Gerobak Mbah Montil in Sleman, research validators, and experts.

DECLARATIONS

- Author Contribution : **Ilham Rais Arvianto:** Conceptualization, Methodology, Validation, Formal Analysis, Investigation, Writing – original draft, and Writing – review & editing; **Abi Fadila:** Validation, and Writing – review & editing; **Adi Nurcahyo:** Validation, and Writing – review & editing; **Muhammad Luthfi Farizqi:** Resources, and Visualization
- Funding Statement : This research was funded and supported by the Institute for Research and Community Service (LPPM), Universitas Teknologi Digital Indonesia.
- Conflict of Interest : The authors declare no conflict of interest.

REFERENCES

- Abdullah, A. A., & Rahmawati, A. Y. (2021). Eksplorasi Etnomatematika pada Batik Kayu Krebet Bantul. *UNION: Jurnal Ilmiah Pendidikan Matematika*, 9(2), 163–172. <https://doi.org/10.30738/union.v9i2.9531>

- Abidin, Z., & Tohir, M. (2019). Keterampilan Berpikir Tingkat Tinggi dalam Memecahkan Deret Aritmatika Dua Dimensi Berdasarkan Taksonomi Bloom. *Alifmatika: Jurnal Pendidikan Dan Pembelajaran Matematika*, 1(1), 44–60. <https://doi.org/10.35316/alifmatika.2019.v1i1.44-60>
- Agustino, V. D., & Susanto, H. A. (2024). Eksplorasi Etnomatematika: Integrasi Matematika pada Kesenian Musik Ngesti Swara di Desa Jatisobo. *Edumatica : Jurnal Pendidikan Matematika*, 14(3), 259–270. <https://doi.org/https://doi.org/10.22437/edumatica.v14i3.37548>
- Ardian, R., & Suparni, S. (2023). Eksplorasi Etnomatematika pada Aksara Batak. *Jurnal Pendidikan Ilmu Pengetahuan Alam*, 1(1), 45–49. <https://doi.org/10.36655/sepren.v2i1.354>
- Ardinata, C. Y., Gulo, D., & Rudhito, M. A. (2024). Kajian Etnomatematika pada Candi Sambisari dan Implementasi dalam Pengembangan Bahan Ajar Materi Bangun Datar SMP. *PHI: Jurnal Pendidikan Matematika*, 8(1), 41. <https://doi.org/10.33087/phi.v8i1.327>
- Arvianto, I. R., & Bhikuning, D. (2022). Analisis Kesalahan Mahasiswa dalam Mengerjakan Soal Cerita Materi Statistika Ditinjau dari Kemampuan Berpikir Kreatif. *Jurnal Pendidikan Matematika Indonesia*, 7(2), 80–84. <https://doi.org/10.26737/jpmi.v7i2.3623>
- Astuti, N., Jana, P., & Marsiyam, M. (2022). Pengembangan LKS Berbasis Etnomatematika untuk Memfasilitasi Kemampuan Representasi Matematis. *Edumatica : Jurnal Pendidikan Matematika*, 12(2), 180–194. <https://doi.org/10.22437/edumatica.v12i02.15814>
- Batiibwe, M. S. K. (2024). The Role of Ethnomathematics in Mathematics Education: A Literature Review. *Asian Journal for Mathematics Education*, 3(4), 383–405. <https://doi.org/10.1177/27527263241300400>
- Bili, F. M., Sujadi, A. A., Arigiyati, T. A., Ledi, F., Kusmanto, B., & Agustito, D. (2019). Identifikasi Etnomatematika pada Motif Kain Tenun Sumba Barat Daya. *UNION: Jurnal Ilmiah Pendidikan Matematika*, 8(1), 87–95. <https://doi.org/10.30738/union.v8i1.5338>
- Cahyanti, A. H. A. P., Kurniawan, I., Kristanto, Y. D., & Kurniawan, H. (2024). Kajian Etnomatematika pada Alat Musik Saron di Daerah Yogyakarta. *Jurnal Ilmiah Matematika*, 5(1), 150–155.
- Christanti, A. D. I., Sari, F. Y., & Pramita, E. (2020). Etnomatematika pada Batik Kawung Yogyakarta dalam Transformasi Geometri. *ProSANDIKA UNIKAL (Prosiding Seminar Nasional Pendidikan Matematika Universitas Pekalongan)*, 1, 435–444.
- Creswell, J. W., & Creswell, J. D. (2018). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. In *Research Defign: Qualitative, Quantitative, and Mixed M ethods Approaches* (5th ed.). Los Angeles: SAGE.
- Dasmasea, J., Urath, S., & Nifangelelyau, J. (2021). Etnomatematika Seni Patung Tumbur. *Jurnal Pendidikan Indonesia*, 2(1), 36–47.
- Deskarina, R., & Atiqah, A. N. (2020). Potensi Kearifan Lokal Desa Bugisan Sebagai Upaya Pengembangan Daya Tarik Wisata Pendukung Kawasan Candi Plaosan. *Khasanah Ilmu : Jurnal Pariwisata Dan Budaya*, 11(1), 41–49. <https://doi.org/10.31294/khi.v11i1.6906>
- Dinas Kebudayaan Kabupaten Sleman. (2020). Gerobak Sapi Yogyakarta Sebagai Warisan Budaya Tak Benda Indonesia. Retrieved April 30, 2025, from <https://kebudayaan.slemankab.go.id/post/gerobak-sapi-yogyakarta-sebagai-warisan-budaya-takbenda-indonesia>
- Dyanningrat, Rr. D. A. (2018). *Perancangan buku nilai sejarah dan filosofi mataram islam pada gerobak sapi*. Institut Seni Indonesia Yogyakarta, Yogyakarta.

- Faizah, H., & Suparni, S. (2023). Eksplorasi Etnomatematika pada Budaya Arak Jodhang Nyadran Makam Sewu Kabupaten Bantul. *JP2M (Jurnal Pendidikan Dan Pembelajaran Matematika)*, 9(2), 273–284. <https://doi.org/10.29100/jp2m.v9i2.4307>
- Febriana, R., Kurniasih, A., Setyaningsih, E., & Maharani, O. P. (2022). Eksplorasi Etnomatematika pada Tugu Jogja. *Pedagogy: Jurnal Pendidikan Matematika*, 7(1), 39–48. <https://doi.org/10.30605/pedagogy.v7i1.1799>
- Fitriah, A., Putri, A. S., Ma'ruf, E. A., Aliyah, H., Sintyaningsih, S., Vionica, Z., & Wulantina, E. (2023). Eksplorasi Etnomatematika Tiga Candi Trimurti pada Kompleks Candi Prambanan. *MATH-EDU: Jurnal Ilmu Pendidikan Matematika*, 8(2), 88–97. <https://doi.org/10.32938/jipm.8.2.2023.88-97>
- Fitriani, L. D. (2022). Eksplorasi Etnomatematika dalam Tarian Bimbang Gedang pada Masyarakat di Kota Bengkulu. *Jurnal Ilmiah Pendidikan Matematika Al Qalasadi*, 6(2), 147–158. <https://doi.org/10.32505/qalasadi.v6i2.4696>
- Hada, K. L., Maulida, F. I., Dewi, A. S., Dewanti, C. K., & Surur, A. M. (2021). Pengembangan Media Pembelajaran Blabak Trarero di pada Materi Geometri Transformasi: Tahap Expert Review. *Jurnal Pendidikan Matematika (Kudus)*, 4(2), 155. <https://doi.org/10.21043/jmtk.v4i2.12047>
- Hasanah, U., Basri, H., Muplihah, M., & Ramadhani, A. R. (2024). Eksplorasi Etnomatematika Permainan Tradisional Kartu Wayang Umbul. *JagoMIPA: Jurnal Pendidikan Matematika Dan IPA*, 4(2), 336–344. <https://doi.org/10.53299/jagomipa.v4i2.596>
- Imaniyah, A., & Zuroida, R. (2020). Eksplorasi Etnomatematika Konsep Geometri Dan Bilangan Dalam Permainan Gobak Sodor. *Prosiding Seminar Pendidikan Matematika Dan Matematika*, 2, 1–9. <https://doi.org/10.21831/pspmm.v2i0.96>
- Ishartono, N., & Ningtyas, D. A. (2021). Exploring Mathematical Concepts in Batik Sidoluhur Solo. *International Journal on Emerging Mathematics Education*, 5(2), 151–164. <https://doi.org/10.12928/ijeme.v5i2.20660>
- Listyowati, M. E., Adelia, J., & Pratini, H. S. (2024). Pembelajaran Statistika Berbasis Etnomatematika dengan Konteks Gua Maria Sendangsono Kulon Progo. *Seminar Nasional Matematika Dan Pendidikan Matematika*, 396–401. Universitas Sanata Dharma.
- Mahanani, C. D. P., Natalia, M., & Nugraha, A. S. (2023). Eksplorasi Etnomatematika pada Bangunan Candi Gebang Daerah Istimewa Yogyakarta. *SEMANTIK: Prosiding Seminar Nasional Pendidikan Matematika*, (November), 188–202.
- Masduki, P. N., & Malasari, P. N. (2023). Konsep Matematis pada Proses Pembuatan Jenang Kudus: Studi etnomatematika. *ALGORITMA: Journal of Mathematics Education (AJME)*, 5(2), 164–179. <https://doi.org/10.15408/ajme.v5i2.39488>
- Muyassar, M. R., & Harahap, E. (2020). Pembelajaran Aritmatika Menggunakan Aplikasi Wolfram Alpha. *Jurnal Matematika*, 19(2), 25–32.
- Novitasari, L. A. (2021). Festival Gerobak Sapi di Sleman Sebagai Ajang Jawaban Sebuah Tantangan Zaman. *Dinamika Sosial Budaya*, 23(2), 349–353.
- Nugroho, H., & Sugiman, S. (2024). Etnomatematika : Eksplorasi Konsep Matematika dalam Batik Parang Yogyakarta. *SEMANTIK: Prosiding Seminar Nasional Pendidikan Matematika*, 2(November), 373–386.

- Nuraeni, D., Uswatun, D. A., & Nurasiah, I. (2020). Analisis Pemahaman Kognitif Matematika Materi Sudut Menggunakan Video Pembelajaran Matematika Sistem Daring di kelas IV B SDN Pintukisi. *Pendas : Jurnal Ilmiah Pendidikan Dasar*, 5(1), 61–75. <https://doi.org/10.23969/jp.v5i1.2915>
- Nurcahyo, A., Ishartono, N., Pratiwi, A. Y. C., & Waluyo, M. (2024). Exploration of Mathematical Concepts in Batik Truntum Surakarta. *Infinity*, 13(2), 457–475. <https://doi.org/10.22460/infinity.v13i2.p457-476>
- Nurpratiwiningsih, L., Kurniawan, P. Y., Indriyani, N., & Purwanti, Y. (2021). Pemanfaatan Media Jam Sudut dalam Pembelajaran SD. *JAMU : Jurnal Abdi Masyarakat UMUS*, 2(01), 72–77. <https://doi.org/10.46772/jamu.v1i02.548>
- Pangestuti, U. T., Sulistyaningsih, D., & Purnomo, E. A. (2025). Pengembangan E-LKPD Berbasis CORE Pendekatan Etnomatematika pada Materi Relasi Dan Fungsi Siswa Kelas VIII. *Jurnal Ilmiah Profesi Pendidikan*, 10(2), 1002–1013.
- Parker, S. P. (2003). *McGraw-Hill Dictionary of Scientific and Technical Terms* (6th ed.). McGraw-Hill Education.
- Prahmana, R. C. I., & D'Ambrosio, U. (2020a). Learning Geometry and Values From Patterns: Ethnomathematics On The Batik Patterns of Yogyakarta, Indonesia. *Journal of Mathematics Education*, 11(3), 439–456. <https://doi.org/10.22342/jme.11.3.12949.439-456>
- Prahmana, R. C. I., & D'Ambrosio, U. (2020b). Learning Geometry and Values From Patterns: Ethnomathematics on The Batik Patterns of Yogyakarta, Indonesia. *Journal of Mathematics Education*, 11(3), 439–456. <https://doi.org/10.22342/jme.11.3.12949.439-456>
- Prahmana, R. C. I., Yudianto, W., Rosa, M., & Orey, D. C. (2021). Ethnomathematics: Pranatamangsa System and the Birth-Death Ceremonial in Yogyakarta. *Journal on Mathematics Education*, 12(1), 93–112. <https://doi.org/10.22342/jme.12.1.11745.93-112>
- Pratikno, A. S., Prastiwi, A. A., & Ramahwati, S. (2020). Pemetaan Ukuran Pemusatan Data. *OSF Preprints*, 3(3), 1–7. <https://doi.org/10.31219/osf.io/v3n9h>
- Putra, R. Y., Alviyan, D. N., Arigiyati, T. A., & Kuncoro, K. S. (2021). Etnomatematika pada Bangunan Umbul Binangun Taman Sari dalam Aktivitas Pembelajaran Matematika. *Ethnomathematics Journal*, 2(1), 21–30. <https://doi.org/10.21831/ej.v2i1.36081>
- Putra, R. Y., Wijayanto, Z., & Widodo, S. A. (2020). Etnomatematika: Masjid Soko Tunggal dalam Pembelajaran Geometri 2D. *Jurnal Riset Pendidikan Dan Inovasi Pembelajaran Matematika (JRPIPM)*, 4(1), 10–22. <https://doi.org/10.26740/jrpijm.v4n1.p10-22>
- Putri, N. E., & Pujiastuti, H. (2022). Studi Etnomatematika: Penentuan Tanggal Masyarakat Baduy dan Hubungannya dengan Konsep Aljabar. *Jurnal Ilmiah Pendidikan Matematika Al Qalasadi*, 6(1), 90–99. <https://doi.org/10.32505/qalasadi.v6i1.4270>
- Retnawati, H. (2016). *Analisis Kuantitatif Instrumen Penelitian (Panduan Peneliti, Mahasiswa, dan Psikometrian)* (1st ed.). Yogyakarta: Parama Publishing.
- Roebyanto, G. (2014). *Gemetri, Pengukuran dan Statistik* (1st ed.). Malang: Gunung Samudra.
- Rosa, M., & Orey, D. C. (2011). Ethnomathematics: The Cultural Aspects of Mathematics. *Revista Latinoamericana de Etnomatemática*, 4(2), 32–54.
- Rubenstein, R., & Schwartz, R. (1999). The Roots of the Branches of Mathematics. *Math Horizons*, 6(3), 18–20. <https://doi.org/10.1080/10724117.1999.11975091>

- Safitri, S. Y., Latifah, D., & Angelani, N. (2022). Etnomatematika pada Batik Kawung Sebagai Referensi Konteks Barisan dan Deret Aritmatika. *Jurnal Pendidikan Matematika Undiksha*, 13(1), 21–27. <https://doi.org/10.23887/jipm.v13i1.36881>
- Sa'id, M. S., Arfinanti, N., & Azka, R. (2021). Etnomatematika pada Budaya Lokal Batik Kawung. *Jurnal Inovasi Pendidikan Matematika (JIPM)*, 3(2), 83–91. <https://doi.org/10.37729/jipm.v3i2>
- Santosa, L. W. (2016). *Keistimewaan Yogyakarta dari sudut pandang geomorfologi*. Yogyakarta: Gadjah Mada University Press.
- Sanyoto, B., Setiana, D., & Agustito, D. (2021). Eksplorasi Etnomatematika pada Bangunan Masjid Agung Mataram Kotagede. *UNION: Jurnal Ilmiah Pendidikan Matematika*, 9(3), 297–308. <https://doi.org/10.30738/union.v9i3.9522>
- Sari, L. I., Fredy, F., & Sabono, L. (2023). Model Pembelajaran Realistics Mathematics Education untuk Meningkatkan Hasil Belajar Materi Keliling Persegi Panjang pada Siswa Kelas IV Sekolah Dasar. *Journal of Education Action Research*, 7(3), 368–375. <https://doi.org/10.23887/jear.v7i3.67010>
- Setiadi, W. (2025). Studi Etnomatematika : Konsep Geometri pada Jajanan Pasar Tradisional Pasar Ngasem, Yogyakarta. *Jurnal PEKA (Pendidikan Matematika)*, 8(8), 98–108. <https://doi.org/10.37150/jp.v8i2.3169>
- Setiana, D. S., Ayuningtyas, A. D., Wijayanto, Z., & Kusumaningrum, B. (2021). Eksplorasi Etnomatematika di Museum Kereta Kraton Yogyakarta dan Pengintegrasian ke dalam Pembelajaran Matematika. *Ethnomathematics Journal*, 2(1), 1–10. <https://doi.org/10.21831/ej.v2i1.36210>
- Shalsabila, A., & Loviana, S. (2024). Pengembangan Video Pembelajaran Berbasis Etnomatematika pada Materi Relasi dan Fungsi. *Euclid*, 11(1), 69–80. <https://doi.org/10.33603/942jtj57>
- Shirley, L., & Palhares, P. (2016). Ethnomathematics and its Diverse Pedagogical Approaches. In *Current and Future Perspectives of Ethnomathematics as a Program* (pp. 13–17).
- Silvia, V. (2020). *Statistika Deskriptif* (1st ed.). Yogyakarta: ANDI.
- Sintauri, B. D., Puspitasari, A. D., & Noviyanti, H. (2020). Kajian Etnomatematika Pada Permainan Gasing Yang Dijual Di Malioboro Yogyakarta. *ProSANDIKA UNIKAL (Prosiding Seminar Nasional Pendidikan Matematika Universitas Pekalongan)*, 1, 419–428.
- Sugiyono. (2013). *Metodologi Penelitian Kuantitatif, Kualitatif dan R & D* (19th ed.). Bandung: Alfabeta.
- Susanti, E. (2020). Eksplorasi Etnomatematika Konsep Operasi Hitung dalam Permainan Tradisional Kempeng. *Suska Journal of Mathematics Education*, 6(1), 1–8.
- Wahyuningsih, S. K., & Surbakti, A. H. (2018). Perubahan Bahasa dan budaya jawa di Yogyakarta pada era globalisasi. *Jurnal As-Salam*, 2(2), 53–59. <https://doi.org/10.37249/as-salam.v2i2.33>
- Wulandari, A. F., Hakim, A. R., & Kasyadi, S. (2024). Eksplorasi Etnomatematika pada Makanan Tradisional Banyumas di Daerah Sokaraja Jawa Tengah. *Edumatica : Jurnal Pendidikan Matematika*, 14(2), 173–185. <https://doi.org/https://doi.org/10.22437/edumatica.v14i2.36947>
- Yuningsih, N., Nursupriah, I., & Manfaat, B. (2021). Eksplorasi Etnomatematika pada Rancang Bangun Rumah Adat Lengkong. *Jurnal Riset Pendidikan Matematika Jakarta*, 3(1), 1–13. <https://doi.org/10.21009/jrpmj.v3i1.19517>