Ethnomathematics: Mathematical Activities of Hand-drawn Batik Craftsmen Community in Giriloyo, Yogyakarta, Indonesia

Ahmad Anis Abdullah
Department of Mathematics Education, Universitas Alma Ata
Jl. Brawijaya 99, Yogyakarta, Indonesia, 55183
E-mail address: ahmad.anis@almaata.ac.id
ORCID: https://orcid.org/0009-0004-0400-6431

Rino Richardo
Department of Mathematics Education, Universitas Alma Ata
Jl. Brawijaya 99, Yogyakarta, Indonesia, 55183
E-mail address: rinorichardo@almaata.ac.id
ORCID: https://orcid.org/0000-0001-8048-5359

Muhammad Najib Mubarok
Department of Mathematics Education, Universitas Alma Ata
Jl. Brawijaya 99, Yogyakarta, Indonesia, 55183
E-mail address: najibmubarok@almaata.ac.id
ORCID: https://orcid.org/0009-0005-1221-2355

Widya Sekar Bayu
Department of Mathematics Education, Universitas Alma Ata
Jl. Brawijaya 99, Yogyakarta, Indonesia, 55183
E-mail address: 201400108@almaata.ac.id
ORCID: https://orcid.org/0009-0004-0832-1519

ABSTRACT

Aim. This study is an ethnomathematical study that aims to describe and interpret the Mathematical Activities of the Hand-drawn Batik Craftsmen Community located in Giriloyo, Yogyakarta, Indonesia

Methods. This report utilized an ethnographic method, with data being obtained through observation, interviews, documentation, and Focus Group Discussion (FGD). The subjects of the study were a group of five hand-drawn batik craftsmen from Giriloyo, Yogyakarta, Indonesia. A literature review on batik was utilized to complement the results obtained through the observations and interviews. Following that, the data was analysed qualitatively.

Results. From the data analysis, it was found that this community engaged in mathematical activities during hand-drawn batik production which include measuring, pattern-making, and estimating. This is reflected in: first, their method of taking measurements and using units to arrange the batik motifs; second, pattern-making that can be seen in batik motifs, especially geometric motifs; and third, estimation activities observed in determining the price of a piece of hand-drawn batik.

Conclusions. The traditional activity of making batik with *canting* is culturally rich in values and philosophies that need to be preserved. Ethno-mathematical research on the activities of the hand-drawn batik community can yield products applicable to school lessons.

Keywords: Hand-drawn Batik, Ethnomathematics, Measurement, Pattern-Making, Estimation

Introduction

A challenge in mathematics education in Indonesia is that classroom learning is far from the students' reality and the culture where they live (Hwang & Ham, 2021). This issue is reflected in Indonesia's low ranking on the PISA assessment (Nusantara et al., 2021). As we know, PISA questions encourage students to use their mathematical competencies to solve problems that arise around them (Zulkardi et al., 2020). The low PISA results of Indonesian students are due to their lack of familiarity with PISA model questions; this issue arises because they are accustomed to solving routine questions, and the learning is heavily focused on memorizing formulas (Stacey, 2011). Therefore, educational transformation is needed to bring mathematics closer to students' reality and culture, one of which is through ethnomathematics (Brandt & Chernoff, 2015). Ethnomathematics is a study in mathematics education motivated by concerns about the conditions of mathematics learning in schools, which are mechanistic and far from students' real experiences and cultural context (Richardo et al., 2019).

Ethnomathematics is a study that analyze the relationship between mathematics and culture in a society (Fouze & Amit, 2023). It aims to investigate and understand the application of mathematics in various communities (Orey & Rosa, 2007). It is a bridge that connects mathematical concepts with culture (Pradana et al., 2022). By connecting mathematical concepts with cultural practices, ethnomathematics reveals how different communities utilize mathematical ideas, fostering reasoning and critical

thinking in reconstructing these activities. This field intersects cultural anthropology, mathematics, and mathematical modeling (Rosa & Orey, 2011). The cultural objects studied by ethnomathematics include mentifacts, artifacts and social facts (Rosa & Orey, 2023). Mentifact are ideas, notions, values, and beliefs applied by a community, such as ethnomathematics studies in determining good days in the Javanese ethnic group (Umbara et al., 2021), the Islam Nusantara culture (Richardo et al., 2020), and ethnomathematics exploration on units and calculus within a village farmer community (Suprayo et al., 2019). Artifacts are cultural relics from a community, such as ethnomathematics studies on temples (Mahmudati & Lailiyah, 2020), cultural heritage buildings (Abdullah et al., 2023), and batik patterns (Charitas et al., 2020). Meanwhile, social facts refer to individual behavior in a community, such as Sundanese mathematical activities (Muhtadi et al., 2017), ethnomathematics in Aceh Coastal Children's Football Game (Wahyuni & Pratiwi, 2023), and ethnomathematics in fish-catching activities along the Musi River (Malalina et al., 2020).

Batik is one of Indonesia's cultural heritages that is widely studied. It is recognized as an intangible cultural heritage by UNESCO (e. a. natanegara & Djaya, 2019). There are numerous ethnomathematics studies on batik in Indonesia, such as ethnomathematics on classic Yogyakarta batik (Sartono & Retnowati, 2019), Kalimantan batik (Sudrajat et al., 2023), Trusmi Cirebon batik (Rahmawati et al., 2024), Solo batik (Faiziyah et al., 2021), Sidoarjo batik (Manoy & Purbaningrum, 2021), Bali batik (Irawan et al., 2019), and others. Among the various ethnomathematics studies on batik, the majority focus on batik motifs. There remains a scarcity of research examining the ethnomathematics involved in the batik-making process, especially for traditional hand-drawn batik (Wahyudi et al., 2021). Hand-drawn batik is the most traditional method which is still maintained in several places. However, the amount is not comparable to stamped batik or digital printed batik. In terms of motifs, there is no difference between the hand-drawn, stamped and digitally printed batik because there are rules (known as *pakem* in Javanese) that need to be adhered to. The fundamental difference is the technique of making it. Hand hand-drawn batik maintains the traditional method, namely drawing batik motifs using a tool called *canting* to inscribe wax on the fabric.

The practice of making batik using the traditional drawing technique is still preserved in various places in Yogyakarta, a renowned batik city. However, the number is decreasing from year to year. One of the remaining areas in Yogyakarta which is the center of hand-drawn batik craftsmen is Giriloyo, Wukirsari, Bantul, Special Region of Yogyakarta, Indonesia (Pribudi, 2020). The Giriloyo batik craftsmen community consists of 600 craftsmen divided into several communities and dominated by housewives. This community has passed down cultural ideas from generation to generation. The Giriloyo hand-drawn batik craftsmen community is particularly interesting to study because they have sustainably preserved their cultural activities and consistently maintained the existence of Yogyakarta as a batik city (Widjanarko et al., 2023). The entire process of making Giriloyo batik is carried out traditionally using canting, with the following stages:

- Preparation: the mori cloth, measuring 250 x 105 cm, undergoes washing, starching and boiling, also known as 'mordating'.
- Pattern making: this process begins with nyungging, which involves creating the batik pattern on 90 x 50 cm piece of paper. It is followed by *njiplak* (tracing), the method of transferring the pattern from paper onto the prepared cloth, by moving the pattern once it is perfected.
- Batik making: this involves applying wax to the cloth using *canting* by following the batik motif pattern, which includes both geometric and non-geometric designs.
- Coloring: the process involves making a composition of dye and water, then dipping the batik cloth in the prepared colored liquid.
- Fixation: covering the fabric that has been colored with wax.
- *Nglorod*: removing wax from cloth by dipping it in boiling water.
- Pricing: fabrics are priced based on neatness, complexity, and labor expended.

Figure 1
The batik Craftsmen are in the middle of Batik making proces

Source. Own photos.

In the batik-making process, craftsmen use a tool called *canting*. This tool is made of metal to hold wax and has a small pipe at the end. Canting has three parts: *nyamplung*, made of copper to hold the night liquid; *cucuk*, the tip of the canting where the hot wax is dispensed; and *gagang*, the handle made of bamboo or wood (Basuki & Astuti, 2022). Based on the number of tips (*cucuk*) (Supriono, 2016), *canting* is divided into:

- *Canting Cecekan*, has one tip
- *Canting Laron/Loron*, has two tips (*loro* in Javanese)
- *Canting Telon*, has three tips (*telu* in Javanese) arranged in an isosceles triangle
- *Canting Prapatan*, has four tips (*papat* in Javanese) arranged in a square
- *Canting Liman*, has five tips (*limo* in Javanese) arranged in a square with one point in the middle
- *Canting Byok*, has more than seven or odd number of tips.
- *Canting Renteng/Galaran*, has four or six tips in the shape of a straight line.

Figure 2
a. Canting and b. Wax

a b

Source. Own photos.

The names of the *canting* types mentioned above are closely related to Javanese numbers (*siji, loro, telu, papat, limo*). Likewise, batik pattern units are divided into three (Budi et al., 2023):

- *Ceplok*: a batik pattern with geometric design in the form of flat shapes, such as rhombus, square, triangle, ellipse, circle, etc.
- *Lereng*: a batik pattern with a design in the form of slanted lines parallel to a 45 degree.
- *Semen*: a batik pattern with a free-form design, usually in the form of mountains, nature, flora, and fauna.

Basically, the process of batik making requires mathematical activities such as measuring the cloth, making the batik patterns, and estimating the price of the finished batik cloth. Therefore, this research aims to examine mathematical activities, including measuring, pattern-making, and estimating the process of making batik in Giriloyo.

Methods

The current research was carried out by employing an exploratory method with an ethnographic approach. This method is designed to search, investigate, and reveal phenomena or events by assessing the symptoms observed (Gulo, 2002). The ethnographic approach is utilized to study and describe the community's cultural practices, focusing on mathematical ideas, processes, and techniques from the perspective of the community (Spradley, 1979). There were several activities involved, such as observation, interviews, documentation, and focus group discussions. The utilized instruments were the observation sheets, interview guidelines, documentation of the batik motif, and documentation of the process of making hand-drawn batik. This research

was conducted in Giriloyo, particularly in Wukirsari Village, Imogiri Subdistrict, Bantul Regency, Yogyakarta Special Region, Indonesia. The subjects of this study consisted of five hand-written batik craftsmen, 1 batik culturist, 3 mathematics education lecturers, and 1 ethnomathematics practitioner, who were selected through purposive sampling method. The 5 hand-drawn batik craftsmen selected as samples are women who serves as the head of the hand-drawn batik craftsmen community, actively involved in the community's activities, have over 10 years of experience in the craft, are over 40 years old, possess a deep understanding of the batik-making process, are willing and available to share their insights, and are capable of effectively conveying information. Passive participant observation was carried out 16 times for two months in Wukirsari Village. The observation focused on hand-drawn batik-making activities carried out by 5 craftsmen, aiming to identify processes comprising measurement, pattern-making, estimation, and other concepts that might emerge during the observation. Guidelines of the observation are presented in Figure 3.

Figure 3

Observation Guidelines for Batik-Making Activity

No	Batik-Making Activities	Description of the Identified Mathematical Concept			
		Measurement	Pattern-Making	Estimation	.....
1	Fabric preparation	.....	.....	.....	.....
2	Pattern making	.....	.....	.....	.....
3	Batik making	.....	.....	.....	.....
4	Coloring	.....	.....	.....	.....
5	Fixation	.....	.....	.....	.....
6	Nglorod	.....	.....	.....	.....
7	Pricing	.....	.....	.....	.....
...	.....	.....	.....	.....	.....
...	.....	.....	.....	.....	.....

Source. Own research

To follow up on the observation results, interviews were conducted with 5 batik craftsmen to gather more in-depth information related to measurement, pattern making, and estimation in batik-making activities. The interviews were conducted twice at different times to ensure valid results, following the interview guidelines shown in Table 1.

Table 1

Interview Guidelines for Batik Craftsmen

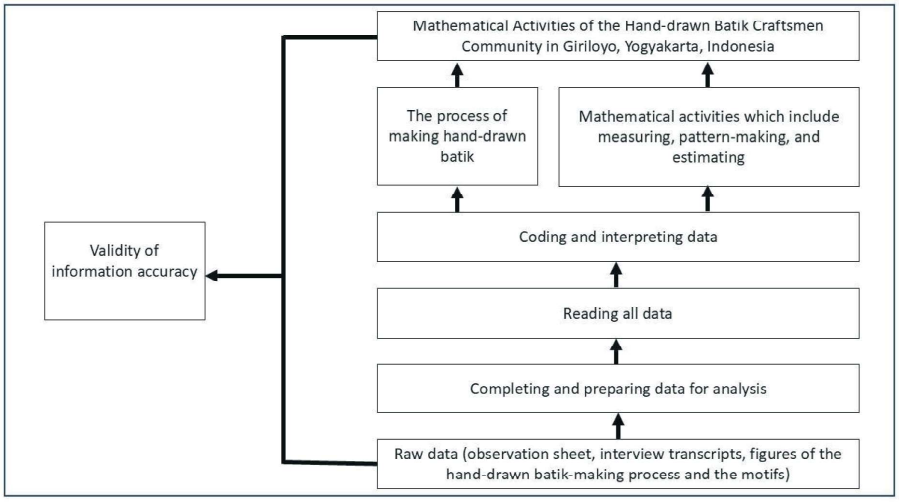
No	Points of Interview
1	How batik craftsmen perform measurement in creating hand-drawn batik
2	How batik craftsmen design patterns for hand-drawn batik
3	How batik craftsmen estimate prices for hand-drawn batik

Source. Own research

To validate and analyze the results of observations and interviews, FGDs were conducted 3 times with a study expert group consisting of 3 mathematics education lecturers, 1 cultural figure, and 1 ethnomathematics practitioner to reveal mathematical concepts in the Giriloyo batik craftsmen community (Madden, 2010). The literature review incorporated 3 books on Indonesian batik and 13 articles related to batik, which helped to enrich the results obtained from the observations and interviews. Tabulation was performed following the data collection to determine the mathematical practices of those craftsmen. The tabulated data was then analyzed to figure out how the batik craftsmen in Giriloyo perform mathematical practices in creating classic hand-drawn batik. The ethnographic data analysis method was also employed for interpretation through general descriptive procedures. Additionally, the analysis adopted the procedure proposed by John W. Creswell & J. David Creswell (2018), as described in Figure 4. below.

Figure 4

Schema of Data Analysis



Source. Adapted from (Creswell & Creswell, 2018).

Results and Discussion

Profile of the Giriloyo Batik craftsman community

The Giriloyo batik craftsmen community consists of 600 craftsmen divided into several communities and dominated by housewives. The hand-drawn batik craftsmanship in Giriloyo is predominantly carried out by women in their respec-

tive homes. The process of making a single batik cloth involves multiple individuals, each handling specific stages of the process. These include workers tasked with cutting the cloth, designing patterns, tracing patterns, creating the main batik pattern, adding decorative motifs, dyeing the fabric, and pricing the finished batik. While the process is predominantly carried out by housewives, some men participate in tasks such as pattern-making, dyeing, and wax removal. Historically, in 1629, the men of Giriloyo served as royal servants at the Yogyakarta Palace, tasked with guarding the tombs of Mataram kings in Wukirsari Village, while the women received batik training from the Yogyakarta Palace (Savitri, 2021). This activity has been passed down through generations and continues to this day.

The hand-drawn batik craftsmen are mainly housewives aged over 30 years, with the oldest reaching 80–85 years. In addition to preserving this tradition, the seniors continue working as batik craftsmen because they are accustomed to this economic activity, and national policies to improve job opportunities for them remain insufficient. The process of making hand-drawn batik itself takes approximately two months. This batik making skills are taught from parents to children through generations. In order to preserve batik as a cultural heritage, the Indonesian government has included it as a subject in elementary, junior high, and high schools (Gumelar, 2019). Furthermore, Giriloyo hand-drawn batik products have entered the national and international markets. Those products can be obtained through online and offline (Nuvriasari, et al., 2022). The Giriloyo batik community also offers educational batik tours that are often visited by both domestic and international tourists. Thus, in addition to creating hand-drawn batik, they also serve as guides for visitors participating in these educational tours in the Giriloyo batik Village. On 14 November 2024, Wukirsari Village won The Best Tourism Village 2024 award from the United Nation World Tourism Organization (UNWTO) (n.d., 2024).

Figure 5

Domestic and Overseas Tourist Visits

Source. Documentation of the giriloyo batik community

Ethnomathematics in this research focuses on the activities of the Giriloyo batik craftsman community, particularly in the process of making classic batik which includes measuring, patterns-making, and estimating. The ethno-mathematical potential of the three mathematical activities was first tabulated in the form of a description of the observation results of batik-making activities carried out by the Giriloyo hand-drawn batik craftsman community. The results of the observations were further confirmed through central studies and interviews that were transcribed and tabulated into supporting data. Descriptions of observations, literature studies, and interviews are further explained in the following description:

Measuring

Measuring is a mathematical activity that cannot be separated from batik-making activities, starting from measuring the length of the cloth, the size of the motif, the size of the pattern paper, the number of waxes, the composition of the dye, and the manufacturing time. Some of the terms that appeared in this activity include motif units (*ceplok, lereng*, or *semen*), size of the *canting* tip (small, medium, or large), *canting* based on the number of bows/tips (*cecekan, loron, telon, prapatan, liman, byok,* or *galaran*). These sizes are often used in batik-making activities. The batik-making activity, which is very closely related to measuring activities, involves the process of preparing a *jarit* (long) cloth. The average size of *jarit* cloth is 250 centimeters long and 105 centimeters wide. To facilitate cutting, craftsmen usually use a pre-measured floor instead of measuring tape. Meanwhile, to determine the edge's size, craftsmen use the *rong ari* technique (two-fingers breadth).

The following interview excerpt reveals how Giriloyo batik craftsmen measure the cloth that will be decorated with batik motifs.

Researcher: What is the size of cloth used for batik?

Craftsman: The size of the cloth used is 250 x 105 cm

Researcher: Do you usually use a measuring tape or another tool to take these measurements?

Craftsman: Usually I use flooring that has been determined in size.

Researcher: Are all the jarit fabrics colored?

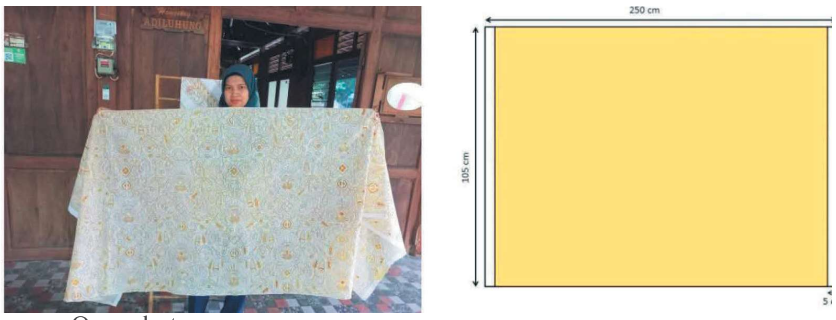
Craftsman: No, the edges of the fabric are leftovers.

Researcher: How many cm is the edge?

Craftsmen: Usually we use the size of two finger breadths or about 5 cm (*rong ari*, while showing 2 fingers)

Figure 6

Area covered in batik



Source. Own photos.

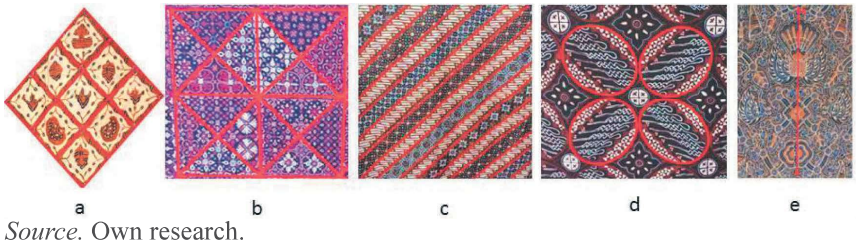
In the activity of preparing *jarit* cloth, craftsmen seem to be accustomed to using tools such as floors, walls, wood, and fingers, to measure the required length of the *jarit* cloth. This practice has become a culture among hand-drawn batik craftsmen in Giriloyo. Based on the results of the interview above, the area of the *jarit* cloth used for batik is the area of the *jarit* cloth minus the area of the edge. It can be written as follows: area covered in batik = (250 × 105) - 2(5 × 105) = 25200 cm^2.

Pattern making

Making patterns is the most important activity in batik production because batik is a collection of several motifs that form a certain pattern and have certain philosophical values. The process of batik-making begins with the craftsman drawing a batik motif on paper, and then proceeds with tracing or transferring the motif from paper to cloth. Batik patterns are divided into two categories based on the motif: geometric and non-geometric motifs. Geometric batik motifs feature flat shapes such as rhombuses in *sido* motifs, oblique lines in *parang* motifs, ellipses in *kawung* motifs, and triangles in the *tambalan* motifs. Meanwhile, non-geometric motifs include those depicting mountains, houses, plants, and animals.

Figure 7

Geometric (a, b, c, and d) and non-geometric (e) batik motifs



Source. Own research.

The following is an excerpt from an interview with hand-drawn batik craftsmen explaining batik motifs.

Researcher: What is the size of the pattern paper, ma'am?

Craftsman: The pattern paper measures 90 x 50 cm, then those patterns will be transferred onto the fabric by tracing them.

Researcher: Do you start tracing from the edge or the center, ma'am?

Craftsmen: It depends on the motif. For *ceplok* and *semen*, the motifs are traced from the center towards the edge.

Researcher: Why don't you start from the edge?

Craftsmen: Since a perfect *ceplok* motif is used on the back, it must be symmetrical in the center. This differs from the *lereng* motif, which starts from the edge and features oblique lines.

Researcher: Is there a certain pattern in batik?

Craftsman: Yes, generally batik motifs are divided into two types, geometric motifs like this (showing the Sido Luhur batik motif on a piece of *jarit* cloth) and non-geometric motifs like this (while pointing to the Wahyu Tumurun motif)

Researcher: Is there a specific purpose in making this geometric batik motif?

Craftsman: Yes, for example, this basic shape of *sido* motif, which has nine rhombuses, contains the Javanese philosophy of "sedulur papat limo pancer" (four brothers, and the fifth as center) and "kiblat papat limo pancer" (four cardinal direction, and the fifth as center).

Researcher: How about this one? (pointing to a batik *kawung* motif with four ellipses)

Craftsmen: For this motif, it comes from the *kawung* fruit (a type of coconut) which is split and arranged geometrically. *Kawung* is also taken from the Javanese word *suwung* (empty) which means emptying oneself of worldly desires and passions.

Researcher: What is the name of this triangle motif? (pointing to a triangular batik motif on a piece of cloth)

Craftsmen: It is called a *tambal* motif. The basic motif is a rectangle divided into four triangles through its two diagonals. The patch motif symbolizes repairing what is damaged, much like how humans must continually refine themselves throughout life.

Researcher: How about non-geometric motifs, ma'am?

Craftsmen: Non-geometric motif like this (pointing to batik motifs from Wahyu Tumurun) is the *semen* motif, which symbolizes blossoming and typically features plants, flowers, animals, or mountains.

Figure 8

a. The pattern paper and b. Pattern tracing

a b

Source. Own photos.

Based on the interview above, it is revealed that there are three units of batik patterns, namely *ceplok, lereng* and *semen* patterns. The *ceplok* and *lereng* patterns are based on geometric motifs, while the *semen* patterns are non-geometric motifs. Furthermore, the geometric batik motifs follow Javanese philosophy symbolized by numbers such as the concept of *nawa* (nine) in the rhombus shape found in the *sidomukti* motif which originates from the concept of *sedulur papat limo pancer pancer* (four brothers, and the fifth as center), which reminds humans when they are born with four things: amniotic fluid, placenta, blood, and umbilical cord, and the concept of *kiblat papat limo pancer* (the four cardinal directions with one central point) (Budi et al., 2023). The concept of *kiblat papat limo pancer* also underlies the construction of four mosques of Pathok Negoro (boundary mosques) and one central mosque at the Yogyakarta Palace (Imawan & Al Ghazali, 2021). Meanwhile, the *kawung* batik motif, consisting of four ellipses with one center point in the middle, is based on the concept of the Javanese philosophy of *sedulur papat limo pancer* (Wahida et al., 2020; Pramesti et al., 2019). Likewise, for the *semen* motif in the non-geometric style, the motif is divided into three levels because it is based on the Javanese concept of the *Triloka*, consisting of the upper world, middle world, and lower world (Ridha et al., 2019). Batik cloth motifs carry certain meanings, so their use is also adjusted to particular events. For example, the *sido mukti* motif is worn for weddings, the *tambal* motif for giving birth, and the *sido luhur* motif for funerals. In ancient times, several batik motifs had specific regulations for their use. These rules still apply in the Yogyakarta palace, such as the *parang barong* motif, which is reserved solely for the king and his family. However, these regulations no longer apply, specifically for those outside the Yogyakarta palace.

Estimating

Estimating is an activity conducted to determine the price of a fine piece of batik because each batik cloth has a different price. Prices range from seven hundred thousand to three million five hundred thousand rupiah per piece. This price difference is determined by several factors, including the batik-making procedures, motifs, neatness, and others. The following is an excerpt from an interview with hand-drawn batik craftsmen explaining how to estimate the price of hand-drawn batik.

The following interview excerpt reveals how Giriloyo batik craftsmen determine the price of batik cloth.

Researcher: How much does a piece of hand-drawn batik cloth cost?

Craftsmen: Prices ranges from 700 thousand to 3.5 million

Researcher: Why do the prices vary?

Craftsman: They depend on the complexity, neatness, and subtlety of the motif.

Researcher: Can prices differ in one motif?

Craftsman: Yes. They depend on neatness and subtlety

Researcher: How do you estimate the price of a piece of hand-drawn batik?

Craftsmen: The price is determined by production costs, level of complexity, and level of subtlety.

Researcher: What do production costs include?

Craftsmen: There are many costs included. Starting from the cost of raw materials (calico cloth), pattern-making services, outlining services (nglowong), filling-in services (isen-isen), redrawing services (ndoblei), dyeing services, dissolving services (nglorod).

Figure 9

a. Batik showroom and b. Batik pricing

a b

Source. Own photos.

The activities of Giriloyo batik craftsmen in measuring, making patterns, and estimating are mathematical activities that have been passed down from generation to generation. Realized or not, those activities apply mathematical concepts. The activity of measuring fabric using the floor as a tool, for example, and measuring edges with the breadth of fingers have been deeply embedded in their daily lives as culture, both consciously and unconsciously.

Moreover, when making geometric patterns such as rhombus-shapes in *ceplokan* patterns, for example*, sidomukti, sidoluhur*, and *sidodrajat* motifs, craftsmen start with a large rhombus and then divide it into nine similar small rhombuses. This division will help craftsmen arrange main motifs, supporting motifs, and additional motifs. Likewise, with the *kawung* motif, pattern making begins by dividing the paper into several squares, by which they will find it easy to draw 4 ellipses in 4 squares. For the *tambalan* motifs, craftsmen will divide the paper into several rectangles and divide the squares into four triangles through the diagonals. With those basic patterns, craftsmen will easily insert motifs or ornaments into each triangle. As for the *semen* motifs, craftsmen divide the paper in half vertically or create a Y-axis to form a sym-

metrical right and left on each motif. In other words, they are using the principle of geometric transformation in the form of reflection on the Y-axis. Bishop calls this activity designing and locating. Meanwhile, the tracing process involves transferring the pattern from paper to fabric. For the *ceplokan* and *semen* motifs, this is performed by moving the fabric from the middle to the edge. For the *pereng* motif, the fabric is shifted from the left edge to the right, utilizing the principle of geometric transformation in the form of translation.

The batik activity of covering the patterns that will be colored using *canting* is a painting process similar to drawing geometric and non-geometric objects. However, instead of using ink like a pen, *canting* uses wax. The activity of dyeing to parts uncovered by wax and wax removal are activity of locating, clustering, or giving boundaries to mutually exclusive sets.

The process of determining the price of a hand-drawn batik cloth is closely related to price estimation. In algebraic form, if the base cost is 500,000, neatness and smoothness are each valued at 100,000 as constants, the level of complexity of the base material is denoted by variable x (ranging from 1 to 5), the level of neatness by variable y (ranging from 0 to 5), and the level of subtlety by variable y (ranging from 0 to 5), then the price of the hand-drawn batik cloth (H) can be modeled mathematically as follows:

$$H=500.000+200.00\ y+200.000z$$

Therefore, a piece of hand-drawn batik with the simplest level of complexity with a value of 1, neatness with a value of 0, and subtlety with a value of 0 is priced at 500,000. Meanwhile, a piece of hand-drawn batik with the most complex level of complexity with a value of 5, neatness with a value of 5, and subtlety with a value of 5 is priced at 3,500,000. According to the calculation, the price of Giriloyo hand-drawn batik cloth ranges from 500,000 to 3,500,000 as stated by the craftsmen during the interview.

The above activities of the Giriloyo hand-drawn batik craftsman community are only a small part of the mathematical activities. Many more activities can be observed further. Given that the traditional activity of making batik with canting is culturally rich in values and philosophies that need to be preserved, ethno-mathematical research on the activities of the hand-drawn batik community can yield products that can be applied in school lessons. Further research needs to be carried out so that the results of this research can be applied in schools, either in the form of developing learning models, teaching materials, or culture-based learning media. Such as the STEAM (Science, Technology, Engineering, Art, and Mathematics) based learning model where students are asked to redesign batik motifs by applying the concept of geometric transformation using Geogebra software.

Conclusion

Based on the findings and the proposed research focus, several conclusions can be drawn. The Giriloyo batik craftsmen community performs mathematical activities in hand-drawn batik-making techniques passed down from generation to generation. This is reflected in the way of taking measurements and the use of units for arranging motifs. Meanwhile, pattern-making can be seen in batik motifs, especially geometric motifs. Furthermore, estimation activities can be seen in the process of determining the price of a piece of hand-drawn batik. The traditional activity of making batik with *canting* is culturally rich in values and philosophies that need to be preserved. Ethno-mathematical research on the activities of the hand-drawn batik community can yield products that can be applied in school lessons.

ACKNOWLEDGMENTS

The researchers would like to express their gratitude to the Indonesian Ministry of Education, Culture, Research, and Technology for funding this research, and to the University of Alma Ata for their support.

REFERENCES

Abdullah, A. A., Richardo, R., Rochmadi, T., Wijaya, A., & Nurkhamid. (2023). Ethnomathematics: Exploration in cultural heritage buildings in Yogyakarta based on geometry perspective. *AIP Conference Proceedings*, *2540*(1). https://doi.org/10.1063/5.0105858

Basuki, D. M. A., & Astuti, K. S. (2022). Nglowong Batik Techniques as One of the Local Culture Preservation. *International Journal of Multicultural and Multireligious Understanding, 9*(4), 406–413. https://ijmmu.com/index.php/ijmmu/article/view/3713/0

Brandt, A.L., & Chernoff, E.J. (2015). The Importance of Ethnomathematics in the Math Class. *Ohio Journal of School Mathematics, 71*, 31–36.

Budi, S., Bina, T., Afanti, & Mataram, S. (2023). *Ikonografi Motif Parang dan Sido Batik Klasik Surakarta* [Iconography of the Parang and Sido Motifs in Classic Surakarta Batik]. UNS Press. https://www.uns-press.online/2023/05/ikonografi-motif-parang-dan-sido-batik.html

Charitas, R., Prahmana, I., & Ambrosio, U. D. (2020). Learning Geometry And Values From Patterns : Ethnomathematics On The Batik Patterns Of Yogyakarta , Indonesia. *Journal on Mathematics Education, 11*(3), 439–456.

Creswell, J. W., & Creswell, J. D. (2018). *Research design: qualitative, quantitative, and mixed methods approaches*. *Fifth edition*. SAGE.

e. a. natanegara & Djaya D. (2019). *Batik Indonesia* [Indonesian Batik]. Yayasan Batik Indonesia. https://fliphtml5.com/bwgzh/itin/Batik_Indonesia/2/

Faiziyah, N., Khoirunnisa, M., Azizah, N. N., Nurrois, M., Prayitno, H. J., Desvian, Rustamaji, & Warsito. (2021). Ethnomathematics: Mathematics in Batik Solo. *Journal of Physics: Conference Series, 1720*(1). https://doi.org/10.1088/1742–6596/1720/1/012013

Fouze, A. Q., & Amit, M. (2023). The Importance of Ethnomathematics Education. *Creative Education, 14*(4), 729–740. https://doi.org/10.4236/ce.2023.144048

Gulo, W. (2002). *Metodologi Penelitian* [Research Methodology] (8th ed.). Gramedia Widiasarana Indonesia. http://repo.darmajaya.ac.id/4019/1/Buku-Metodologi-Penelitian-by-W-Gulo.pdf

Gumelar, P. C. (2019). Batik Extraculicular As a Means of Planting Values of Culture. *Sunan Kalijaga International Journal on Islamic Educational Research, 3*(2), 25–34. https://doi.org/10.14421/skijier.2019.2019.33.03

Hwang, J., & Ham, Y. (2021). Relationship Between Mathematical Literacy And Opportunity To Learn With Different Types Of Mathematical Tasks. *Journal on Mathematics Education. 12*(2), 199–222. https://doi.org/10.22342/jme.12.2.13625.199–222

Imawan, D. H., & Al Ghazali, M. N. (2021). The Influence of the Posonan Tradition at the Pathok Negoro Mlangi Mosque on Mad'u Behavior. *Munazzama: Journal of Islamic Management and Pilgrimage, 1*(1), 47–62. https://doi.org/10.21580/mz.v1i1.8788

Irawan, A., Lestari, M., Rahayu, W., & Wulan, R. (2019). Ethnomathematics batik design Bali island. *Journal of Physics: Conference Series*, *1338*(1). https://doi.org/10.1088/1742–6596/1338/1/012045

Madden, R. (2010). *Being ethnographic: A guide to the theory and practice of ethnography*. Sage Publications.

Mahmudati, R., & Lailiyah, S. (2020). The Study of Ethnomathematic Objects in the Dieng Temple Wonosobo, Central Java. *Matematika Dan Pembelajaran, 8*(2), 133–143. https://doi.org/10.33477/mp.v8i2.1606

Malalina, M., Putri, R. I. I., Zulkardi, Z., & Hartono, Y. (2020). Ethnomathematics of fish catching exploration in Musi River. *Journal of Physics: Conference Series*, *1663*(1). https://doi.org/10.1088/1742–6596/1663/1/012007

Manoy, J. T., & Purbaningrum, M. (2021). Mathematical Literacy Based on Ethnomathematics of Batik Sidoarjo. *Jurnal Didaktik Matematika, 8*(2), 160–174. https://doi.org/10.24815/jdm.v8i2.21644

Muhtadi, D., Sukirwan, Warsito, & Prahmana, R. C. I. (2017). Sundanese ethnomathematics: Mathematical activities in estimating, measuring, and making patterns. *Journal on Mathematics Education, 8*(2), 185–198. https://doi.org/10.22342/jme.8.2.4055.185–198

n.d. (2024). *UN Tourism Announces Best Tourism Villages 2024 : 55 Rural Communities Shaping the Future of Sustainable Travel*. UN Tourism. https://www.unwto.org/news/un-tourism-announces-best-tourism-villages-2024–55-rural-communities-shaping-the-future-of-sustainable-travel

Nuvriasari, A., Candrawati, K., Wicaksono, G., Lestianengrum, S., & Ayunda, S. E. (2022). Development of Education-Based Tourism and Expansion of Marketing Networks in Kampung Batik Giriloyo. *IMPACTS: International Journal of Empowerment and Community Services, 1*(1), 37–42. https://doi.org/10.30738/impacts.v1i1.13061

Nusantara, D. S., Ilma, R., & Putri, I. (2021). Designing Pisa-Like Mathematics Task Using A Covid-19 Context (Pisacomat). *Journal on Mathematics Education, 12*(2), 349–364. https://eric.ed.gov/?id=EJ1313713

Orey, D., & Rosa, M. (2007). Cultural Assertions and Challenges towards Pedagogical Action of an Ethnomathematics Program. *For the Learning of Mathematics, 27*(1), 10–16. http://www.jstor.org/stable/40248554

Pradana, K. C., Rizki Putra, A., & Rahmawati, Y. (2022). Ethnomathematics on Traditional Culture: A Bibliometric Mapping Analysis and Systematic Review on Database Scopus. *International Journal Corner of Educational Research, 1*(1), 1–8 https://doi.org/10.54012/ijcer.v1i1.61

Pramesti, N. A., Pamadhi, H., & Garbo, A. (2019). *Local Wisdom Values in Kawung Batik and Its Relevance to Moral Education*. In Kuswarsantyo, D. Sartono, A. N. Machfauzia, D. R. S. Ambarwati, & T. Herawan (Eds.), *Proceedings of the International Conference on Art and Arts Education (ICAAE 2018)* (pp. 178–182). Atlantis Press. https://doi.org/10.2991/icaae-18.2019.34

Pribudi, A. (2020). Community-based Approach to Sustain Batik Tourism Village Area in the Special Region of Yogyakarta (The Case of Giriloyo Village). *Journal of Sosial Science, 1*(4), 113–122. https://doi.org/10.46799/jsss.v1i4.47

Rahmawati, D., Noto, M. S., Subroto, T., Amiruddin, M. H., & Hafizatunnisa, H. (2024). The Exploration of Mathematics on Batik Trusmi. *Rangkiang Mathematics Journal, 3*(1), 11–26. https://doi.org/10.24036/rmj.v3i1.48

Richardo, R., Abdullah, A. A., Martyanti, A., Sholihah, D. A. & Nurshanti, W. (2020). Learning mathematics through Islam Nusantara culture: An etnomathematics study in Indonesia. *Ethnomathematics Journal, 7*(1), 30–35. https://doi.org/10.21831/ej.v1i1.33129

Richardo, R., Martyanti, A., & Suhartini. (2019). Developing ethnomathematical tasks in the context of yogyakarta to measure critical thinking ability. *Journal of Physics: Conference Series*, *1188*(1). https://doi.org/10.1088/1742–6596/1188/1/012063

Ridha, P. N., Utami, N. R., & Pamadhi, H. (2019). *An Axiological Study of Tumpal Batik Motif and Its Relevance to the Character Education*. In Kuswarsantyo, D. Sartono, A. N. Machfauzia, D. R. S. Ambarwati, & T. Herawan (Eds.), *Proceedings of the International Conference on Art and Arts Education (ICAAE 2018)* (pp. 188–191). Atlantis Press. https://doi.org/10.2991/icaae-18.2019.36

Rosa, M., & Orey, D. C. (2011). Ethnomodeling: An Ethnomathematical View on Mathematical Modeling. *RIPEM, 1*(1), 19–35. https://doi.org/10.37001/ripem.v1i1.1126

Rosa, M., & Orey, D. C. (2023). Interações Entre As Perspectivas Socioculturais Da Modelagem Matemática E Da Etnomatemática Em Uma Abordagem De Etnomodelagem [Interactions between Sociocultural Perspectives of Mathematical Modeling and Ethnomathematics in an Ethnomodelling Approach]. *Vidya, 43*(2), 113–132. https://doi.org/10.37781/vidya.v43i2.4606

Sartono, D., & Retnowati., T. H. (2019). *Study of the Value of Yogyakarta Batik Character and Its Implementation in Learning Batik in Vocational School.* In Kuswarsantyo, D. Sartono, A. N. Machfauzia, D. R. S. Ambarwati, & T. Herawan (Eds.), *Proceedings of the International Conference on Art and Arts Education (ICAAE 2018)* (pp. 8–13). Atlantis Press. https://doi.org/10.2991/icaae-18.2019.2

Savitri, M. (2021). The role of local wisdom on the preservation of the Imogiri Royal Cemetery Site. *Berkala Arkeologi, 41*(1), 69–88. https://doi.org/10.30883/jba.v41i1.567

Spradley, J. P. (1979). *The ethnographic interview* (1st ed.). Holt, Rinehart and Winston, Inc.

Stacey, K. (2011). The PISA view of mathematical literacy in Indonesia. *Journal on Mathematics Education, 2*(2), 95–126. https://doi.org/10.22342/jme.2.2.746.95–126

Sudrajat, S., Winarto, A., & Wicaksono, B. (2023). Ethnomathematics of Kalimantan Batik in field Geometry learning in elementary school. *International Journal of Trends in Mathematics Education Research, 6*(1), 26–32. https://doi.org/10.33122/ijtmer.v6i1.172

Suprayo, T., Noto, M. S., & Subroto, T. (2019). Ethnomathematics exploration on units and calculus within a village farmer community. *Journal of Physics: Conference Series, 1188*(1). https://doi.org/10.1088/1742–6596/1188/1/012104

Supriono, P. (2016). *Ensiklopedia The Heritage of Batik Identitas Pemersatu Kebanggaan Bangsa [Encyclopedia of The Heritage of Batik, Unifying Identity, National Pride]*. Andi Offset Yogyakarta.

Umbara, U., Wahyudin, W., & Prabawanto, S. (2021). How to predict good days in farming: ethnomathematics study with an ethnomodelling approach. *JRAMathEdu (Journal of Research and Advances in Mathematics Education), 6*(1), 71–85. https://doi.org/10.23917/jramathedu.v6i1.12065

Wahida, A., Handayani, E. S., & Supriyadi, S. (2020). The Philosophical Values of Kawung Batik Motif in Contemporary Batik Painting. *Mudra Jurnal Seni Budaya, 35*(1), 76–82. https://doi.org/10.31091/mudra.v35i1.1001

Wahyudi, H., Widodo, S. A., Setiana, D. S., & Irfan, M. (2021). Etnomathematics: Batik Activities In Tancep Batik. *Journal of Medives : Journal of Mathematics Education IKIP Veteran Semarang, 5*(2), 305–315. https://doi.org/10.31331/medivesveteran.v5i2.1699

Wahyuni, & Pratiwi, S. H. (2023). Ethnomathematics in Aceh Coastal Children's Football Game. *Jurnal Ilmiah Sekolah Dasar, 7*(1), 150–158. https://doi.org/10.23887/jisd.v7i1.49924

Widjanarko, H., Utomo, H. S. & Suratna. (2023). Unlocking Success for Cultural Tourism Villages in Yogyakarta: Insights from Wukirsari Village. In B. Sobirov, D. Sugandini & M. T. Multazam (Eds.), *Proceedings of the International Conference on Advance Research in Social and Economic Science (ICARSE 2022)* (pp. 505–511). Atlantis Press. https://doi.org/10.2991/978–2-38476–048–0_53

Zulkardi, Meryansumayeka, Putri, R. I. I., Alwi, Z., Nusantara, D. S., Ambarita, S. M., Maharani, Y. & Puspitasari, L. (2020). How Students Work With Pisa-Like Mathematical Tasks Using Covid-19 Context. *Journal on Mathematics Education, 11*(3), 405–416. https://doi.org/10.22342/jme.11.3.12915.405–416