Ethnomodeling on Activities of Giriloyo Hand-Written Batik Craftsmen

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Abstract

School mathematics is often considered formal and rigid, so it requires a culture-based learning approach, namely ethnomathematics. Many ethnomathematics studies in cultural communities have been carried out, but have not yet touched on pedagogical aspects, so an ethnomodeling approach is needed. One of the cultural communities that still survives in Yogyakarta is the Giriloyo Yogyakarta batik craftsman community. This research aims to explain the activities of the Giriloyo batik craftsman community from an ethnomathematics and ethnomodeling perspective. The method used in this research is qualitative research with a phenomenographic and ethnomethodological approach. The subjects of this research were 5 hand-written batik craftsmen in Giriloyo Yogyakarta. Data collection techniques include participant observation and interviews. The analysis techniques in this research include domain, taxonomy and content analysis. Based on the research results, it was found that the activity of making batik contains mathematical activities which include measuring, calculating, playing, explaining, determining location, and designing. the concept of geometric transformation which includes rotation, reflection, translation and dilation is also found in the motif. This activity can be applied to mathematics learning at school which includes literacy, numeracy and collaboration activities with technology.

Keywords: Ethnomathematics, Ethnomodeling, batik activity.

Most Indonesian students still consider Mathematics to be a difficult subject. This is because there are many formulas that have to be memorized and involve numbers. The teacher asks students to understand the formula and apply the formula in routine questions. School mathematics seems like a science that is far from everyday life. As a result, when students encounter problems in life, they are unable to apply the mathematical concepts they learn at school (Hwang & Ham, 2021). Therefore, teachers need to teach mathematics to students starting from things that are closest to the students' world and get them used to solving non-routine or contextual problems (Chirove, M., Mogari, D., 2022). Students' ability to use their mathematical concepts to solve everyday problems is often called mathematical literacy.

Mathematical literacy is a person's ability to solve everyday problems using mathematical concepts efficiently (Hapsari, 2019). Mathematical literacy also includes students' ability to use mathematics as a tool to analyze, explain and predict the results of a given problem. Indonesian students' mathematical literacy is currently still relatively low, this is

shown by the results of the 2023 PISA assessment where Indonesia ranks at the bottom among 81 countries (OECD, 2023). One of the causes of the low literacy skills of Indonesian students is that students are not used to solving daily life problems, and are more likely to memorize formulas (Ulfah, H. K., and Fuad, Y., 2019). Therefore, a contextual approach to mathematics is needed, one of which is the cultural approach or better known as ethnomathematics.

Ethnomathematics as a study in mathematics has an important role in exploring mathematical concepts that originate from culture (Wulandari, D. U., Mariana, N., Wiryanto, Amien, M. S., 2024). Ethnomathematics is research that connects mathematics and culture in a particular cultural community (Fouze & Amit, 2023). Ethnomathematics has opened up a lot of research on cultural communities (Alghar & Radjak, 2024), starting from calculation systems (Charitas, Prahmana, Yunianto, Rosa, & Orey, 2021), traditional ceremonies (Kholid, Fitriana, Adnan, Hendriyanto, & Sahara, 2022), decorations (Abdullah, 2020), traditional games (Wahyuni & Pratiwi, 2023), temple (Andriani & Marsigit, 2020), and so on. Ethnomathematics is mathematical research applied by cultural groups, in the form of Artifacts, mentifacts, and sociofacts (Rosa. M. & Orey. D. C., 2023). Ethnomathematics is the meeting point of cultural anthropology, mathematical modeling, and mathematics (Hendriyanto et al., 2023). Ethnomathematical studies on Indonesian culture have been widely carried out. One of them is an ethnomathematics study of batik.

Batik is one of Indonesia's intangible heritages which has been recognized by UNESCO. Almost every region in Indonesia has its own batik motif. One of the cities famous for batik is Yogyakarta and Surakarta. The results of ethnomathematics exploration on Surakarta and Yogyakarta batik are numerous, but research on batik motifs is still dominated by ethnomathematics explorations on Surakarta batik motifs (Astriandini & Kristanto, 2021), Yogyakarta batik (Risdiyanti & Prahmana, 2018), Sidomukti batik (A. A. Abdullah et al, 2024), Gringsing batik (Permita, Nguyen, & Prahmana, 2022), Kawung batik (Syahdan, 2021), Gedog batik (Wati, Mutamainah, Setianingsih, & Fadiana, 2021), truntum batik (Nurcahyo, Ishartono, Pratiwi, & Waluyo, 2024), and others. Several mathematical concepts have been discovered in batik motifs through ethnomathematics exploration. However, the exploration of batik motifs has not yet touched on the application and development of mathematical modeling in pedagogy (Orey, 2010). Apart from batik motifs, the concept of ethnomathematics is also found in the activity of making written batik. Written batik is batik made by maintaining the original tradition of making batik, namely by canting. These written batik craftsmen still survive amidst the development of stamped and printed batik.

Mathematical modeling from the results of the exploration of ethnomathematic studies of a culture in pedagogy is known as ethnomodeling (Orey, 2010). Ethnomodeling studies the ethnomathematics practices of a community group by involving mathematical formulas (Orey. D. C. & Rosa. M., 2021). Ethnomodeling has 3 approaches, namely emic, etic, and dialogue (Rosa & Orey, 2022). The emic approach is a way of understanding and describing a culture from the perspective of the culture owner. The etic approach is a way to understand and describe a culture by referring to the researcher's point of view. The dialogue approach is to synchronize emic and ethical. Aspects of ethnomathematics, cultural anthropology, and mathematical modeling are the constituent components of ethnomodeling with strict verification to emerge mathematical values from mathematical practice in the real world (Umbara, Wahyudin, & Prabawanto, 2021a). Based on the description above, the researcher views this as interesting research when it is able to explore the activities of Giriloyo Yogyakarta batik craftsmen, especially regarding the transformation of the

ethnomathematics concept into an ethnomodeling concept so that it can have useful value in the pedagogical aspect for developing mathematics curriculum in schools.

Methods

Qualitative research with a phenomenographic and ethnomethodological approach was applied in this research. Phenomenography is a research approach that aims to explore people's lives based on a cultural perspective. The ethnomethodological approach aims to explain social reality using common sense which is carried out continuously. The exploration of ethnomathematics in this research is based on fundamentalist mathematical activities which include discovering, designing, explaining, calculating, measuring, and playing (Fitriyani & Abdullah, 2022), (Fadillah et al., 2024). The ethnomodeling in this research uses emic, etic and glocal/dialogical approaches.

The research design in this study is an ethnographic design. The research design in this study is an ethnographic design. Ethnography aims to describe, interpret and analyze in depth the culture of a group (Creswell, 2009). The ethnographic research design in this research aims to explore ethnomathematics in the Giriloyo Yogyakarta written batik craftsman community. The researcher adopted the ethnographic category in this research procedure, so that the setting of the research subject was left natural (no treatment), but the researcher played the role of participant observation. This procedure aims to examine in depth the traditions of the Giriloyo Yogyakarta hand-written batik craftsman community in daily life so that new ideas or ideas can be discovered.

The research was conducted in Giriloyo Village, Wukirsari, Bantul, DIY. In order to obtain data validity, the subjects in this research were key informants, main informants and supporting informants. The selection of research subjects was based on the following criteria;

a. The informant is the head of the Giriloyo Yogyakarta batik craftsman who often interacts with the Giriloyo Yogyakarta batik craftsman community

b. The informant is the head of the Giriloyo Yogyakarta written batik craftsmen who is active in various activities carried out by the Giriloyo Yogyakarta written batik craftsmen community with frequent intensity.

c. The informant has a good understanding of the written batik making process carried out by the Giriloyo Yogyakarta batik craftsmen.

d. The informant has free time and is willing to provide the required information

e. Informants can use Javanese or Indonesian to convey information.

An ethnographic research design was used in data collection techniques through interviews and participant observation. Researchers are the main instrument in this research, while additional instruments include observation sheets, interview guides and ethnographic notes. The analysis techniques in this research include domain, taxonomy and content analysis.

Results and Discussion

The Giriloyo written batik community is the largest community of batik craftsmen using the writing method in Yogyakarta. This community still maintains the traditional method of making batik using canting and natural dyes which has been passed down for generations (Zubaedah & Hidayah, 2023). The Giriloyo hand-written batik community still exists to this day, maintaining its traditions, and has even become the center of hand-written batik in Yogyakarta. In the Giriloyo written batik community, a written batik making workshop is provided which is often visited by students, the arts community, and even foreign tourists (Anggarani Pribudi, 2020). Most of the written batik motifs made in the Giriloyo batik community are Yogyakarta palace motifs and Surakarta palace motifs (Mitasari, Zefanya, & Puspitasari, 2022). The process of making

written batik includes preparing the cloth, making a batik pattern on paper, tracing the pattern on the cloth, making batik or covering the pattern on the cloth with wax using a tool called a canting, adding color, and removing the wax by boiling (Mas, Basuki, & Astuti, 2022). Based on the results of observations, documentation and interviews in the Gililoyo batik craftsmen community, the following mathematical activities were found;

a. Calculation activities in the process of making written batik include calculating the number of candles and the number of colors needed in the process of making written batik. Counting activities also include counting the number of dots or lines on the batik pattern, this is closely related to the number of canting tips that will be used. Canting as a tool for batik has a variety of tip ranging from one tip to seven tips according to use.

b. The locating aspect is found in the process of making batik patterns on paper. To make it easier and keep batik motifs symmetrical, craftsmen use the help of Cartesian diagrams. This Cartesian diagram is very helpful in determining the location of the elements of batik so that they are parallel, symmetrical and proportional.

Figure 1. Cartesian Diagram as a Tool for Batik Patterns

c. The measurement aspect is when measuring the cloth to be painted, batik craftsmen usually use walls, floors and wood that have been marked to make the process of measuring the cloth easier. Craftsmen also use two fingers to determine the width of the uncolored batik edge. Craftsmen also measure the thickness of the line to determine the radius of the canting. Apart from having different numbers of tips, canting also has different widths, according to their respective functions

d. The design aspect is the activity that is most closely related to mathematics, especially pattern design on geometric batik motifs. Some geometric batik motifs have certain basic patterns, such as batik motifs with the prefix sido (sidomukti, sido drajat, sido asih, sido mulya) which have a basic pattern in the form of a rhombus, parang batik motifs (parang gendreh, parang rusak, parang barong, parang klitik) have a basic motif in the form of parallel lines with a slope. 45 degrees, the patch batik motif has a basic pattern in the form of a square which is divided into 4 triangles through its diagonals, the kawung batik motif has a basic pattern in the form of circles arranged to form an ellipse. Apart from drawing basic patterns, the process of drawing elements in geometric batik motifs is very closely related to geometric transformations, whether translation, reflection, rotation or dilation. This activity occurs naturally without the craftsmen realizing it. Almost all batik motifs apply geometric concepts in the form of geometric transformations.

e. The playing aspect is in determining the location and color of a motif by following a certain pattern to produce good variations of motifs, such as facing each other, opposite each other, or alternating. From this playing aspect, geometric batik can be arranged to form beautiful arrangements.

f. The explanatory aspect is found in explaining the philosophical meaning of the patterns created, such as the meaning of the four ellipses in Kawung batik which contain the meaning "sedulur papat limo pancer" (four brothers, five as the center) which means that at birth humans are accompanied by four things, namely the ari- ari, blood, umbilical cord, and amniotic fluid (Wahida, Handayani, &

Supriyadi, 2020). This philosophy reminds people of the origin of the event or is known as "sangkan paraning dumadi" in Javanese philosophy, three levels of the sido mukti motif which contains the triloka philosophy in Javanese philosophy. There are seven dots on cecek which means pitulungan. Each batik motif has its own meaning, so that the wearer also suits a particular event. Such as batik with the "sido" motif which means hope, worn at weddings (Budi, 2023), batik with patch motifs for childbirth and when sick, parang motifs worn by kings and the royal family (Supriono, 2016)

In batik motifs there are several mathematical concepts, one of which is the concept of geometric transformation which includes the concepts of rotation, reflection, translation and dilation. Geometric transformation is a change in a geometric element which includes its position, size and shape, which is caused by translation, dilation, matrix-related transformations, rotation, reflection, scale changes and the composition of two transformations. The details of the mathematical model for geometric transformations contained in batik motifs are as follows

a. Reflection is a change in the location of a point with the properties of a flat mirror. Figure 2 is example of x-axis and y-axis reflection in batik motif.

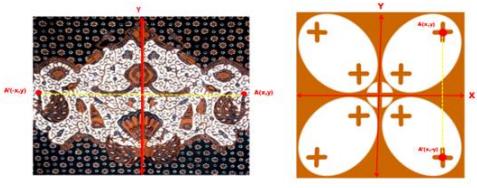

Figure 2 Reflection on the x-axis and y-axis

Reflection on the vertical Y axis, we can take the example of point A (x, y) in Figure 2 above being reflected on the Y axis, becoming A'(-x, y). The matrix equation in the case above is as follows;

$$A' = \begin{pmatrix} -x \\ y \end{pmatrix} = \begin{pmatrix} -1 & 0 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix}$$

$$-x = -1.x + 0.y$$

$$y = 0.x + 1.y \qquad (1)$$

Reflection on the X axis, for example, point A(x,y) Figure 2 is reflected on the X axis, becoming A'(x,-y). The matrix equation in the case above is as follows;

$$A' = \begin{pmatrix} x \\ -y \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix}$$

$$x = 1.x + 0.y$$

$$-y = 0.x + -1.y \qquad (2)$$

Rotation is a change in the location of a point by rotating it around a certain center, in a certain direction, and at a predetermined rotation angle. The concept of rotation can be found in batik motif, as in Figure 3.

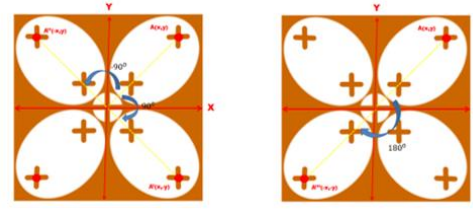

Figure 3. Rotation in Kawung batik with center at O(0,0) is 90^0, -90^0, and 180^0

Rotation of point A(x,y) by 90^0 with center at point O(0,0) clockwise in Figure 3. produces A'(x,-y). The matrix equation in the case above is as follows;

$$A' = \begin{pmatrix} x \\ -y \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix}$$

$$x = 1.x + 0.y$$

$$-y = 0.x + -1.y \qquad (3)$$

The rotation of point A(x,y) of 270^0 with the center at point O(0,0) clockwise is the same as the rotation of A of 900 with the center at point O(0,0) counterclockwise in Figure 3., resulting

in A" (-x,y). The matrix equation in the case above is as follows;

$$A'' = \begin{pmatrix} -x \\ y \end{pmatrix} = \begin{pmatrix} -1 & 0 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix}$$

$$-x = -1.x + 0.y$$

$$y = 0.x + 1.y \qquad (3)$$

The rotation of point A(x,y) is 180^0 with the center at point O(0,0) clockwise in Figure 3., producing A'"(-x,-y). The matrix equation in the case above is as follows;

$$A' = \begin{pmatrix} x - \\ -y \end{pmatrix} = \begin{pmatrix} -1 & 0 \\ 0 & -1 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix}$$

$$-x = -1.x + 0.y$$

$$-y = 0.x + -1.y \qquad (5)$$

c. Translation is the shift of a point from a certain position to a certain direction in a straight line on a flat plane. The concept of translation can be found in batik motif, as in Figure 4.

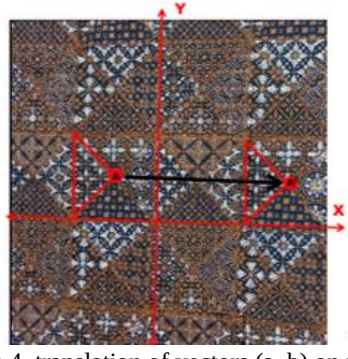

Figure 4. translation of vectors (a, b) on patched batik motifs

Translating point A(x,y) to vector (a,b) in Figure 4 produces P(x+a, y+b). The matrix equation in the case above is as follows;

$$A' = \begin{pmatrix} x \\ y \end{pmatrix} + \begin{pmatrix} a \\ b \end{pmatrix} = \begin{pmatrix} x + a \\ y + b \end{pmatrix} \qquad (6)$$

d. Dilation is a change in the size of an object with a certain scale and a certain center. The concept of dilation can be found in batik motif, as in Figure 5.

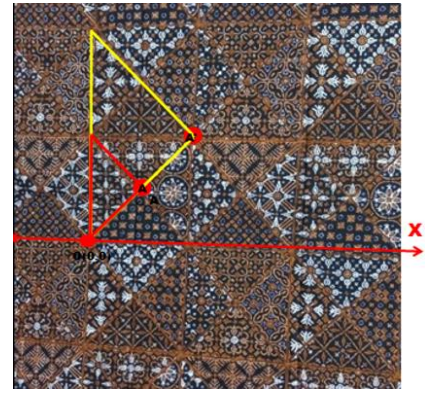

Figure 5. Dilation of scale k on the patched batik motif

For example, if we take point A (x, y) then enlarge it to scale k with the center at O(0,0), it will produce A'(k.x, k.y). The matrix equation in the case above is as follows;

$$A' = \begin{pmatrix} k & 0 \\ 0 & k \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} k.x + 0.y \\ 0.x + k.y \end{pmatrix} = \begin{pmatrix} k.x \\ k.y \end{pmatrix} \qquad (7)$$

If viewed from the perspective of applying ethnomodeling to the mathematics curriculum, ethnomodeling learning on batik motifs fulfills three components, namely literacy, Matheracy, and Technoracy (Umeh, E. C And Rosa, 2022).

a. Literacy, the ability to understand and use mathematic tools to solve everyday problems (Hapsari, 2019). The teacher's role in making batik a learning context in the classroom is very important. This is because batik is clothing that is attached to student life. Even though many students often wear batik clothes, very few know the names of batik motifs, types of batik, the philosophical meaning of the motifs, who can wear them, and when they should be worn. Literacy about batik really needs to be taught so that students understand the beauty of their culture. In this ethnomodeling, students see batik not only from an artistic and cultural perspective.

But batik as an intangible culture contains mathematical concepts. Students look at batik motif patterns in detail, read, study and analyze the mathematical concepts contained therein. Students can also be invited to observe and practice making written batik to directly experience the value of this batik. By directly experiencing the process of making batik, students will gain invaluable experience.

b. Matheracy/numeracy, the ability that students develop to analyze and interpret mathematical models that develop in cultural communities, whether in the form of artifacts, mantefacts, or social facts. After knowing the mathematical concepts in batik motifs, students then look for mathematical models contained in these batik motifs. The mathematical model can be adapted to the material taught by the teacher. In general, batik motifs, both geometric and non-geometric, contain concepts including [a] geometric transformation, this is because in one batik cloth, there are repetitions of patterns, the elements in batik patterns are symmetrical and paired (Prahmana & D'Ambrosio, 2020), the elements in Batik patterns influenced by Javanese philosophy rotate clockwise around a central point. [b] the concept of flat shapes, this is because the basic patterns in batik include squares, rhombuses, circles, and parallelograms. [c] the concept of rows and arithmetic series, this can be seen in the arrangement of the same elements in batik motif patterns (Safitri, Latifah, & Angelani, 2022). Non-geometric batik motifs contain the concept of fractal geometry (Dewi, Yudianto, & Susanto, 2022), but this concept is not included in the school curriculum for both elementary and high schools.

c. Technoracy is the ability to use technology in the form of calculators, applications, or software to redesign artifacts, mantifacts, and ideas using the mathematical concepts learned. In this batik ethnomodeling, students are asked to redesign batik motifs using the geogebra application (Sartika & Saputra, 2024). In the redesign process, students use mathematical concepts such as drawing flat shapes, geometric transformations which include translation, dilation, reflection and rotation. The geogebra application is used because it can be easily used by students either via PC or smart phone (W Widada, D Herawaty, 2021). Next, students can develop new batik motifs after mastering the concept of existing batik motifs, either by combining previous batik motifs, or by developing new batik motif models according to what students like. This activity will be very interesting, because students can develop creativity with technology, without having to leave local culture.

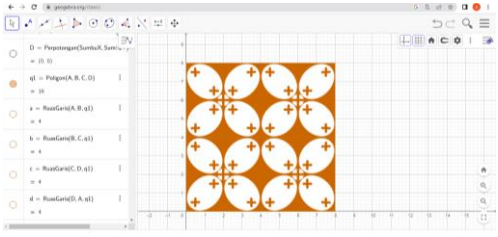

Figure 6. Kawung batik motif pattern with Geogebra application

The concept of learning mathematics with the context of batik motifs can be done outside the classroom, such as visiting a batik museum, a batik making workshop in a batik tourist village, or practicing batik in the school garden. Meanwhile, in the classroom this can be done by redesigning students using smart phones or practicing in the computer laboratory. Teachers can also collaborate with art teachers and information technology teachers to develop STEAM [Science, Technology, Engineering, Arts, and Mathematics] based projects (Rodríguez-Nieto & Alsina, 2022). This learning will be very interesting and provide deep meaning to students. This is because students gain direct experience in designing and developing mathematical concepts from their culture. Batik motifs are an example of a cultural artifact that can be used as a context for learning mathematics, there are many other artifacts such as temples (Andriani & Marsigit, 2020), cultural

heritage buildings (Bakhrodin, Istiqomah & Abdullah, 2019), and others. Likewise, the mathematical concepts contained in artifacts are not limited to geometric transformations, the concept of flat shapes, arithmetic sequences and series. Three-dimensional artifacts certainly contain the concept of spatial structure (Abdullah, A. A. And Rahmawi, 2021). Many algebraic concepts are contained in buying and selling systems, good days calculation systems (Umbara, Wahyudin, & Prabawanto, 2021b), and so on. In the end we can conclude that mathematical concepts are deeply embedded in the culture around students.

Conclusion

Mathematics is an integral part of culture. Exploration of mathematical concepts in culture needs to be continued with ethnomodeling to be pedagogically meaningful. The activity of making hand-drawn batik contains mathematical activities that include measurement, calculation, games, explanations, location determination, and designing. the concept of geometric transformation which includes rotation, reflection, translation and dilation is also found in the motif. This activity can be applied to mathematics learning which includes literacy, numeracy, and collaboration with technology.

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