



The Exploration of Geometrical Concept in Batik Pamekasan

Dimas Danar Septiadi¹, Ahmad Wachidul Kohar², Akmalus Sholehein³, Moh. Zayyadi⁴,
Hasan Basri⁵

¹Jl. Panglegur Km. 4 Pamekasan, IAIN Madura, septiadi.dimasd@iainmadura.ac.id

²Jl. Ketintang, Universitas Negeri Surabaya, ahmadkohar@unesa.ac.id

³Jl. Panglegur Km. 4 Pamekasan, IAIN Madura, jehonpark201@gmail.com

⁴Jl. Panglegur Km. 3.5, Universitas Madura, zayyadi@unira.ac.id

⁵Jl. Panglegur Km. 3.5, Universitas Madura, hasan_basri@unira.ac.id

ABSTRACT

Indirectly, mathematical themes can be found throughout Indonesia's unique culture, one of which is mathematics in batik cultural items. Exploring ethnomathematics will be really beneficial for teacher in designing mathematics learning based on local culture. Apart from acquiring the concept of mathematics in Indonesian culture, it can also sharpen Indonesian culture's sense of love for the nation. The purpose of this study is to describe the philosophical meaning of the geometrical concepts contained in Pamekasan batik, the geometrical concepts contained in Pamekasan batik, and the implementation of Batik pamekasan as the context in learning geometry. This is ethnomathematics study which gather the data by observation and interview. The interview held two regions in Pamekasan with four informants. As a result, scholars aim to conduct an ethnomathematics examination of traditional Pamekasan batik. This research shows that aside from the Batik itself, the mathematical objects found in Batik each have their own meaning and hopes. As a result, mathematical motifs such as the point that depicts a rice or maize seed have philosophical significance. Meanwhile, reflection reveals that human life requires balance. Each mathematical object in the pattern has its own meaning. Meanwhile, geometrical objects in Batik Pamekasan are two-dimensional figures such as circles, rectangles, squares, lines, points, angles, and curves. In addition, transformative geometry like as rotation, reflection, and translation exist in Batik Pamekasan. Besides, batik pamekasan can be used as the context in learning geometry. This can be seen from the learning outcomes that was written in Merdeka curriculum. Moreover, problem-based learning and project-based learning are two models that support ethnomathematics-based learning.

Keywords: *Ethnomathematics; Geometrical Concepts, Batik Pamekasan.*

Eksplorasi Konsep Geometri Pada Batik Pamekasan

ABSTRAK

Secara tidak langsung, tema matematika dapat ditemukan di seluruh budaya khas Indonesia, salah satunya adalah matematika pada benda budaya batik. Mempelajari etnomatematika akan sangat bermanfaat bagi guru untuk mendsain pembelajaran matematika berbasis budaya lokal. Selain untuk memperoleh konsep matematika dalam budaya Indonesia juga dapat mempertajam rasa cinta budaya Indonesia terhadap bangsa. Tujuan penelitian ini adalah untuk mendeskripsikan makna filosofis konsep geometri yang terkandung dalam batik Pamekasan, konsep geometri yang terkandung dalam batik Pamekasan, dan implementasi Batik pamekasan dalam konteks pembelajaran geometri. Ini adalah studi etnomatematika yang mengumpulkan data melalui observasi dan wawancara. Wawancara dilakukan di dua daerah di Pamekasan dengan empat informan. Akibatnya, para sarjana bertujuan untuk melakukan pemeriksaan etnomatematika batik tradisional Pamekasan. Penelitian ini menunjukkan bahwa selain Batik itu sendiri, objek matematika yang terdapat pada Batik memiliki makna dan harapan masing-masing. Akibatnya, motif matematis seperti titik yang menggambarkan biji padi atau jagung memiliki makna filosofis. Sedangkan refleksi mengungkapkan bahwa kehidupan manusia membutuhkan keseimbangan. Setiap objek matematika dalam pola memiliki arti tersendiri. Sedangkan objek geometris pada Batik Pamekasan adalah bangun ruang dua dimensi seperti lingkaran, persegi panjang, bujur sangkar, garis, titik, sudut, dan kurva. Selain itu, geometri transformatif seperti rotasi, refleksi, dan translasi ada di Batik Pamekasan. Selain itu, batik pamekasan dapat dijadikan sebagai konteks dalam pembelajaran geometri. Hal ini terlihat dari capaian pembelajaran yang tertuang dalam kurikulum Merdeka. Selain itu, pembelajaran berbasis masalah dan pembelajaran berbasis proyek adalah dua model yang mendukung pembelajaran berbasis etnomatematika.

Kata Kunci: Etnomatematika, Konsep Geometri, Batik Pamekasan

1. Introduction

Sources of learning mathematics are not only obtained from technological developments, but can be obtained from cultural exploration which is commonly known as ethnomathematics. Ethnomathematics can be interpreted as a step or perspective applied by certain cultural groups in carrying out mathematical activities [1]. This view of mathematics validates and confirms everyone's experience of mathematics because it shows that mathematical thinking is embedded in their lives [2]. Along with the development of various cultures in Indonesia, of course the perspectives and steps are different according to the cultural practices of each [3], [4], [5].

Rosa and Orey argue that in an ethnomathematics perspective, mathematical thinking is developed in different cultures according to the general problems encountered in the cultural context [6], [7], [8], [9]. According to D'Ambrosio, the goal of ethnomathematics is to recognize that there are various approaches to applying mathematics while taking into account the academic mathematical knowledge developed by various societal sectors and the various ways that various cultures negotiate their mathematical practice (including how to group, count, measure, design objects or games). As a result, it is possible to describe

ethnomathematics as a cultural anthropology of mathematics [10], [11], [12], [13], [14], [15].

Recognizing that there are several ways of expressing and practicing mathematics outside of formal education in schools is the goal of ethnomathematics. One of the earliest cultural gems of Indonesia that has been passed down from our ancestors is batik. Batik is a type of pictorial fabric that is traditionally created by writing on the fabric using a specialized method that has its unique qualities. Batik, according to Ramadanti et al [16], is a particular fabric that is manufactured specifically and contains features that allow the general public to recognize it right away. Batik, on the other hand, is a fabric with a lovely shape that is specifically created, namely by utilizing batik wax as a barrier material in the coloring process [17], [18], [19], [20]. Seeing the importance of the perspective of the existence of mathematics in that culture, making ethnomathematics exploration very important as an alternative source of learning mathematics.

It is inevitably that every region in Indonesia has their uniqueness related to their culture. This is also happened in Batik. Batik is the unique product from Indonesia. It can be seen that there are a lot of batik motif from all around Indonesia. Furthermore, this must be very interesting in talking batik as cultural products. Similar to this, Pamekasan, as part of Madura Island, has unique motif and technique in Batik [21]. Moreover, compare to the other region in Madura, batik Pamekasan has a distinction motif and painting technique. The Batik Pamekasan artists, moreover, are able to export their products. According to this, researchers interested in paying attention Batik Pamekasan as their concern.

Several studies on ethnomathematics inquiry have now been conducted, particularly in the context of batik or batik. However, there hasn't been a lot of ethnomathematics research that looks at a culture as a whole. Mathematical studies previously available in scientific papers are only related to the notion of motives supplied by numerous regions with unique, varied, and separate outcomes. This study looks on the ethnomathematics inherent in typical Solo batik. By merging anthropological and mathematical conceptual concepts, ethnomathematics inquiry is carried out in an innovative method. However, this investigation is limited to solo batik. Apart from that, Zayyadi also conducted ethnomathematics exploration on Madura batik [2]. In his research, Zayyadi emphasized more on the results of the mathematical concepts contained in Madura batik. However, an immature anthropological approach is emphasized, as is Anggraen et al [21]. They emphasize more on how a mathematical concept is embodied in the motif of a batik in Surakarta. The ethnic side that should be contained in ethnomathematics has not been clearly defined.

Based on this background, the researcher is interested in exploring ethnomathematics on the culture of making batik of the Pamekasan. There are three objectives that the researcher wants to describe, namely to describe the philosophical meaning contained in the geometric motifs on Pamekasan batik, to describe the mathematical concepts contained in Pamekasan batik motifs, and the describe how ethnomathematics in Batik Pamekasan works mathematical instruction.

2. Methods

This research is qualitative research with ethnomathematics approach. It means that researchers explore the mathematical concepts that exist in making batik at Pamekasan region and then, the result is described qualitatively. Researchers used interview and observation in gathering the data. The main instrument used in this research is *human instrument* as the main characteristics of qualitative research. Meanwhile, to guide researchers in conducting interview and observation, researchers used interview and observation sheets. Researchers used semi-structured interview which mainly guided by

interview sheet while the further/detail question depended on respondents' result. The interview and observation relate to the meaning of Pamekasan motifs, the way how to make the batik, and how the products are sold. The observation held in two villages in Pamekasan, namely Klampar, and Larangan. These become the representation of Pamekasan as one of the producers of traditional Batik in East Java. To analyze the data, researchers used Miles, Huberman, and Saldana steps. The step can be seen in Figure 1.

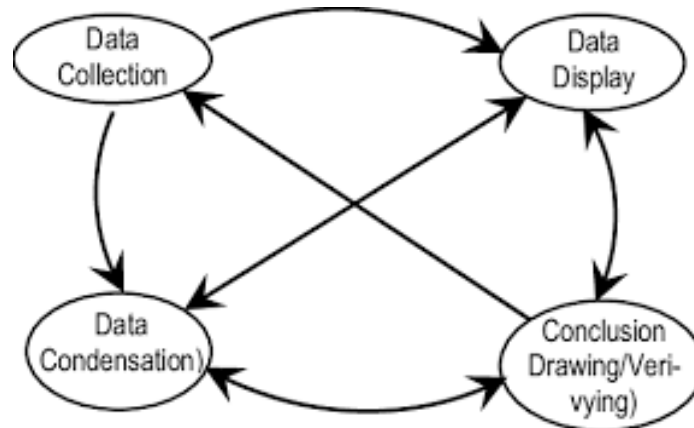


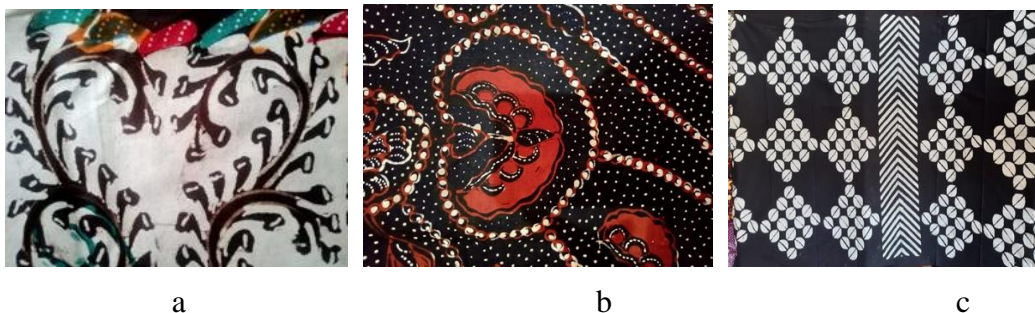
Figure 1. Steps in doing research

It can be seen in Figure 1 that these steps consist of data collection, data condensation, data display, and verification [22]. As illustrated, researchers used this as interactive model in analyzing the data.

3. Result and Discussion

Philosophy perspective toward geometrical motif in Batik Pamekasan

After the research conducted, Batik Pamekasan mostly dominated by natural object. It can be in the form of either plants and flowers or animals. However, some people still make non-biological objects pattern. Researchers also classified there are two main things in Batik Pamekasan about its shapes and pattern, which are regular shapes (shaped) and irregular shape (unshaped). There are 3 batiks as the main object in this research. Those batik can be seen in Figure 2.a, b, and c.



a

b

c

Figure 2. Traditional Batik pattern from Pamekasan Regency.

From Figure 2 above, researchers analyze the mathematical concept exist in those batik. The analysis of Batik a, b, and c then performed in Table 1, Table 2, and Table 3 respectively. Figure 2a shows a plant pattern. Most of the picture consist of leaves, flowers, etc. meanwhile, Figure 2b shows an animal mixed with plants pattern. In this pattern, animal is not the main object. There are some plants and leaves become the other pattern or background. Finally, Figure 2c shows non-biological objects pattern. In this pattern consist of circle, and line pattern. The analysis of pattern in figure 1a is performed in Table 1.

Table 1. The mathematical concept that exists in Batik a




No	Motif	Mathematical Concepts	Local Term	Cultural/Philosophical Meaning
1		Reflection concepts	<i>Jeng bejeng</i>	This concept shows that in some shape, life must be balance, between the right and left side. That's why both origin and the mirror must be the same
2		Translation concepts	<i>Loros or Sepak</i>	The Pamekasan batik always contain such a <i>loros</i> or <i>sepak</i> motif. This is concept just part of decorative art to make it different from previous pattern
3		Abstract or unpattern	<i>Rombuh or Salbut</i>	This geometrical concept shows that in some part life cannot be patterned. Somehow, an arbitrary is needed.

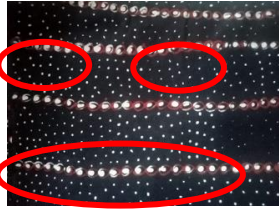


Table 1 shows that Figure 1a contains a transformative geometry object. The shape can be formed by reflects and moves the objects into another objects. Unfortunately, the transformative geometry in this pattern reflects and copies a plant pattern. From the interview, it can be seen that Batik Pamekasan consist of two types related to their pappttern.

“Batik Pamekasan itu kadang tidak bisa dijeneralisir polanya. Kenapa? Karena memang ada yang dibuat beraturan da ada yang tidak beraturan. Sesuai dengan kreativitas si pelukisnya. Tapi memang untuk motif-motif tertentu dia mempunyai makna yang berpola”

It can be seen from the interview transcript that Batik Pamekasan can be pattern or unpattern. This can be seen clearly in Figure no 3 Table 1. This concept can be found in the regular geometry objects or irregular geometry objects. All the pattern shows unique philosophy.

Different to the plants and flowers pattern, the animals pattern performs more attractive figures. In this pattern, there are combination among animals and flowers. The analysis of animal pattern can be seen in Table 2.

Table 2. The mathematical concept that exists in Batik b

Motif	Mathematical concepts	Local term	Cultural/Philosophical meaning
	Point	<i>Titek</i>	Every Pamekasan Batik always contain points in its motif. It shows a rice. There is such a wish that someone who wear that, he wishes not to be worry about their food (rice)
	Small Circle	<i>Bunter</i>	The circle shape in this batik has similar meaning. It shows a corn seed as the prior carbohydrate/staple food in Pamekasan.
	Curve	<i>Kurva</i>	Curve means that life is not easy. Somehow, people must turn right and then turn left and soon. This is as the opposite of being straight in a life.
	Line	<i>Garis</i>	No meaning (just decorative meaning)
	Reflection concepts	<i>Jeng bejeng</i>	This idea demonstrates that life must, in some way, strike a balance between the right and left sides. Because of this, the origin and the mirror must be same. This is demonstrated by the butterfly's design.
	Rhombus and rectangle	<i>Masaghi empa'</i>	No meaning (just decorative meaning)

From table 2 above it can be seen that, culturally, Pamekasan societies believe that rice represents the success and well-organized life. It shows that with the existence of rice, Pamekasan society will not get hunger. Therefore, their Batik always contain points which is represented the shape of rice. Beside rice, Pamekasan people eat corn as their prior carbohydrate or staple food. Therefore, this object become part of pattern in Batik which represented as small circle. Additionally, there are non-biological pattern in batik Pamekasan such as rhombus and rectangle. Pamekasan people do not believe anything in this pattern. This statement can be seen in the interview result:

“Sama dengan pola-pola tadi, motif di Batik pamekasan itu ada yang tetap, ada yang berubah, ada yang punya makna, dan ada yang engga. Semua bergantung dari pelukisnya. Jadi ada yang Cuma ya biar bagus aja gitu”

They just used it as a decorative pattern because the main object is the plant that exist in the rhombus and rectangle.

The last pattern in Batik Pamekasan is totally non-biological pattern as shown in Figure 1c. This pattern exists as the imagination of the creator. Therefore, the creators just consider about the geometrical object that exist around them, such as circle, rectangle, rhombus, etc. The analysis of this pattern can be seen in table 3.

Table 3. The mathematical concept that exists in Batik c

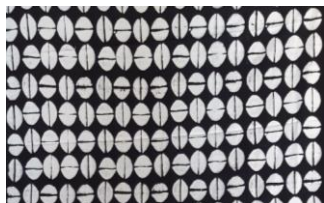
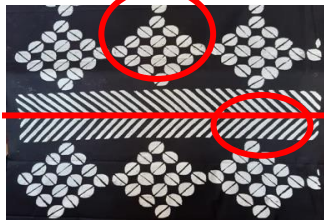


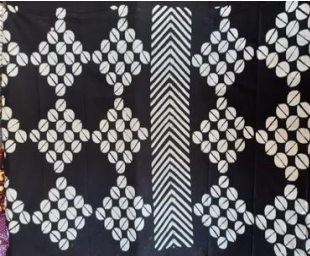
Motif	Mathematical concepts	Local term	Cultural/Philosophical meaning
	Circle	<i>Bunter</i>	Some believe this represented a corn seed. However, some others (in this Batik) believe that this is imaginative pattern.
	Rotation	<i>Aliyer</i>	It can be seen in the pattern “vertical” then changed to “horizontal” (in the circle). This shows that in human life, people can change, sometimes they are in above, sometimes they are in the bottom.
	Segment/line	<i>Garis</i>	Some people believe that life, sometimes, can be represented as a line which is straight (the opposite of curve)
	Angle	<i>Padhdhu</i>	No meaning (just decorative meaning)
	Square	<i>Masaghi</i>	No meaning (just decorative meaning)
	Reflection	<i>Jeng bejeng</i>	This concept shows that in some shape, life must be balance, between the right and left side. That’s why both origin and the mirror must be the same

Table 3 above shows that some pattern in Batik Pamekasan have philosophical meaning and just contain decorative meaning. In Batik c, the pattern is form by rotating the circle into several pattern. Rotation means, in this pattern, human life is never stable or steady. Sometimes people are above, and sometimes they move bellow. Therefore, they illustrate as a rotation of a pattern. As the opposite, consider about human life, there is a change that human life can be stable which is illustrated as a line. When the initial point of two lines/segments meets each other, then an angle is shaped. Therefore, this is just a decorative meaning. Meanwhile, the circle pattern in this batik shows a seed of corn which was believed that this is the staple food of Madurese people.

Geometrical concept in Batik Pamekasan

From three batik above, researchers then classified some mathematical concept that always exist in Batik Pamekasan. The mathematical concept can be seen in Table 4.

Table 4. The mathematical concept that exists in Batik Pamekasan

Pattern of batik	Mathematical concepts
 <p data-bbox="475 1122 729 1155">Plants and Flowers</p>	<ul style="list-style-type: none"> • Reflection • Translation • Abstract/unpattern
 <p data-bbox="544 1496 660 1529">Animals</p>	<ul style="list-style-type: none"> • Point • Small circle/circle • Curve • Line • Reflection • Rectangle
 <p data-bbox="453 1870 754 1904">Non-biological objects</p>	<ul style="list-style-type: none"> • Circle • Line • Angle • Square • Reflection • Rotation • Translation

As stated by Anggraen et al [21], Batik Surakarta contains transformation geometry as well as in Batik Pamekasan. She further emphasizes that in reflection the matrix of:

$$\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} \dots\dots\dots (1)$$

Equation 1 then reflects pattern No 1 in Table 1. It shows that the plant then reflects so that form different figure. Meanwhile, in pattern 2, it can be seen that translation also exist. It shows that Batik Pamekasan contains the equation 2.

$$\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} x + a \\ y + b \end{pmatrix} \dots\dots\dots (2)$$

To move or form such presented object such as no 2 objects, the equation 2 can be used. Another transformation geometry also exists in making Batik Pamekasan. The creators have to rotate the pattern such that new figure can be formed. The equation to form this figure can be seen in Equation 3

$$\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} \cos \alpha & -\sin \alpha \\ \sin \alpha & \cos \alpha \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} \dots\dots (3)$$

Even though the creators did not recognize about this concept, but mathematically it can be illustrated in forming pattern 3 (in Figure 1c). Meanwhile, no 3 in table 1 can be compared to non-particular objects such as unpattern polygon.

The concept of line is a unique thing. Actually, line is an abstract thing [21], [23]. In Batik Pamekasan, the idea of line, as stated by Tversky, does exist. The line can be formed as a straight line or the collection of points. The straight line is illustrated by pattern in Figure 1c, while line as collection of points can be seen in Figure 1b. in this figure, points as representation of corn seed or rice are arranged in order. While, angle is form by intersecting two lines such as in Figure 1c [9].

Another two-dimensional figure that exists in Batik Pamekasan is circle. Similar to the other Batik, from different region, circle is also existed. Circle is defined as collection of point that have similar distance to a point called a center. As the philosophy of Batik Pamekasan form, the concept of point as an axiom also formed [23], [24]. There are small points and big points, it depends on what objects are represented.

Ethnomathematics-based learning by using Batik Pamekasan

Based on the exploration above, it can be seen that Pamekasan batik can be used as part of learning mathematics. This learning is a mathematics learning based on ethnomathematics. There are several studies that have been conducted on the use of batik as a learning context [25], [26], [27]. In designing the learning activities, teachers have to find the connection between the context, Batik, and the curriculum content. In using Batik Pamekasan, teachers can use the two-dimensional figure chapter in grade 9 in the newest Indonesian curriculum (Kurikulum Merdeka)[28]. In that chapter students will learn the shape of two-dimensional figure as well as the transformative geometry. Students' will learn the property of transformative geometry as can be seen in Figure 2.

it can be seen in Figure 3 that the ordinary two-dimensional figures (triangle, rectangle, etc) can be illustrated as batik motifs. The property of reflection also can be seen, for example, $AA' \perp l$, as well as $BB' \perp l$. Besides, $|AO'| = |A'O'|$ and $|BO''| = |B'O''|$. Those properties also work in Batik Pamekasan. Consider about this, then we can map the basic competence in Merdeka Kurikulum with Batik Pamekasan as the context. This can be seen in Table 5.

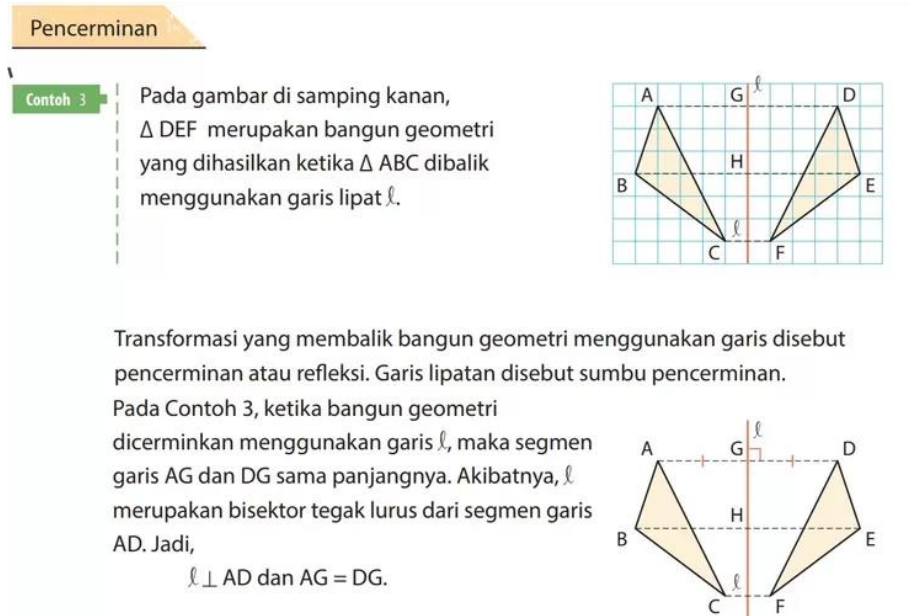


Figure 2. The reflection-sub in Merdeka Belajar Curriculum

It can be seen in figure 2 that students will learn about the property of reflection. In the studying this property, teacher can use the context of Batik Pamekasan. This can be seen in Figure 3.

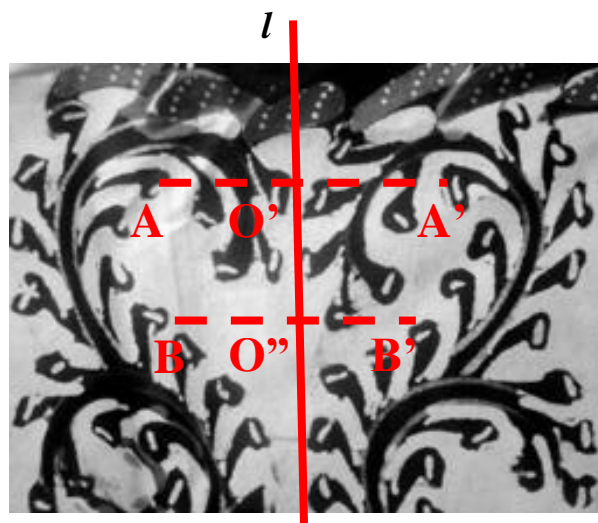
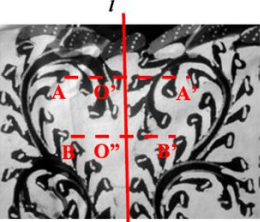

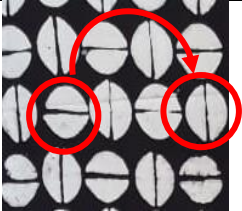


Figure 3. Reflection in batik Pamekasan as learning instruction

It can be seen from Table 5 that Batik Pamekasan is matched in the transformative geometry that was designed by government. This can be seen how the context can be used as reaching the learning outcomes as stated in Merdeka curriculum (as the 2023 Indonesian curriculum) [29][30]. Meanwhile, in the last learning outcomes, teachers are able to design it in accordance with project-based learning or problem-based learning methods [31]. Prahmana, furthermore, emphasize through his research that ethnomathematics can be used as one strategy in performing local culture context in teaching mathematics [21].

Table 5. The mapping of basic competence in Merdeka curriculum and Batik Pamekasan

Merdeka Curriculum			Batik Context
Element	Basic competence	Learning outcomes	
Geometry (Grade 9)	Students are able to perform single transformations (reflection, translation, rotation, and dilation) of points, lines, and plane shapes on the Cartesian coordinate plane and use them to solve problems.	Doing a single reflection of points, lines, and two-dimensional figures on the Cartesian coordinate plane.	
		Doing single translations of point, line, and two-dimensional figure translations on the Cartesian coordinate plane.	
		Doing a single rotation of points, lines, and plane shapes on the Cartesian coordinate plane.	
		Doing single dilatation of points, lines, and plane shapes on the Cartesian coordinate plane.	<i>Does not exist</i>
		Solving problems related to transformation.	Can be design by problem solving based learning

4. Conclusion

As part of local culture, Batik contributes a lot of things not only in social or economic field. Mathematically, there are a lot of concepts that can be explored. Batik Pamekasan contains unique meaning and story depends on the imagination of the creator. Beside the Batik itself, the mathematical objects that exist in Batik has a unique meaning and hopes. Therefore, the mathematical motifs have philosophical meaning such as point which illustrates a rice or corn seed. While reflection shows that human life must be balance. Every single mathematical object in its motif has its own meaning. Meanwhile, the geometrical object that exist in Batik Pamekasan is two-dimensional figure such as circle, rectangle, square, line, points, angle, and curve. Furthermore, there also exist some transformative geometry such as rotation, reflection, and translation in Batik Pamekasan. Batik Pamekasan, actually, can be used the context in learning transformative geometry. This can be seen in grade 9 of Merdeka curriculum that the learning outcomes are proper to Batik Pamekasan as the context. This research just explores ethnomathematics of Batik in Pamekasan region, therefore, we suggest to conduct further research in Madura in general. Besides, we need to use the result of ethnomathematics exploration to design mathematics learning kits.

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