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Exploring Local Culture through Geometry Transformation: a Study of Banyumasan Batik

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ABSTRACT

Banyumasan batik is one of Indonesia's cultural heritages from Banyumas Regency, which has unique and interesting patterns and motifs. This research paper describes the mathematical modelling of geometric transformations in Banyumasan batik. Geometric transformation is a mathematical technique for changing the shape or position of an object on a plane. This is qualitative research with an ethnographic approach. Data is collected through observation, interviews, and documentations. The data obtained were analysed using content analysis to identify various Banyumasan batik motifs that can be transformed into geometric forms. This study describes the basic geometric transformations, namely translations in Sekar Tirta batik motif, reflections in Bawor Kembar batik motif, dilations in Kawung Jenggot batik motif, and rotations in Manggar Bawor batik motif which applied to Banyumasan batik motifs. The results of this study include geometric transformations of Banyumasan batik motifs which are expected to positively contribute to the development of Indonesian art and culture, especially in the field of batik, enrich insight and knowledge about the application of mathematics in everyday life, and can be used for mathematical modelling and mathematics education based on local culture.

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A. INTRODUCTION

Education is closely related to culture; hence, it plays a central role in enriching students' learning experiences by maintaining a rich and diverse cultural heritage. Through education that focuses on culture, students can develop a deeper understanding of their cultural identity and appreciate and understand the diversity of cultures around them. According to Brion (2023), culture and education influence each other, and teachers can use cultural resources as learning tools for students. The study of Fatkhurohman et al. (2021) explain the compilation of mathematics and culture is called as ethnomathematics, where culture can be explained by mathematical concepts (Rosa & Orey, 2017).

One of the cultural heritages owned by the Indonesian nation is batik. Batik is an Indonesian cultural heritage recognized by UNESCO as a World Intangible Cultural Heritage. As such, batik is a brand of Indonesian national identity (Hakim, 2018). Banyumasan batik is one of the popular types of batik that is characterized by unique and interesting motifs. Banyumasan batik motifs are inspired by the local flora and fauna. Local wisdom values are reflected in several batik motifs such as manggar (coconut flower), bawor (Banyumasan puppet characters), and others. This shows evidence of public awareness of nature and the environment (Sholikhah et al., 2017).

The characteristics of Banyumasan batik motifs are diverse, slightly unique, and have different patterns from other regional batik motifs. Several Banyumasan batik motifs provide a painting pattern of plant tendrils as depicted in the Sekar Tirta, Manggar Bawor, and Manggar Banyumas motifs, which represent the dense forest in the Banyumas area in the past. The colors of Banyumasan batik are dominated by dark and dense colours, which symbolize harmony with nature (Luwistiana & Septianingsih, 2019). The example of Banyumasan batik can be seen in Figure 1.

Figure 1. Several Banyumasan Batik Plant Motifs

Many of the motifs in Banyumasan batik are influenced by Yogyakarta, Solo, and Pekalongan batik. The origin of the Banyumasan batik motif cannot be traced. According to information from elders and Banyumas batik artisans, Banyumas batik emerged because of the establishment of kademangan in the Banyumas area and the followers of Prince Diponegoro who fled to the Banyumas area. Currently, most of the Banyumas batik industry centres are located in Banyumas District (Pekunden Village, Pasingnggang, Sudagaran, Papringan) and Sokaraja District (Sokaraja Lor Village, Sokaraja Kidul, Sokaraja Tengah, Sokaraja Kulon, Karang Duren) (Ratnadewi et.al, 2021).

Historical and geographical factors unique to the people of Banyumas have fostered a unit of cultural ties known as the Banyumasan culture. The characteristics of this culture are democratic, with people from all social strata being honest and egalitarian. This cultural attitude is synonymous with the Bawor character in wayang or the Kudi weapon prized by the Banyumas people. Bawor is one of the inspirations for Banyumasan batik motifs. Banyumas batik has specific characteristics that make it unique, namely, the relationship between the name and the form of the motif is easy to comprehend, the motifs tend to be iconic, the motif structure is simple and straightforward, does not demonstrate a specific function, and can be used by anyone. Banyumas batik essentially expresses the cultural values of its people, is populist, and embodies egalitarianism (Purwanto, 2015), as shown in Figure 2.

Figure 2. Bawor Figures in Banyumasan Batik Motifs

The lack of records explaining the development of batik in Java has led to several speculations that the skills of Javanese batik were teachings from immigrants who spread culture in the North Coast region of Java Island and into the interior of Java Island. According to Inger Mc., Cone Elliot, in his book "Batik Fabled Cloth of Java," suggests that the term batik comes from the word dot. Batik in Indonesia began to develop concurrently with the development of Hinduism in Indonesia when Indonesian artists learned to make objects or items for religious worship, which indirectly gained knowledge about batik in India. The development of Banyumasan batik motifs was not only influenced by batik motifs from Central Java but also influenced by West Javanese batik motifs. Ratmini Sujatmoko has said that the ups and downs of Banyumasan batik occurred around 1970 with the emergence of the famous batik company Koo Siang Kie. Then around 1990, this company closed and was followed by H. Rosidi's company in Purwokerto in 1995 due to a lack of the next generation. The company that has continued to produce batik in the Banyumas area starting in 1957 until now is Hadi Priyanto's company (Hoei Loei). In 2003, the number of batik entrepreneurs in the area increased to around 12 people, employing approximately 446 workers. In 2004, the number of batik entrepreneurs in Banyumas Regency experienced an increase, with approximately 50 people joining the association of batik entrepreneurs in Sokaraja. Banyumas batik companies that have survived and are considered quite influential in the Banyumas area and its surroundings, apart from Hadi Priyanto's company, include Rusmini Darmono's company located in the Banyumas District and Anto Djamil's company located in the Sokaraja District (Apriliyanto, 2019).

Batik is one of Indonesia's cultural heritages that has its own unique characteristics. In Banyumasan batik, there are geometric motifs that can be used as objects in mathematical modeling, particularly in geometric transformations. Mathematical modelling involves describing a real-life phenomenon using mathematical language and theories and is characterized using certain mathematical concepts and techniques to inform reasoning (Prahmana & D'Ambrosio, 2020). Mathematical modelling can be applied in various disciplines, including in the context of Islam Ulpah & Novikasari (2020) and local culture, such as Banyumasan batik.

Geometry transformation is the study of a change in shape and position, and its representation in an image and matrix while preserving its geometric attributes. Geometry not only about how to find connection between other concepts but also to explore and investigate in everyday life (Budiarto & Artiono, 2019) and there are various ways to connect geometry to other study (Patkin, 2015). According to Jelatu et al. (2018), geometry is one of the essential materials in Indonesia that taught from elementary school level until college. Learning geometry provides the benefit of increasing the ability to think mathematically (Nopriana, 2014). Geometry transformation can also be used to describe motif variations in Banyumasan batik. Hence, geometric transformation mathematical modeling in Banyumasan batik has tremendous potential to be applied in various fields, such as art, design, and computer science. As such, studies Hollebrands et al. (2021) employ application-based tools to gain a better understanding of geometric transformation.

This article will explore the application of mathematical modelling of geometric transformations in Banyumasan batik, with a particular focus on the geometric motifs used. This study describes the basic geometric transformations, there are translations, rotations, reflections, and dilations applied to Banyumasan batik motifs. Geometry is a mathematical concepts that easy to find in everyday life (Wulandari, 2017). This research aims to demonstrate how mathematics can be applied to local arts and culture, as well as enhance our comprehension of geometric transformations.

B. METHODS

This is a qualitative research with an ethnographic approach. The subject of this research is Banyumasan batik motifs and the object is the concept of geometric transformation in the Banyumasan batik motifs. Data is collected through observation, interviews, and documentations. The research's method can be found in Figure 3.

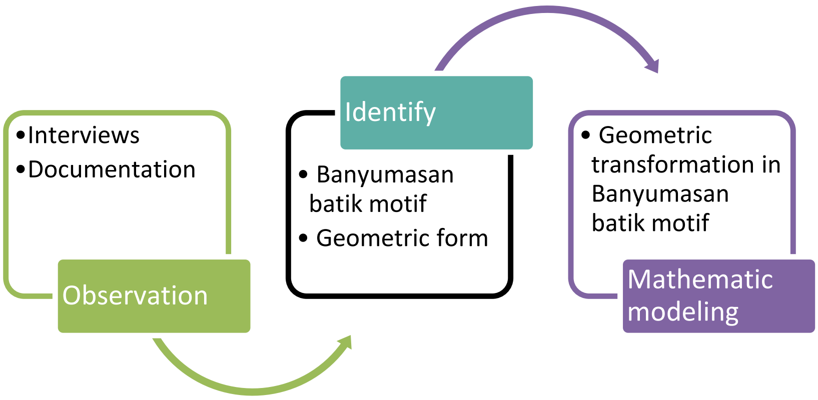

Figure 3. The research's method

Data obtained in this research came from direct observation as the result of interviews and documentation. Banyumasan batik motifs which described is batik motifs from Batik Banyumasan store in Kranji, Purwokerto Timur, Banyumas that provides Banyumasan batik motif from various craftsmen in Banyumas. This data obtained were analysed using content analysis to identify various Banyumasan batik motifs that can be transformed into geometric forms. This transformation provides another form of mathematical modelling, which can be applied in learning. According to Gross (2018), systematic document analysis is used to answer research questions. The visualization of batik motifs for geometric transformations in the Cartesian coordinate plane is done using the GeoGebra software. The results of the geometric transformation model can be used to create variations in Banyumasan batik motifs using the language of mathematics. The geometric transformation of the resulting Banyumasan batik motifs can be used as a mathematical modelling based on local culture. Making mathematical modelling means formulating problems following mathematical rules (Hartono & Karnasih, 2017). It is expected that these findings contribute to the development of applied mathematics studies related to local cultural arts, particularly Banyumasan batik, as well as modelling materials in mathematics education based on local culture.

C. RESULT AND DISCUSSION

Exploration of Banyumas batik by looking at the various motifs that exist in typical Banyumas batik. Mathematical modelling is described in geometric transformations and described in mathematical languages based on the original Banyumasan batik motifs as follows.

1. Translation

Translation is a type of transformation that moves a point along a straight line with the direction and distance. It means, the translation is only a point displacement, as shown in Figure 4.

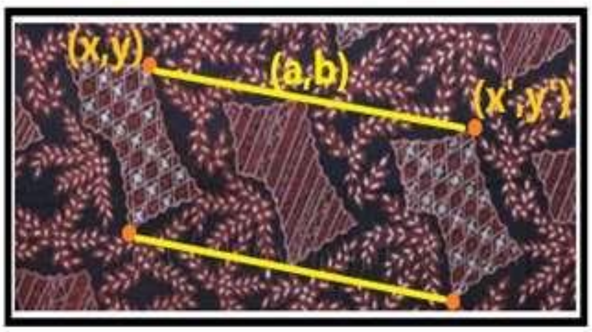

Figure 4. Translation on motif of Sekar Tirta's batik

The point *(x, y)* is translated by the vector *(a, b)* then it shifts to a point *(x', y')* so that it can be written in the following equation.

$$(x',y') = (a,b) + (x,y) \qquad (1)$$

Every single corner point in the irregular plane translated to the vector *(a, b)*, so that exactly the same or congruent planes will be formed at different coordinate points. The results of many translations of these irregular areas produce a batik pattern with the Sekar Tirta motif, which is typical of Banyumas. One of the motifs on the Banyumas Sekar Tirta batik is depicted in a cartesian coordinate plane. The corner points of the motif are translated to certain vectors so that the corner points with the new coordinates of the translation results are obtained, as shown in Figure 5.

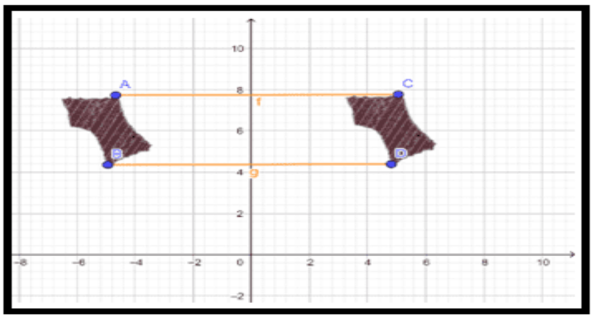

Figure 5. One of translation of the Sekar Tirta batik motifs on the Cartesian coordinate plane

Point A is translated to vector f to produce point C. Point B moves to the position of point D after being translated to vector g. If every corner point on the motif is translated, it will produce another motif shape that is exactly same as the initial shape but on the different coordinate position. Translation is a type of transformation that moves a point or shape along a straight line with a certain direction and distance. Shifts can be made up, down, right, and left or a mixture of the four directions. That is, the translation is only the transfer of a point to another point position. The general translational mathematical equation can be written as follows.

$$P(a,b) \xrightarrow{T_1=\binom{h}{k}} P'(a+h, b+k) \quad (2)$$

P is the initial coordinate point, P' is the coordinate point after being translated to the translation vector T_1.

2. Reflection

The following is the batik motif of Bawor Kembar, as shown in Figure 6.

Figure 6. Bawor Kembar Batik Motif

On the Bawor Kembar batik motif, there is an image of the two Bawor motifs that are exactly the same but in an inverted or mirrored position. This is a form of geometric transformation, namely reflection, as shown in Figure 7.

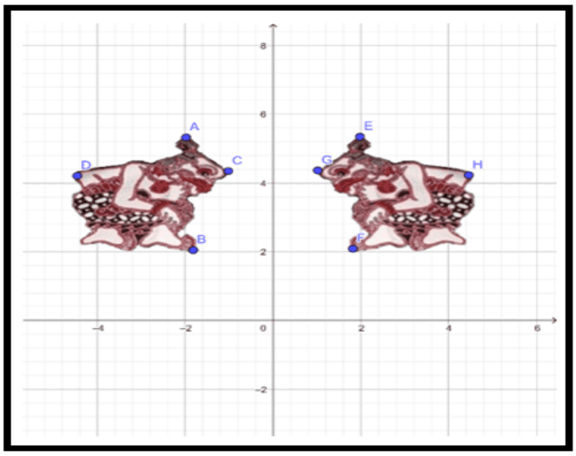

Figure 7. Reflection of Bawor Kembar Batik Motif

Point EFGH is reflected about the y-axis to produce ABCD points, as shown in Figure 8.

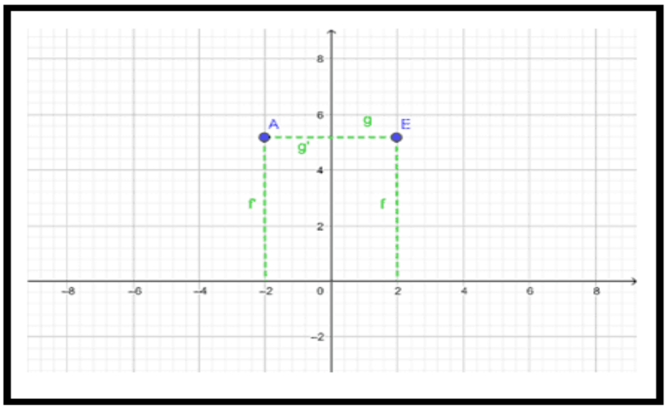

Figure 8. Reflection of point E on the y-axis produces point A

Transformation matrix for Figure 8:

$$E\ (g,f) \xrightarrow{y\ axis} A = \begin{pmatrix} g' \\ f' \end{pmatrix} = \begin{pmatrix} -1 & 0 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} g \\ f \end{pmatrix} = \begin{pmatrix} -g \\ f \end{pmatrix} \quad (3)$$

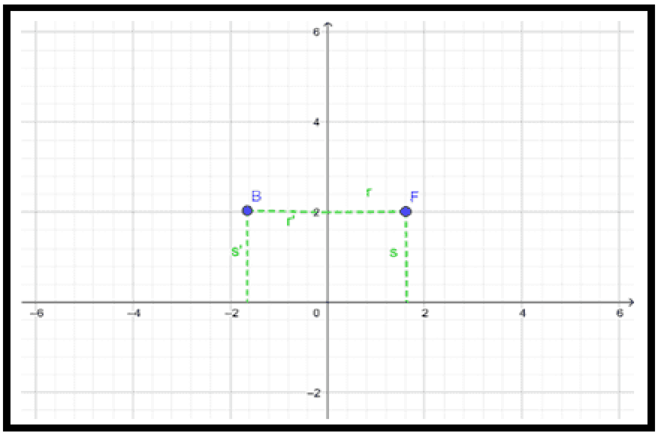

Figure 9. Reflection of point F on the y-axis produces point B

Transformation matrix for Figure 9:

$$F\ (r,s) \xrightarrow{y\ axis} B = \begin{pmatrix} r' \\ s' \end{pmatrix} = \begin{pmatrix} -1 & 0 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} r \\ s \end{pmatrix} = \begin{pmatrix} -r \\ s \end{pmatrix} \quad \dots (4)$$

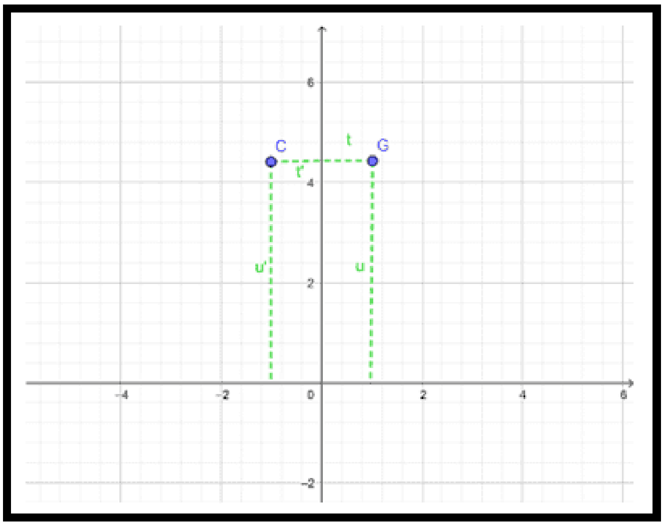

Figure 10. Reflection of point G on the y-axis produces point C

Transformation matrix:

$$G\ (t,u) \xrightarrow{y\ axis} C = \begin{pmatrix} t' \\ u' \end{pmatrix} = \begin{pmatrix} -1 & 0 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} t \\ u \end{pmatrix} = \begin{pmatrix} -t \\ u \end{pmatrix} \quad \dots (5)$$

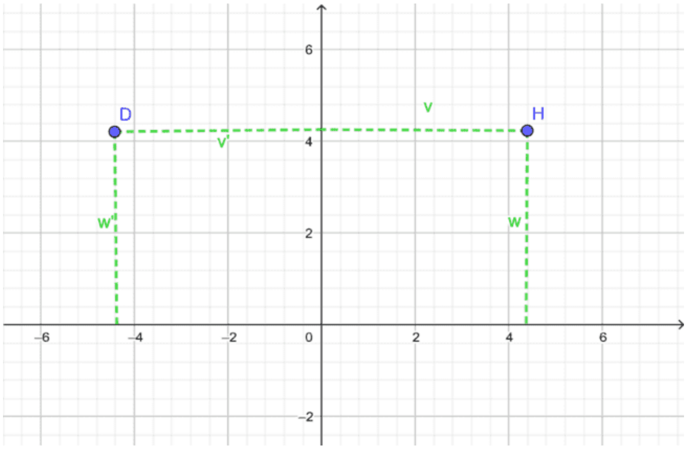

Figure 11. Reflection of point H on the y-axis produces point D

Transformation matrix:

$$H\ (v,w) \xrightarrow{y\ axis} D = \begin{pmatrix} v' \\ w' \end{pmatrix} = \begin{pmatrix} -1 & 0 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} v \\ w \end{pmatrix} = \begin{pmatrix} -v \\ u \end{pmatrix} \quad \ldots (6)$$

The result of the reflection of the EFGH point on the y-axis is the point ABCD, with the following coordinates.

$$E\ (g,f) \xrightarrow{y\ axis} A\ (-g,f)$$
$$F\ (r,s) \xrightarrow{y\ axis} B\ (-r,s)$$
$$G\ (t,u) \xrightarrow{y\ axis} C\ (-t,u)$$
$$H\ (v,w) \xrightarrow{y\ axis} D\ (-v,w)$$

3. Dilatation

The Kawung Jenggot Banyumasan batik motif has certain characteristics compared to the kawung motifs in other regions. Symmetrical motifs that are continuous with various basic colours of the fabric, as shown in Figure 12.

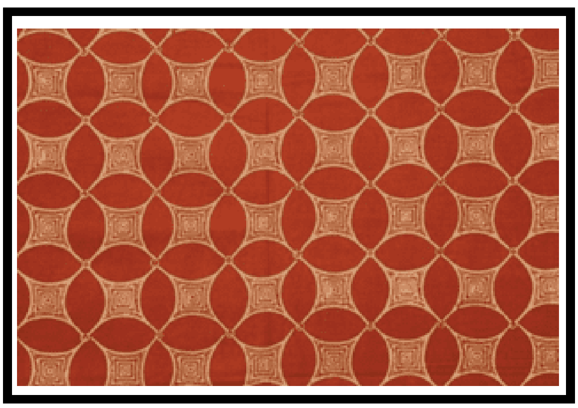

Figure 12. Kawung Jenggot Batik Motif

The Kawung Jenggot batik motif has a similar pattern that is not congruent. In mathematics, there is a dilation geometric transformation as shown in the Figure 13.

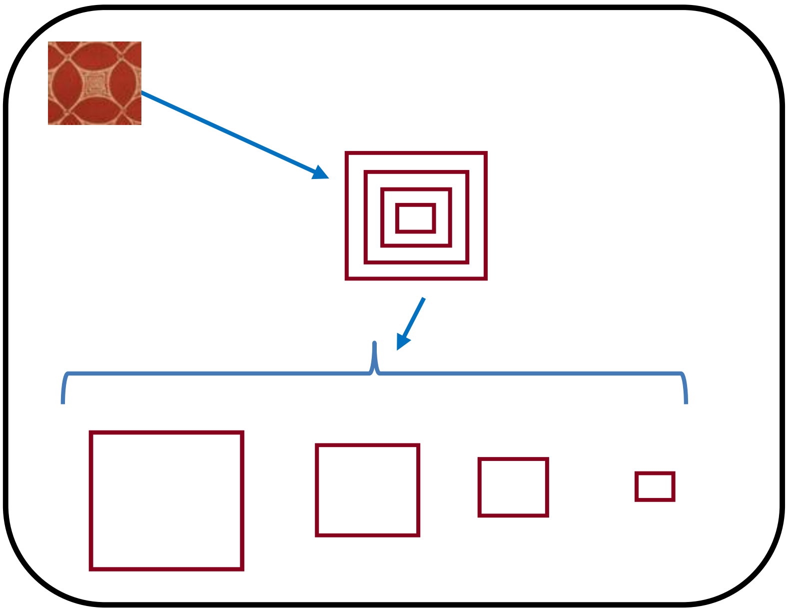

Figure 13. Dilatation on Kawung Jenggot Batik Motif

Dilation is a geometric transformation in the form of multiplication that enlarges or reduces a geometric building. In the concept of dilation, there are so-called dilatation points and dilatation factors. The dilatation point is the point that determines the position of a dilation. The dilation point is the meeting point of all straight lines connecting the points in a shape to the resulting points of dilation. The dilation factor is the multiplication factor of a dilated geometric shape. This factor shows how much the results are dilated to the geometric shape and is denoted by k. If $k < -1$ or $k > 1$, so the results of the dilatation is increased; If $-1 < k < 1$, so the results of the dilatation is decreased; If $k = 1$, so the results of the dilatation is constant. The positive sign means that the geometry and dilatation result coexist on either side of the dilation point. Meanwhile, the negative sign means that the geometry and dilatation results are reversed and have different sides at the point of dilation. Dilatation can be written by: (D, k) = (dilatation point, dilatation factor).

4. Rotation

Rotations in the typical Banyumasan batik motif can be found in the Manggar Bawor motif. The motif depicting manggar or coconut flowers (in Javanese) is manifested in several rotating images of the same shape, as shown in Figure 14.

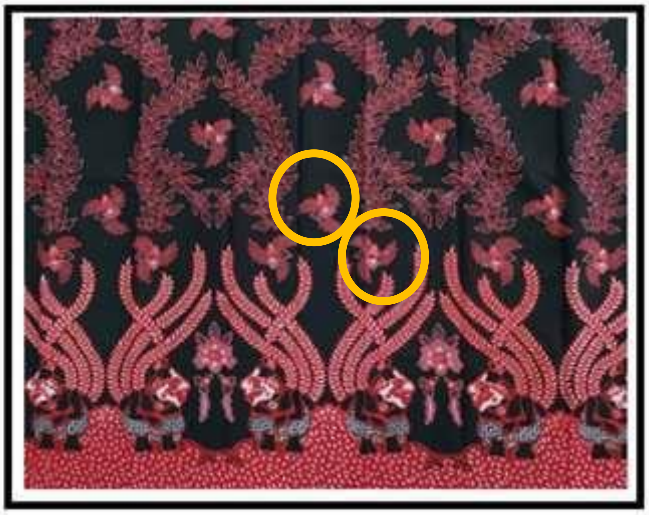

Figure 14. Batik Motif Manggar Bawor with a rotating "manggar" image

The "manggar" motif image is placed on the Cartesian coordinate plane, as can be seen in the following Figure 15.

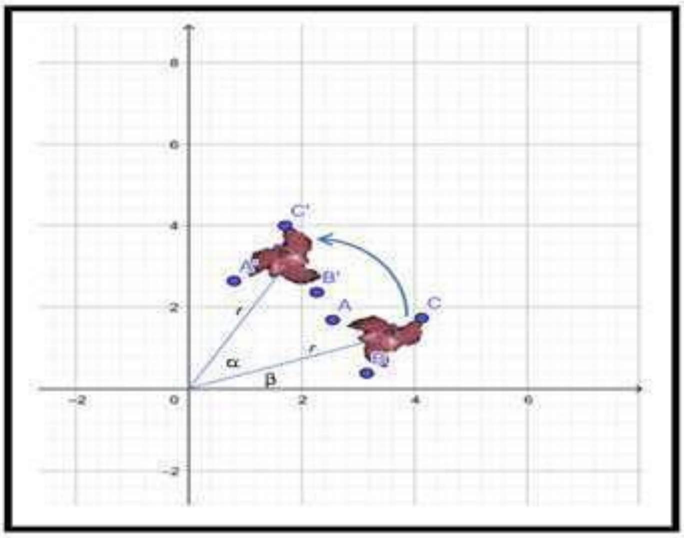

Figure 15. Rotation of “manggar” batik motif

Point ABC is rotated by α with the center point O (0,0) producing point A'B'C', then the resulting "manggar" motif image rotates according to the direction and angle of rotation. The initial position of the “manggar” motif can also be written in polar coordinates, A(r cos β, r sin β). The position of the "manggar" motif after being rotated by α in the opposite direction to the direction of the needle rotation can be written as A'(r cos β+α). So, expressed in matrix form, the equation becomes the following matrix.

$$A' = \begin{pmatrix} a' \\ b' \end{pmatrix} = \begin{pmatrix} r\cos(\beta + \alpha) \\ r\sin(\beta + \alpha) \end{pmatrix}$$
$$= \begin{pmatrix} r\cos\beta\cos\alpha - r\sin\beta\, sin\,\alpha \\ r\cos\beta\sin\alpha + r\sin\beta\, cos\,\alpha \end{pmatrix}$$
$$= \begin{pmatrix} a\cos\alpha - b\sin\alpha \\ b\sin\alpha + b\cos\alpha \end{pmatrix}$$
$$= \begin{pmatrix} \cos\alpha & -\sin\alpha \\ \sin\alpha & \cos\alpha \end{pmatrix}\begin{pmatrix} a \\ b \end{pmatrix} \quad \ldots (7)$$

The results of geometric transformations in the form of translations, rotations, reflections, and dilatations on Banyumasan batik are one of the local culture-based mathematical models that can be used as material for learning mathematics, making a positive contribution to the development of Indonesian art and culture through the integration of culture with the field of mathematics, especially the field of batik, as well as enrich insight and knowledge about the application of mathematics in everyday life. The study of Hafizh et al. (2023) the concept of geometric translation was found in the bead crafts motifs of the Dayak Kenyah tribe which shows ethnomathematics in local culture. In the ethnomathematics study of Geulis Tasikmalaya Umbrella craftsmen, West Java the geometry of rotation and reflection was also found in the motifs drawn on umbrella crafts (Muslim & Prabawati, 2020). Beside that, geometric translation is also found in Lebak batik with Angklung Buhun batik motif which is typical batik from Lebak, Banten (Mahuda, 2020). The geometric transformation of Banyumasan batik can be used as mathematics learning model. This is in line with the statement from Stillman & Brown (2019) that mathematical modelling is applying mathematics concept in a real life including local culture. The mathematical modelling approach use "model" to explain and define the concepts in real life (Arseven, 2015). The limitations of this study are discussing geometric transformations on only a few Banyumasan batik motifs. In the future, research on other batik motifs and other local cultures can be developed as mathematical modelling.

D. CONCLUSION AND SUGGESTIONS

Based on the results of the research conducted, it can be concluded that mathematical modelling of geometric transformations in Banyumasan batik can be carried out using several techniques and mathematical formulas, such as translations in Sekar Tirta batik motif, reflections in Bawor Kembar batik motif, dilations in Kawung Jenggot batik motif, and rotations in Manggar Bawor batik motif which applied to Banyumasan batik motifs. In this modelling, mathematical concepts about transformation matrices, determinants, and inverse matrices are used. Through this mathematical modelling, batik motifs can be produced which are different from the original motifs, but still follow the basic characteristics and forms of Banyumasan batik. It is hoped that the results of this research can make a positive contribution to the development of Indonesian art and culture, especially in the field of batik, enrich insight and knowledge about the application of mathematics in everyday life, and can be used as a mathematical model based on local culture. Meanwhile, for future research, other local culture can be explored by mathematics concepts so that there are a lot of study about mathematics' exploration in local culture for mathematics learning models.

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