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Exploring ethnomathematics in Donggala woven based on geometry and calculus concepts

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***Abstract*:**
Donggala woven has various patterns that can be used in the mathematics learning process. Qualitative ethnographic research explored ethnomathematics in Donggala weaving based on geometry and calculus concepts. The data collection techniques were literature review, observation, interviews, and documentation. Observations were made at the Job Training Institution (JTI) and shops selling Donggala fabrics, and interviews were conducted with the head of the Donggala Weaving Association in the city of Palu. Data were analyzed using the Miles & Huberman model and triangulated based on sources, methods, and time. The findings show that Donggala weavings can be explored in the mathematics learning process to find geometry concepts (lines and angles and two-dimensional shapes), geometry transformations, and function graphs in calculus. Donggala woven fabric is also intended to make learning more meaningful because it can be a concrete example of the mathematical concept and, at the same time, introduce local wisdom through mathematics learning.

Keywords: Calculus; Donggala Woven; Ethnomathematics; Exploration; Geometry.

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Introduction

The province of Central Sulawesi has various characteristics and local wealth that should be preserved. One of the characteristics, especially in the city of Palu and Donggala, is that Donggala is woven. Donggala woven fabric has various patterns/motifs that combine the skills of Bugis and Kaili tribal weavers in Donggala Regency (Gerta & Ramadhani, 2020; Zeintatieni & Nahari, 2014). Steps can be taken to introduce the patterns of Donggala weavings into the learning process for recognition and preservation, especially in mathematics classes. Education and culture are related elements (Firdaus & Hodiyanto, 2019; Radiusman & Juniati, 2022). Cultural elements

can enter the world of education through the learning process. Learning from or based on culture can be divided into three types, namely learning 'about,' learning 'with' and learning 'through' culture (Lubis et al., 2018; Saputra et al., 2022). Learning based on local wisdom (culture) in understanding, articulating, and explaining symbols, practices, and a form with the study of mathematics is called ethnomathematics (Fauzi & Lu'luilmaknun, 2019; Karimah et al., 2021; Merdja & Restianim, 2022).

When a mathematical concept is linked to an ethnomathematical approach and the student's environment, the learning is contextualized (Bustan et al., 2022; Sudirman et al., 2017). The combination of contextual learning with an ethnomathematics approach contributes to an education that causes socialization and interaction between cultures so that it has an impact on the improvement of mathematical skills and mathematical learning outcomes without abandoning ancestral cultural values while preserving local wisdom (Dhiki & Bantas, 2021; Dosinaeng et al., 2020; Febriyanti & Ain, 2021; Lubis et al., 2018; Zayyadi, 2017).

There have been many previous studies on the topic of ethnomathematics, for example, linking ethnomathematics with traditional games (Fauzi & Lu'luilmaknun, 2019; Pratiwi & Pujiastuti, 2020; Risdiyanti & Prahmana, 2018), ethnomathematics with musical instruments (Lubis et al., 2018), ethnomathematics with woven crafts (Prabawati, 2016), ethnomathematics with buildings (Hardiarti, 2017), ethnomathematics with traditional fabrics (Bustan et al., 2022; Karimah et al., 2021; Radiusman & Juniati, 2022; Sudirman et al., 2017; Warli & Musa, 2022; Zayyadi, 2017), and others. Ethnomathematical research on traditional fabrics primarily explores the concepts of lines and angles and two-dimensional and geometric transformations. Although ethnomathematical research has also raised the characteristics of Palu City, the fabric raised is Bomba batik, which is associated with the geometry concept (Warli & Musa, 2022). In this ethnomathematics research, in addition to increasing the culture of Palu City, Central Sulawesi, which is still not discussed in the study. This research also takes one of the concepts in calculus, namely function graphs. This research also takes a fabric type that has never been raised in ethnomathematics research, namely Donggala woven. So, this study uses function graphs and Donggala woven fabrics, which have never been studied.

Based on the above explanation, this study aims to explore ethnomathematics in Donggala weavings from the concepts of geometry, geometric transformation, and calculus. The geometry concepts studied are lines, angles, and two-dimensionals. The idea of transformation studied refers to transformation, reflection, and rotation. The concept of calculus studied is related to function graphs.

Research Methods

Qualitative research was conducted using ethnographic methods to explore the ethnomathematics of Donggala weaving and to find the mathematical elements contained in the motif of Donggala weaving. Ethnography is one of the qualitative research approaches used to describe, explain, and find out the aspects of a culture in a particular environment or tribe by analyzing the data collected (Karimah et al., 2021; Zayyadi, 2017). This research was conducted at the Weaving and Batik Vocational Training Institute and shops selling Donggala woven in Jalan Mangga, West Palu District, Palu City, Central Sulawesi Province. The informant for this research was the chairman

of the Donggala Weaving Association in Palu City, Mr Imam Basuki. In determining the research informants, the researchers pay attention to the requirements that must be met, namely informants who know the ins and outs of Donggala weaving and have a Donggala weaving business.

The instrument of this research is the researcher himself, who plays a role in collecting data using literature review techniques through the Google Scholar database, observation, interviews, and documentation. The literature study is intended for literature analysis and reference search relevant to this research, namely, ethnomathematics, Donggala woven cloth, and the concept of Geometry and Calculus in mathematics. Observation is intended to see Donggala Woven Cloth and its motifs directly. Interviews are designed to obtain information on the History and Philosophy of Donggala Woven Cloth. Documentation is carried out to receive photos of the Donggala Woven cloth motifs.

The Miles & Huberman model was used to analyze the research data, namely (Hajerina et al., 2022): (1) Data collection containing information about Donggala weavings, such as types of motifs, meanings and sources, (2) data reduction, where the data are selected according to the objectives of this study, (3) data presentation, where the data are arranged and presented based on the basic concepts of geometry, geometry transformation, and function graphs, (4) inference, where conclusions are drawn and research problems are answered.

Data triangulation is performed according to sources, techniques, and time to attain data validity. Source triangulation is used to check the validity of data obtained from different sources, such as primary (direct) and secondary (website) sources. Primary sources come from the Weaving and Batik Job Training Institute and shops selling Donggala woven fabrics on Jalan Mangga, while secondary sources come from articles obtained through Google Scholar. Method triangulation checks data validity based on different methods: observation, interviews, documentation, and literature review. Meanwhile, time triangulation is carried out to check the validity of data taken at various times, namely during observation and literature studies (Karimah et al., 2021; Sudirman et al., 2017).

Results and Discussion

Donggala woven is one of the typical Central Sulawesi garments, with a variety of patterns that are a combination of the weaving skills of the Bugis and Kaili tribes in Donggala Regency (Gerta & Ramadhani, 2020; Zeintatieni & Nahari, 2014). Based on the results of interviews with sources, Donggala's woven cloth has a history and philosophy.

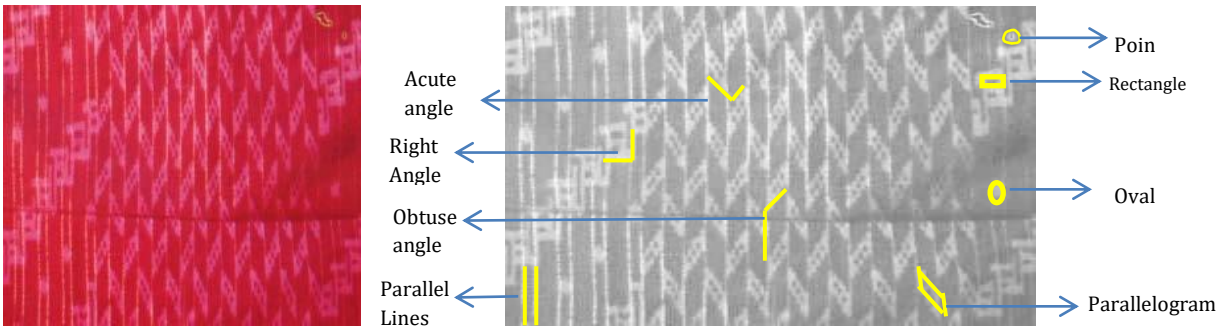
> "During the Banawa Kingdom, Donggala woven cloth was used as clothing and as a symbol of social status and used in traditional ceremonies. Donggala woven cloth shows cultural acculturation influenced by the Bugis and Kaili tribes. The manufacturing process begins with the selection of cotton or silk thread. Furthermore, natural coloring is carried out (bark, leaves, flowers, and so on). The weaving process uses traditional tools or non-machine looms (ATBM), which require high precision and perseverance. Each motif produced has a philosophical meaning, such as in Buya Bomba, which means beauty and harmony between

humans and nature. Buya bomba also symbolized fertility and prosperity. Buya Subi means wisdom, peace, and social harmony. The symmetrical pattern on Buya Subi reflects the balance between spiritual and worldly life. Buya Subi also symbolizes honor and respect for someone. Meanwhile, Buya Cura symbolizes hard work, struggle, and perseverance. The diagonal lines on the motif reflect a life journey full of challenges that can be overcome with enthusiasm and togetherness. For other motifs, they are modern variations that reflect the development of the times."

Ethnomathematics in terms of the Geometry concept

a. Buya Bomba Motif

The Buya Bomba design is an ornamental motif inspired by local traditional cakes that are cut into pieces. Buya Bomba itself means sarong (Buya) and flower (bomba), so Buya Bomba means flower sarong. Before weaving, the weft thread is tied and dipped in pink dye to create the design. The tied part is the desired pattern, while the untied part will change color according to the color of the dye (Zeintatieni & Nahari, 2014). The number of Buya bomba sarongs that can be made in a week is about 2-3 sarongs.

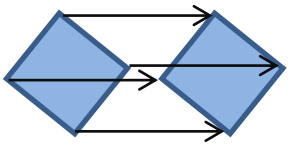


Picture 1. Sarong Motifs and Analysis of Buya Bomba Motifs

In addition to the above concept of geometry, if we pay attention from the point of view of the motif pattern, then we get the idea of geometric transformation, namely:

Translation

Translations are a form of geometry transformation that moves all points on the geometry plane in the same direction or distance (constant).

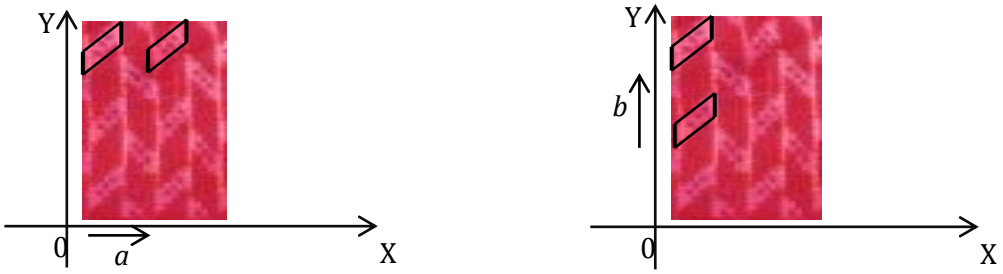


Picture 2. Translation

In the Buya Bomba motif, the concept of translation can be seen on both the x-axis and the y-axis. The process of displacement (Translation) to a parallel to the x-axis and displacement (translation) to b parallel to the y-axis is defined as follows.

$$\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} x \\ y \end{pmatrix} + \begin{pmatrix} a \\ b \end{pmatrix} \quad \dots (1)$$

Where a and b are the translation (shift) components, here is the translation (shift) of the Buya Bomba motif.

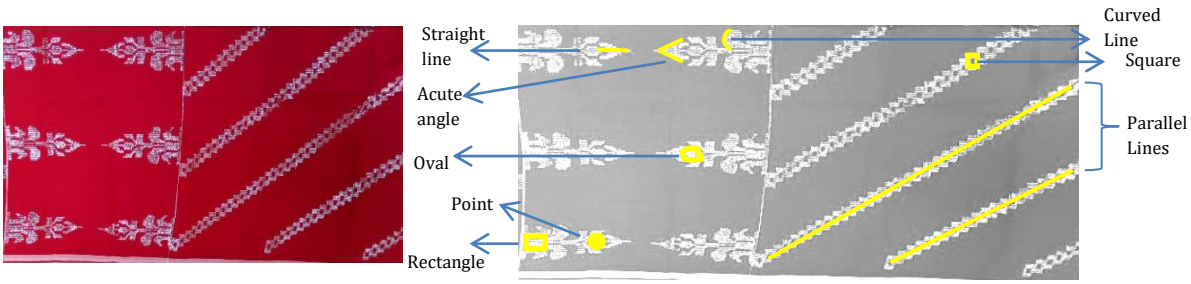


Picture 3. Translations along *a* parallel to the *x*-axis and *b* parallel to the *y*-axis

b. Buya Subi Motif

The Buya Subi design is ornamental and uses the Sungkit or songket technique. Buya Subi motifs are divided according to the type of Sungkit thread, including (Zeintatieni & Nahari, 2014):

a) Buya Subi Sabe is Buya Subi that uses embossed decoration with silk threads of different colors on a plain fabric base.
b) Buya Subi Kumbaja uses embossed silver or gold threads on a plain background.

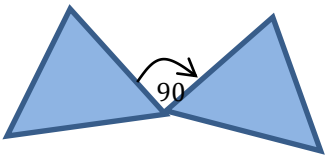


Picture. Sarong Motifs and Analysis of Buya Subi Motifs

In addition to the basic geometry concept, when we look at the motif pattern, we get the transformation geometry concept, namely:

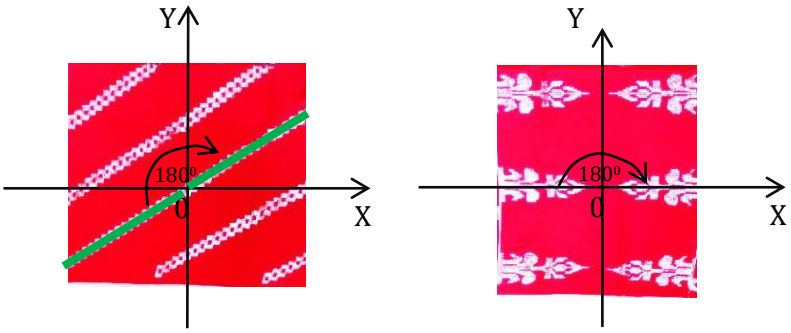
1) Rotation

Rotation is a type of geometry transformation that moves or displaces all points in the geometry plane around a given point of rotation or angle of rotation. The displacement can be clockwise or counter-clockwise.



Picture 5. Rotation

The following is a geometric transformation in the form of a rotation in the Buya Subi design.



Picture 6. Rotation at point O (0,0)

Based on Figure 8, the type of rotation illustrated is a type of negative rotation due to clockwise rotation. In addition, the design rotates to 180^0 with a center of (0,0), which can be found in the formula:

$$\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} -1 & 0 \\ 0 & -1 \end{pmatrix} \begin{pmatrix} x & -a \\ y & -b \end{pmatrix} + \begin{pmatrix} a \\ b \end{pmatrix} \quad \dots (2)$$

Where (x', y') is the result of the rotation, (a, b) is the center, and (x, y) is the starting point. So, for a rotation with the center O (0,0), we get the formula:

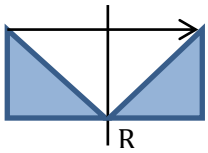
$$\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} -1 & 0 \\ 0 & -1 \end{pmatrix} \begin{pmatrix} x & 0 \\ y & 0 \end{pmatrix} + \begin{pmatrix} 0 \\ 0 \end{pmatrix}$$

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

$$\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} -x \\ -y \end{pmatrix} \quad \dots (3)$$

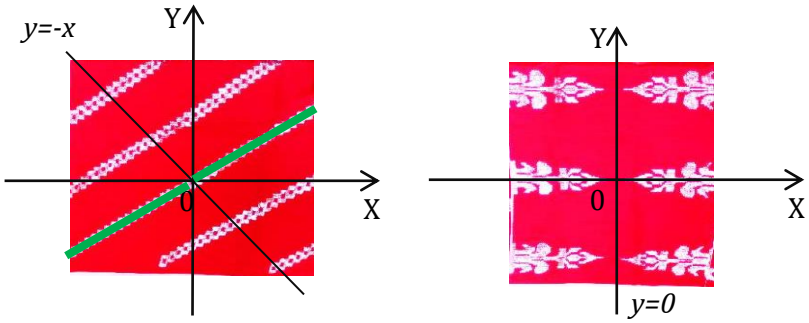
2) Reflection

Reflection is a form of geometry transformation that moves or shifts all points in a geometry plane that uses mirror image properties (flat) by the same distance and twice the distance from the origin to the mirror.



Picture 7. Reflektion

Here is the geometry transformation in the form of a reflection of Buya Subi's motifs:



Picture 8. Reflektion at $y = -x$ and $y = 0$ - axis

Based on Figure 10, the motif can be entered into the formula:

- For reflection on the $y = -x$ axis, then:

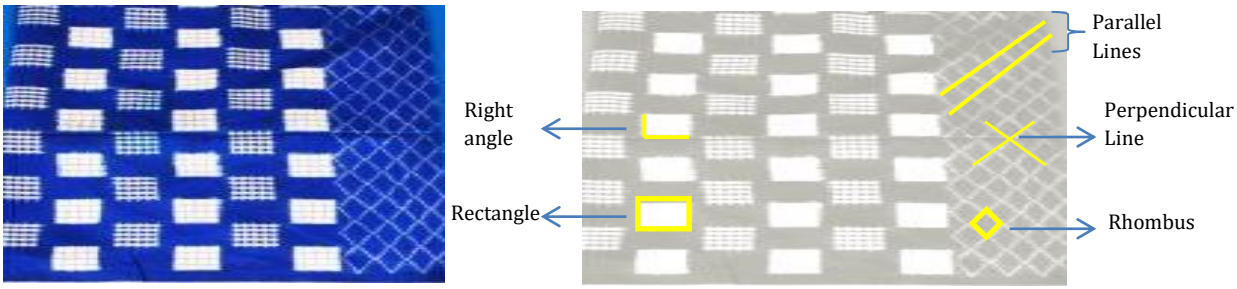
$$\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} 0 & -1 \\ -1 & 0 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} -y \\ -x \end{pmatrix} \quad \dots (4)$$

- For reflection on the $y = 0$ axis, then:

$$\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} -1 & 0 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} -x \\ y \end{pmatrix} \quad \dots (5)$$

c. Pelekat Garusu dan Buya Cura Motif

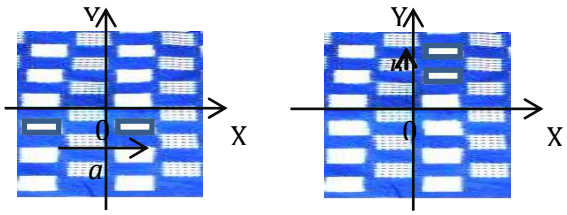
The Palekat Garusu and Buya Cura motifs are ornamental motifs with large and small checkerboard patterns (Zeintatieni & Nahari, 2014).



Picture 9. Sarong Motif and Analysis Palekat Garusu and Buya Cura Motifs

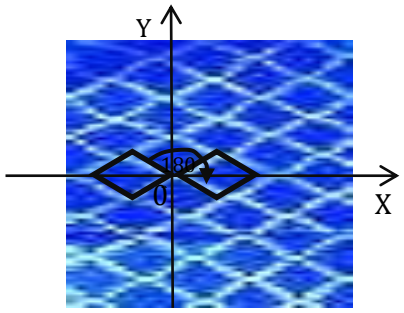
The concept of geometric transformation in the motifs of Palekat Garusu and Buya Cura, among others:

1) Translation



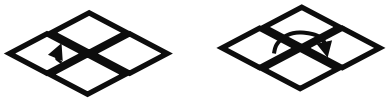
Picture 10. Translation along *a* parallel *x-axis* and *a* parallel *y-axis*

2) Rotation



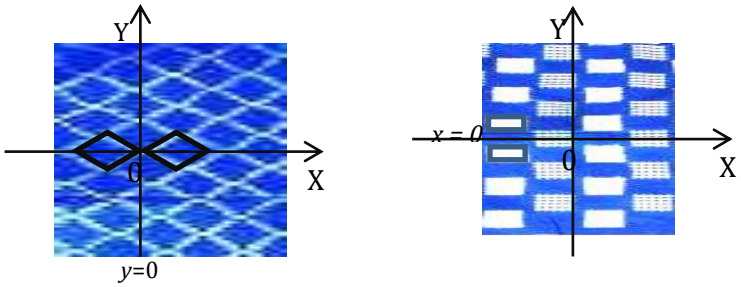
Picture 11. Rotation at point O (0,0)

The Palekat Garusu and Buya Subi motifs can be rotated to 90^0, 270^0, and 180^0 degrees (Picture 12).



Picture 12. Rotation along 90^0 and 270^0.

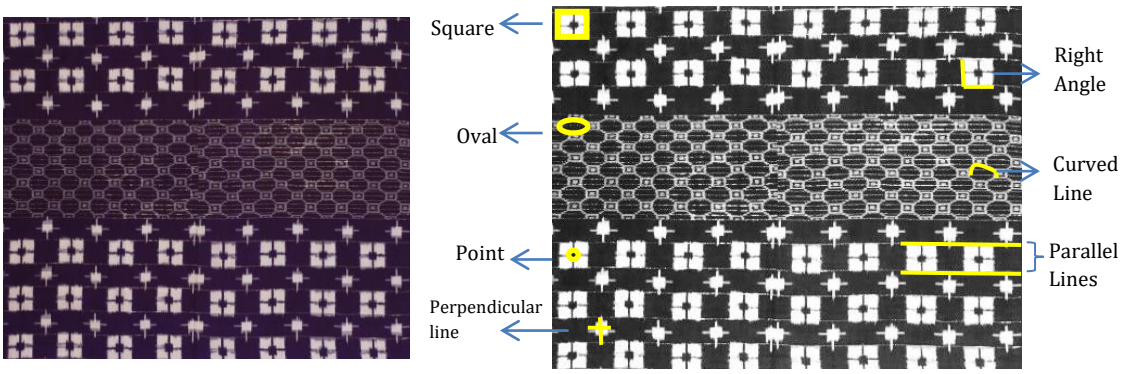
3) Reflection



Picture 13. Reflektion at $y = 0$ and $x = 0$ axis

d. Buya Bomba Kota Motif

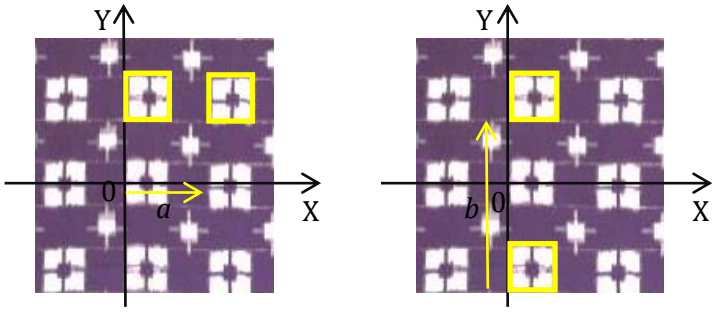
Buya Bomba Kota design is an ornamental motif with a box-shaped floral pattern made by interlacing lungsi (vertical) and weft (horizontal) threads (Zeintatieni & Nahari, 2014).



Picture 14. Sarong Motif and Analysis Buya Bomba Kota Motifs

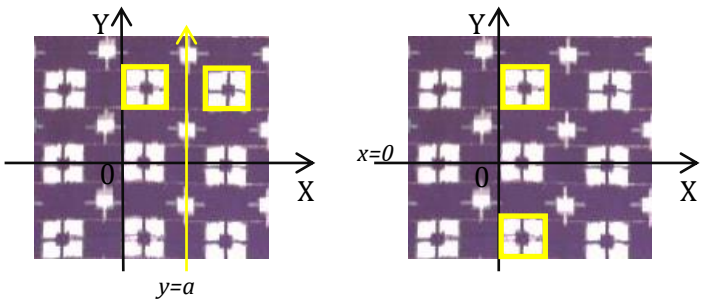
The concept of geometric transformation in the motifs of Buya Bomba Kota, among others:

1) Translation



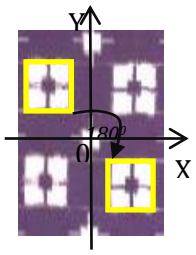
Picture 15. Translation along *a* parallel *x-axis* and *a* parallel *y-axis*

2) Reflection



Picture 16. Reflection at $y = a$ and $x = 0$

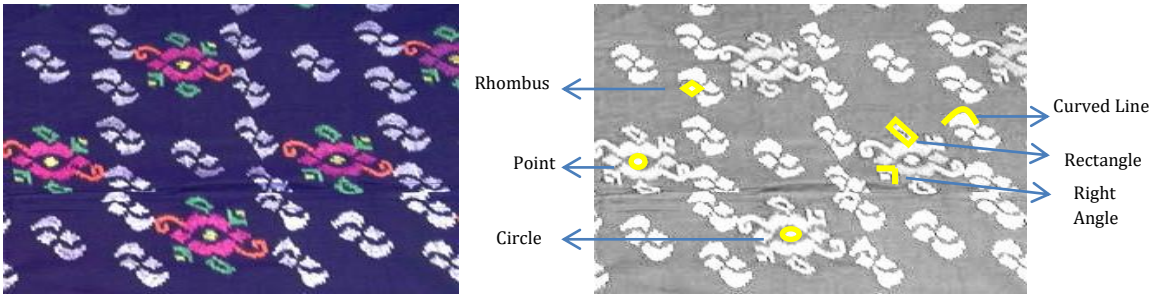
3) Rotation



Picture 17. Rotation along 180^0.

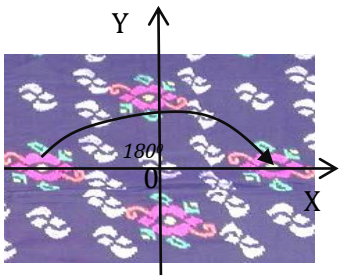
e. Buya Bomba dan Subi Combination Motif

The Buya bomba and subi combination design is an ornamental design using a combination of techniques on Buya bomba and Buya subi. First, the decorative pattern of the bomba is placed on the tied thread. Next, the base color is dyed on the fabric, after which the ties are removed from the thread. The unique pattern of the fabric is then decorated with gold or silver embossed threads. Yellow polish can also be applied to these areas. The position of the decorated Nupusua (weft thread) is arranged during weaving so that the shape is appropriate. The sabe or kumbaja thread is placed over the yellow part (Zeintatieni & Nahari, 2014).



Picture 18. Sarong Motif and Analysis Buya Bomba dan Subi Combination Motif

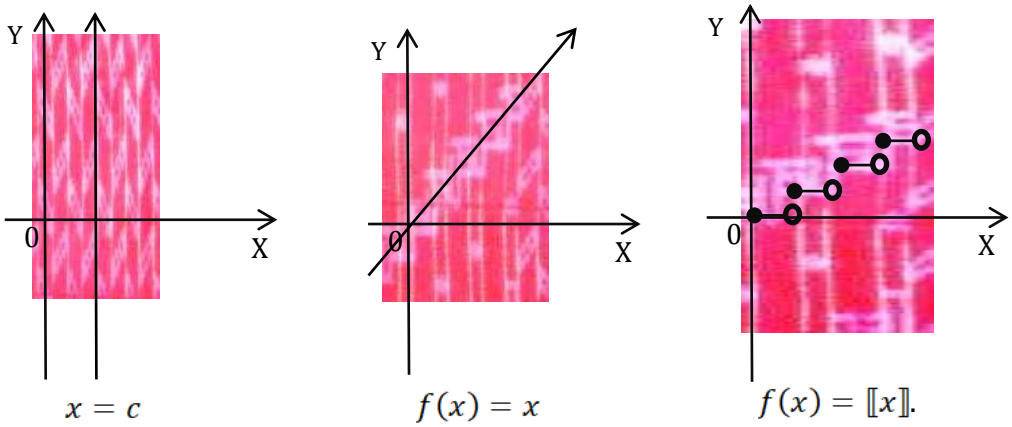
Rotation is the idea of transformation geometry in the motifs of a Buya Bomba and Subi combo.



Picture 19. Rotation along 180^0.

Ethnomathematics to the function graphs concept

a. Buya Bomba Motif

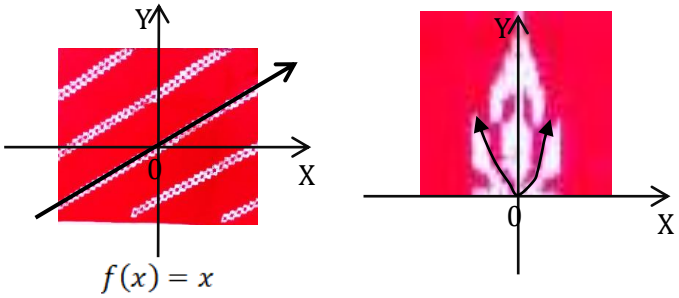


Picture 20. Function graph on Buya Bomba motif

Based on Picture 20, the function graph that can be generated by the Buya Bomba motif, among others:

1) Constant Function Graph
2) Linear Function Graph
3) Ladder Function Graph

b. Buya Subi Motif

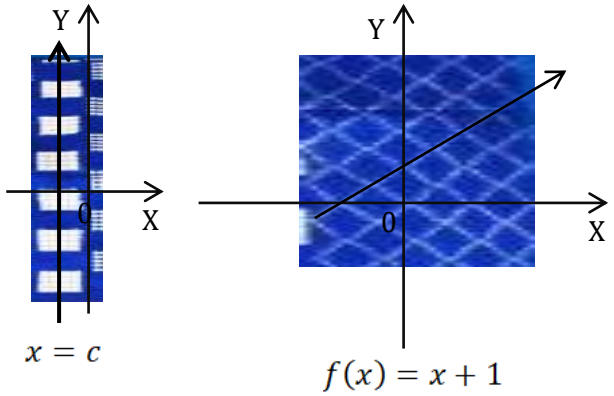


Picture 21. Function graph on Buya Subi motif

Based on Picture 21, the function graph that can be generated by the Buya subi motif, among others:

1) Linear Function Graph
2) Quadratic Function Graph

c. Pelekat Garusu dan Buya Cura Motif

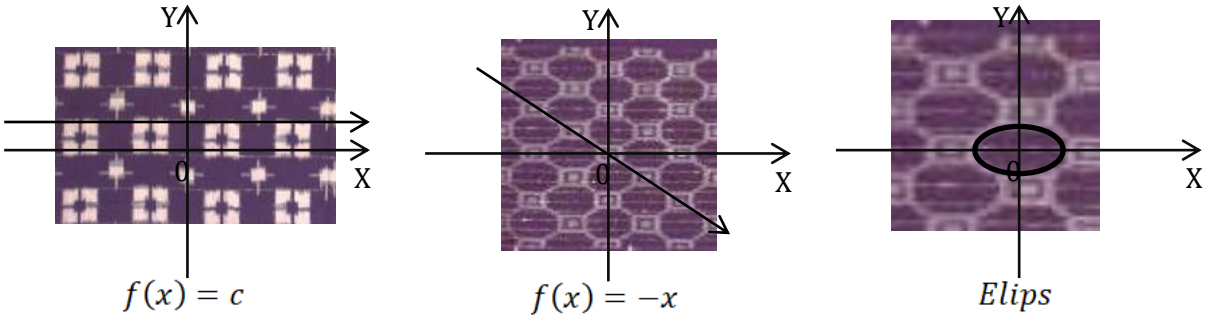


Picture 22. Function graph on Palekat Garusu dan Buya Cura motif

Based on Figure 22, the function graph that can be produced by the Palekat Garusu and Buya Cura motif, among others:

1) Constant Function Graph
2) Linear Function Graph

d. Buya Bomba Kota Motif

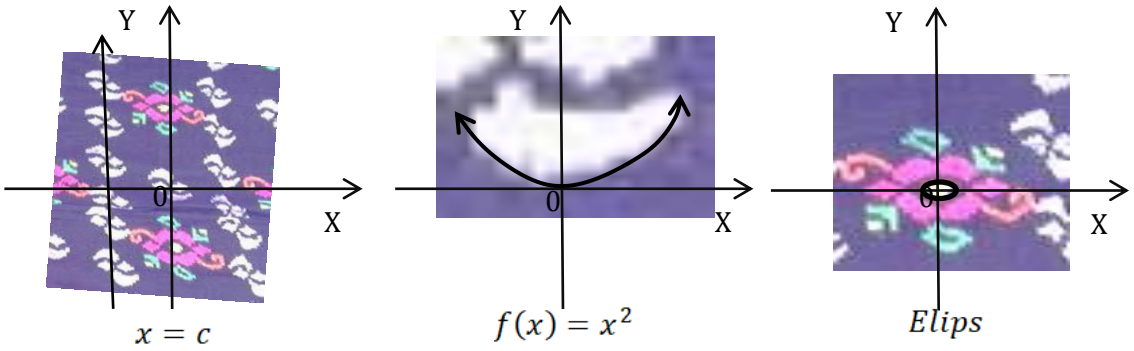


Picture 23. Function graph on Buya Bomba Kota motif

Based on Picture 23, the function graph that can be generated by the Buya Bomba Kota motif, among others:

1) Constant Function Graph
2) Linear Function Graph
3) Elips

e. Buya Bomba dan Subi Combination Motif



Picture 24. Function graph on Buya Bomba and Subi combination motif

Based on Picture 24, the function graph that can be produced by the Buya Bomba and Subi combination motif, among others:

a) Constant Function Graph
b) Quadratic Function Graph
c) Elips

From the research result above, the five motifs of Donggala weavings all have the same motif, namely rectangles, and most contain points and right angles. All the motifs can be made in the translation concept based on transformation geometry. As for the idea of function graphs, the woven motifs are dominated by constant and linear function graphs.

The above findings are in line with the philosophy of the Donggala Woven fabric motif itself. The rectangular shape and right angles symbolize order, balance, and stability in life. The rectangle reflects the lifestyle of the Donggala community, which values harmony and order in social relations and interactions with nature. While the geometric meaning of the rectangle and right angles show simplicity, they are full of meaning. The combination of points and right angles depicts a solid structure. The concept of translation (shift) in the Donggala Woven fabric motif shows the continuity of tradition from generation to generation. It reflects that cultural values continue to move and are inherited without losing their essence. Geometrically, the meaning of translation shows harmony. The meaning of the constant function graph is to describe stability and consistency in the culture and life of the community. In other words, it reflects the principle of life that does not change despite facing various challenges. The meaning of the linear function graph is to describe growth, life journey, and dynamics of directed change. It reflects that life continues to move forward but still holds the path and values.

Based on the above explanation, Donggala woven motifs can provide information related to the concepts of geometry, transformation geometry, and calculus that can be used in the learning process. Mathematical concepts introduced through woven motifs become more meaningful because Donggala woven fabric is a typical fabric from Central Sulawesi that is familiar to the environment of students, especially students in Palu City, and mathematical concepts can be contextually illustrated.

Geometry and calculus are complicated subjects and require good mathematical skills, as conceptual errors are common (Anam, 2021; Suciati et al., 2023). Therefore, it

is essential to use engaging learning media to help learners represent the concept (Chuseri et al., 2021; Rachmawati et al., 2021). One is through ethnomathematics, where abstract mathematical concepts can be visualized through cultural contexts, such as the motif of the Donggala woven (Yudhi & Septiani, 2024). It is in line with Dienes' theory, which states that abstract concepts in mathematics will be easy to understand if they can be visualized. Visualization helps improve students' understanding of abstract and complex mathematical concepts (Suciati et al., 2023). Donggala Woven Fabric Motifs can help students develop mathematical thinking skills. It aligns with Ausubel's views on meaningful learning, Gagne's on the concept of demonstrated learning, and Bruner's on constructive learning (Darmayanti et al., 2023; Suciati et al., 2023).

Conclusion and Recommendations

Based on the findings obtained, the motif of Donggala woven fabric can be explored in learning mathematics to find the concepts of geometry, geometric transformation, and calculus. For the geometry concept with the theme of lines and angles, the concepts of point, straight line, curved line, parallel line, perpendicular line, acute angle, right angle, and obtuse angle are obtained. For plane forms, the concepts are parallelogram, rectangle, square, rhombus, oval, and circle. For the concept of geometric transformation, the concepts of translation, reflection, and rotation are obtained. The calculus concept on the material of function graphs, constant function graphs, linear function graphs, quadratic function graphs, ladder function graphs, and ovals are obtained. The discovery of the concepts of geometry, geometric transformation, and calculus is not only an aesthetic symbol. Still, it is also in line with the philosophy of the Donggala woven cloth motif, namely the representation of the philosophy of life of the community, which is rooted in traditional values and science. The use of Donggala weavings is also intended to make learning more meaningful because it can be a concrete example of the mathematical concept and, at the same time, introduce and preserve the local culture through mathematics teaching.

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