Batak ulos ethnomathematics exploration based on geogebra software

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Abstrack

Ethnomathematics is a science that bridges mathematics and culture. One of the Toba Batak cultures that is related to mathematics is the traditional craft of *Saddum ulos* cloth which they use as clothing in rituals or series of birth, death and wedding events. Toba Batak culture, in the form of traditional *Saddum Ulos* cloth crafts, is interesting to reveal and explore through ethnomathematics based on Geogebra software. Therefore, the aim of this research is to analyze the mathematical concepts contained in Saddum ulos cloth and the use of Geogebra software in making the motifs. The research method used was a descriptive method with an ethnographic approach. The data sources were obtained from interviews, observation and documentation. Data were analyzed through triangulation of data sources and descriptive methods. The research results show that Saddum ulos batik has mathematical concepts such as lines and angles, number patterns, plane geometry, and geometric transformations. Making the Saddum ulos motif using Geogebra makes the Saddum ulos motif better visualized and its relationship with mathematics clearly illustrated.

Keywords: ethnography, ethnomathematics, frieze pattern, geogebra, saddum ulos

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INTRODUCTION

Initially, mathematics was defined as a field of science that studies structure, change and space patterns. Informally, mathematics is also known as numerical science. From a formal point of view, mathematics is the study of abstract structures defined by axioms using symbolic logic and notation (Heruman, 2007). Rachmawati (2012) stated that mathematics grows and develops because of the life challenges faced by humans in various regions with different cultural backgrounds, they develop mathematics in their own way. From this statement, it can be concluded that mathematics is the result of an abstraction of the human mind so that it can be said that there is a connection between mathematics and culture. The relationship between mathematics and culture is called ethnomathematics.

D'Ambrosio (1985) stated that ethnomathematics is mathematics carried out by certain cultural groups such as tribes in a place, workers' unions, and professional groups. Ethnomathematics is also defined as the use of mathematics from an identifiable group of cultures and can be considered as a study of mathematics found in various cultures. Ethnomathematics means modeling, explaining, knowing, understanding, and carrying out activities such as coding and measuring (Wahyuni dkk, 2013). Ethnomathematics consists of two words, ethno (ethnicity/culture) and mathematics. In short, ethnomathematics itself is mathematics that exists in culture. Hasanuddin (2017) stated "Ethnomathematics is a new awareness about recognizing people's potential in the field of mathematics, namely that mathematics is designed within cultural groups, both from indigenous tribes and people who have an interest in mathematics". D'Ambrosio's main concern (Turmudi, 2018) is used to guide research on ethnomathematics and identify the rules, forms, styles, arts and techniques that are regulated by

different cultural groups to understand, explain, learn and carry out activities as well as to overcome various problems involving the environment both natural, social, cultural and even imaginary. The presence of mathematics which has a cultural nuance (ethnomathematics) will have a big impact on mathematics learning, because formal education is a social institution that is different from others, thus allowing for intercultural socialization. (Zayyadi, 2017). Ethnomathematics is described as culture which refers to culture. The culture in question refers to the language of society, places of rituals/traditions, ways of organizing, interpreting, conceptualizing and giving meaning to the world (Puspadewi, 2014).

Bishop (1994) states that ethnomathematics is divided into six basic activities and can always be found in cultural groups. These mathematical activities are counting/counting, measuring, determining location, designing, playing and explaining. These ethnomathematics objects can be traditional crafts, artifacts, traditional games, customs, traditional ceremonies and other activities that take the form of culture. According to D'Ambrosio (2001), the aim of ethnomathematics is to make a good contribution to understanding culture and understanding mathematics, especially in appreciating the relationship between mathematics and culture. Ethnomathematics is a science that can bridge the gap between mathematics and culture. In this research, the mathematical object is Toba Batak culture regarding Saddum ulos cloth. *Saddum Ulos* cloth is not only a cultural heritage, but also an implementation of Ethnomathematics in the form of cultural preservation in North Sumatra Province. The Toba Batak people always use ulos in traditional ceremonial activities. Whatever type of event is taking place or being held, every Batak halak always wears a ulos, the only difference is in the name and meaning depending on what traditional ceremony they attend and what ulos they have to wear (Agustina, 2016). Not only is it used as clothing, but it is also used in rituals and ceremonies such as birth, death and weddings. This causes ulos to become an inseparable part of the traditional life of the Batak tribe (Erlyana, 2016).

The indicators in Ethnomathematics provide a framework for understanding patterns in counting, measuring, determining direction and location and making designs. In Ulos weaving, there are motifs which contain mathematical concepts as found in research conducted by Astuti (2019).

Based on research by Peradhayana (2021), it was found that there is an ethnomathematics concept in endek cloth motifs using motif design through creating quadratic functions in Geogebra software. The aim of the research carried out by Peradhayana began with students' problems in distinguishing graphs if the coefficients and constants were changed. So Peradhayana took the endek cloth motif to research using Geogebra software.

This research focuses on *Saddum Ulos* cloth to reveal an understanding of mathematical values that are realized in cultural arts and implemented through ethnomathematics. The aim of this research is to provide in-depth insight into mathematical concepts in the cultural and artistic life of the Toba Batak people. In this research, analysis of the frieze pattern on the *Saddum Ulos* motif was used to find the ethnomathematics elements contained in the fabric. Frieze patterns as symmetry groups are produced through unidirectional translation to form repeating linear patterns (Copper, 2013). The characteristic of Frieze patterns is that they are formed by translation, providing a rich symmetry dimension (Rahmawati et al, 2018). There are seven frieze patterns related to one-plane symmetry groups such as redreflection, translation, rotation and shear reflection (Andriani et al, 2020).

In this research, Geogebra software was used to make *Saddum Ulos*. According to Hohenwarter (2008), Geogebra is a computer program for learning mathematics, especially geometry and algebra. This software combines geometry, algebra, tables, graphics, statistics and calculus. This software can visualize mathematical concepts and act as a tool to help construct these concepts (Syahbana, 2016).

Developed by Markus, Geogebra combines the convenience of dynamic geometry software with the power of a computer algebra system, making it an ideal tool for mathematics learning (Hidayat and Tamimuddin, 2015). Geogebra is a very useful tool in exploring and teaching ethnomathematics, especially in the context of geometric patterns on traditional fabrics, such as *Saddum Ulos*. By utilizing Geogebra, we can draw, visualize, and analyze these patterns in an interactive and immersive way, enriching our understanding of the relationship between mathematics and culture. In more detail, the use of Geogebra in analyzing *Saddum Ulos* is intended to make it easier to identify geometric patterns, create pattern models, explore geometric transformations (understanding how patterns are repeated and arranged on ulos cloth), and as a mathematical analysis tool. The use of Geogebra in this research is also something that differentiates it from previous research. The aim of this research is to: 1) find out what mathematical concepts are contained in a ulos cloth, 2) find out how to use Geogebra software in making Saddum ulos motifs.

METHOD

This research method was designed to ensure the accuracy of the results. The subjects of this research involve ulos craftsmen or traditional leaders who understand about Batak ulos. Subjects are selected based on provisions, namely: (1) The person concerned is a member of the Batak tribe and understands Batak customs, (2) The person concerned has a profession or is an expert in their field, (3) The age concerned is mature and mentally healthy.

The selection of subjects in this research was based on criteria that had been created by the researcher and was consistent with the quality of the subject's knowledge and experience regarding *Saddum Ulos*. This criterion was designed by researchers to create consistency in subject selection so that the data can be relevant to the research objectives. The subject's background was selected in detail to provide a better understanding of the research. Background selection includes factors relevant to the subject.

On the other hand, the approach used in this research is an ethnographic approach, namely an empirical and theoretical approach, to identify how society organizes its culture, and to obtain an in-depth cultural description and analysis based on intensive field research (Arifin, 2012). The aim of this approach is to focus on mental effort and then use the culture of life.

Research variables were measured through participant observation methods, semi-structured interviews and documentation. This research variable aims to obtain information regarding the subject's knowledge, experience and understanding regarding Saddum ulos cloth. The participant observation method procedure is in the category of passive participation techniques to observe behavior that appears in the research object, this is in accordance with the definition of observation, namely the process of collecting information directly by observing certain objects, whether individuals, groups of people, or places at the research location (Creswell, 2014). The aim of this observation method is to describe something related to Ulos Batak Saddum, then draw conclusions from the observation results so that they are compiled into a relevant report. Another data collection technique is interviews. Through interviews it is possible to gain a deeper understanding of how participants interpret situations and phenomena that occur (Sugiyono, 2016). The type of interview used in this research is a semi-structured interview technique which is in-depth interviewing to obtain various primary data and is related to the *Saddum Ulos* problem with the aim that the ongoing interview leads to a free series which allows new questions to emerge. When the answers given by the sources regarding Ulos Batak become more numerous, the researchers are able to develop new questions to explore the information they want to obtain. The data collection technique in the form of documentation in this research is to record what is

written in documents or archives (Sugiyono, 2013). The interview will relate to Ulos Batak Saddum, then draw conclusions about the meaning of the discovery.

The qualitative analysis method uses an ethnographic approach to identify how society organizes its culture to obtain in-depth cultural images and analysis based on intensive field research. The aim of this approach focuses on mental effort and the implementation of culture in life. In connection with this research, the researcher tried to find information through an interview process with various figures or the Batak community, as well as mathematicians who know information about excavated objects, through observation and literature study. The aim of this research is to explain the results of the research in the form of an ethnomathematics exploration of the Batak people in the form of mathematical concepts in Ulos Batak.

The analysis procedure includes the steps used to process and interpret the data. The following are the steps in qualitative analysis:

1. Transcript of data obtained from interviews, observations and documentary literature studies. The data collected is in the form of expressions from interviews, views and experiences in making Ulos Batak Saddum.
2. Coding which aims to obtain an ethnomathematics description of *Saddum Ulos* which is related to mathematics. In the analysis, each subject is given a code in the form of initials to make the analysis process easier.
3. Test validity using triangulation. For this research, data validity testing was carried out through data triangulation using two types of approaches (Moleong, 2012). The following is a source triangulation approach and method triangulation approach where:
    a. Triangulation of data sources means that researchers attempt to check the validity of data obtained from one source with other sources. In this case, this means that apart from getting sources from traditional leaders, researchers also get sources from people who understand Ulos Batak and then double-check the validity of the two data.
    b. Method triangulation is an effort to check the validity of data according to valid methods and also data checking is carried out repeatedly through several data collection methods. In this case, the researcher double-checks whether there are differences between the observation method and the interview and documentation methods and re-checks the validity of the data.

RESULTS AND DISCUSSION

Saddum Ulos is a woven cloth originating from North Sumatra Province and is a symbol of the Batak people. Ulos, including *Saddum Ulos*, are an inseparable part of Batak people's lives (Erlyana, 2016) and are used as a sacred symbol in traditional or religious ceremonies (Rudiyanto, 2005). *Saddum Ulos* is made by weaving using traditional tools or machines. *Saddum Ulos* is usually used at weddings, deaths, giving names to children in church (baptism), and at non-formal events. *Saddum Ulos* is well known among the Batak community as a ulos that can be used anytime and anywhere. In *Saddum Ulos* there are motifs that have certain meanings and symbols.

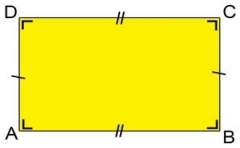
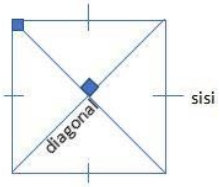
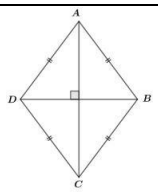
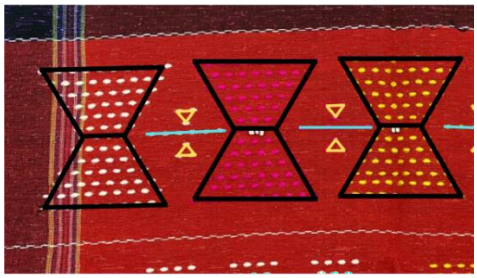
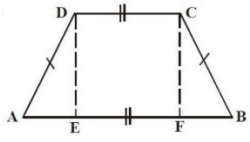
The motifs on *Saddum Ulos* are made by embroidering during the weaving process. Usually *Saddum Ulos* has many kinds of motifs, in fact each existing *Saddum Ulos* has a different motif from other *Saddum Ulos*. This is because the making of *Saddum Ulos* itself does not have specific criteria, so there are differences between one *Saddum Ulos* and another. Even so, *Saddum Ulos* still has its distinctive characteristics, namely the mirrored trapezoidal motif, and usually *Saddum Ulos* has a slightly dark and slightly bright red color. In the *Saddum Ulos* motif, there is ethnomathematics. The *Saddum Ulos* motif apparently depicts mathematical concepts that are applied consciously or unconsciously by the *Saddum Ulos* weavers. The *Saddum Ulos* motif will be studied regarding its relationship to

mathematical concepts such as plane geometry, geometric transformations, number patterns, lines and angles.

1. Plane Geometry and Arithmetic Number Patterns

The table below will explain the geometry of flat planes and arithmetic number patterns.

Table 1. Ethnomathematics Concept of Plane Figures and Arithmetic Number Patterns

No	Etnomathematics	Mathematical Concepts
1		 A rectangle is a two-dimensional flat shape that has two pairs of parallel sides of the same length, and has four right angles. AB = CD = p BC = AD = l Area Formula: L = $p \times l$ Perimeter Formula:K = 2 (p + l) Diagonal Formula:d = $\sqrt{(p^2 + l^2)}$
2		 A square is a quadrilateral with four sides and four vertices. All four sides of a square are equal in length. Area Formula: L = (vertice length)^2 Perimeter Formula: K = 4 × vertice length
3		 A rhombus is a quadrilateral parallelogram. This means that it has four sides and that opposite sides will be parallel to each other. Perimeter Formula: K = 4 × s Area Formula: L = $\frac{1}{2} \times d_1 \times d_2$
4.		 A trapezium is a quadrilateral having two parallel sides of unequal length and the other two sides are non-parallel.

The sum of adjacent angles between two parallel sides of a trapezoid is 180° (unilateral angles)

∠DAB + ∠ADC = 180°

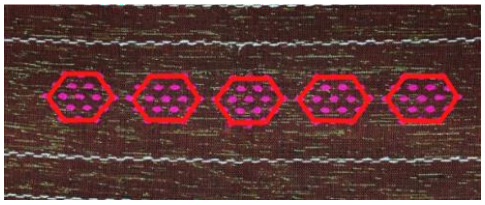
∠ABC + ∠BCD = 180°

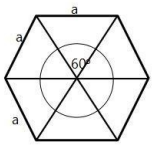
An isosceles trapezium is a trapezium where the two non-parallel sides are equal in length. This also means that each set of base angles are the same size.

Area Formula:

$L=\frac{1}{2}$ × the sum of the parallel sides × height

5.

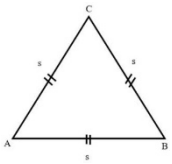




A hexagon is a flat shape with six straight sides. Hexagons are divided into two types, namely regular hexagon and irregular hexagon.

Irregular hexagons with parallel opposite edges are called parallelogons and can also tile the plane by translation.

6.

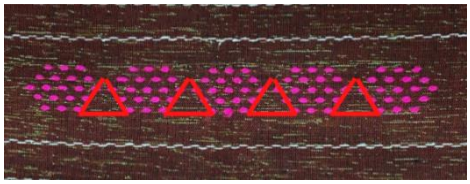


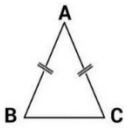
An equilateral triangle is a triangle that has all its sides equal in length. Since the three sides are equal therefore the three angles, opposite to the equal sides, are equal in measure.

Are Formula : L = $\frac{1}{2}$ × base × height

Perimeter Formula: K = the length of side a + the length of side b + the length of side c

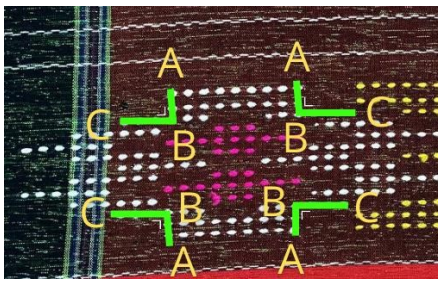
7.

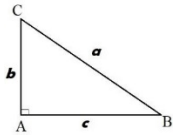




an isosceles triangle is a triangle with two sides of equal length. In an isosceles triangle, if two sides are equal, then the angles opposite to the two sides correspond to each other and are also always equal.

8.



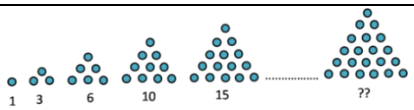


A right triangle is a triangle in which one of the interior angles is 90°.

The longest side of the right triangle, which is also the side opposite the right angle, is the hypotenuse and the two arms of the right angle are the height and the base. The hypotenuse, the side opposite the right angle, is the longest side.

Right triangles do not have rotational symmetry or line symmetry.

9



Pola Bilangan Segitiga

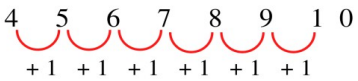
A triangular number pattern is an arrangement of numbers that will form a triangle. The number pattern formed is

1, 3, 6, 10, 15, …

So the formula for the triangular number pattern is:

$Un = \frac{1}{2} n\,(n + 1)$

10



The arithmetic sequence is the sequence where the common difference remains constant between any two successive terms.

$U_1 = 4$

$U_2 = 4+1 = 5$

$U_3 = 5+1 = 6$

with the number sequence formula, namely:

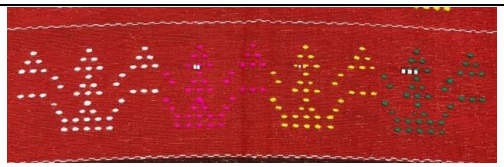
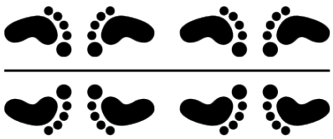
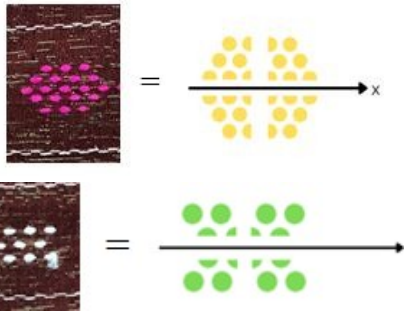
$U_1, U_2, U_3, U_4, \ldots, U_{n-1}, U_n$

From the Table 1 above, it can be seen that in *Saddum Ulos*, there are concepts of flat shapes, such as rectangles, squares, rhombuses and trapezoids. These flat shapes are common shapes that also exist in other traditional fabric motifs, such as the Buna fabric motif (Natun, et al, 2021), the Sikka woven fabric motif (Herlince, et al, 2021), and the Minangkabau Songket motif (Syahriannur, 2019).

1. Frieze Pattern in *Saddum Ulos* Motif

The art patterns in the *Saddum Ulos* motif are related to mathematics. The patterns contained in the *Saddum Ulos* motif can be classified into seven types of patterns based on frieze group theory. Below are several art patterns in the *Saddum Ulos* motif.

Tabel 2. Persamaan Pola Langkah Kaki dengan Motif *Saddum Ulos*

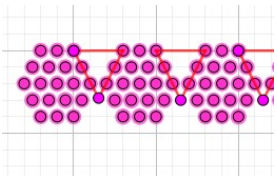
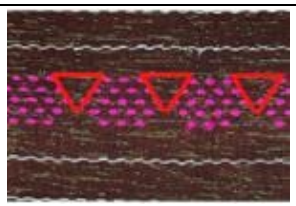
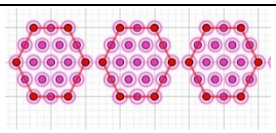
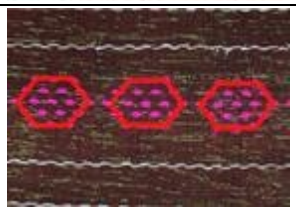
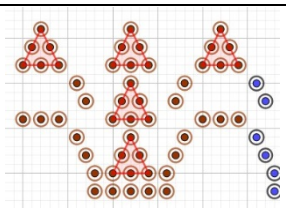
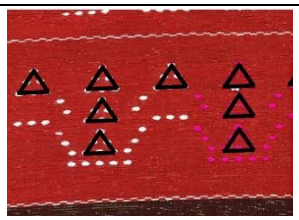
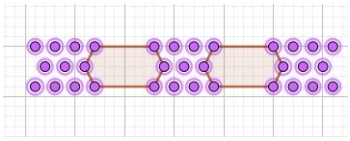
Frieze	**Example of Foot Pattern**	***Saddum Ulos* motif**
F1		
F2		-
F3		-
F4		-
F5		-
F6		-
F7		

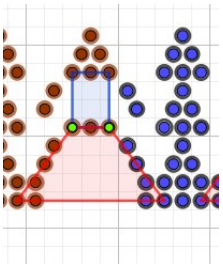
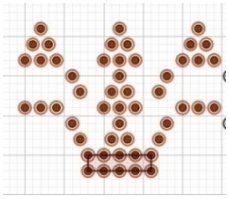
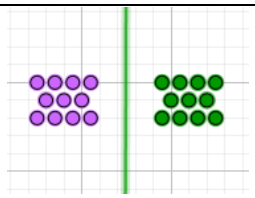
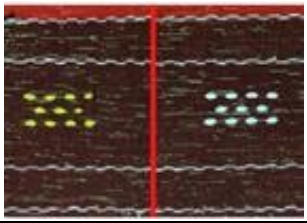
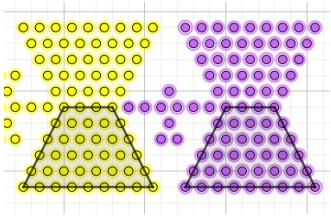
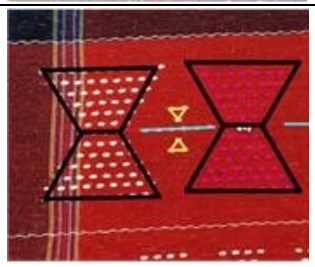
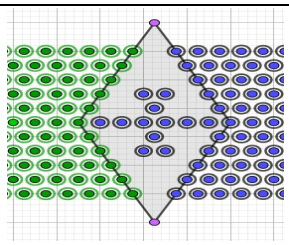
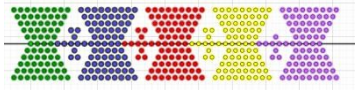
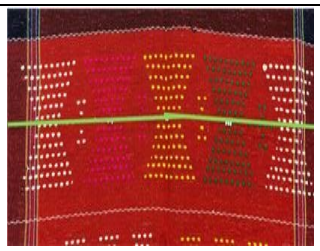
Based on the results of the discussion that has been described in Table 1 and comparing it with the results of research conducted by Astuti (2019), it was found that in *Saddum Ulos* there are not only geometric and left-right symmetrical concepts but there are also concepts of lines and angles as well as arithmetic number patterns. In this research, the researcher also only focused on one fabric, namely *Saddum Ulos*, then the researcher also linked the frieze pattern and *Saddum Ulos* motif so that this research is something new in researching Ethnomathematics on *Saddum Ulos*.

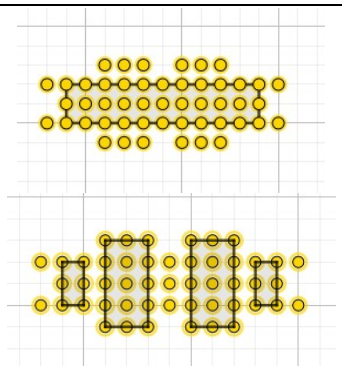
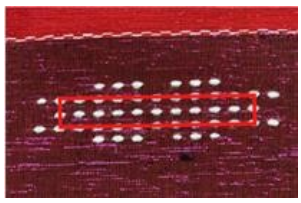
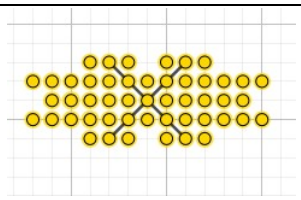
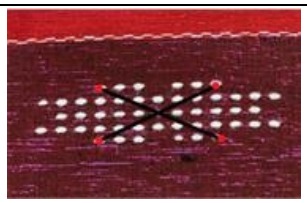
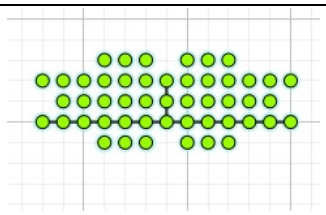
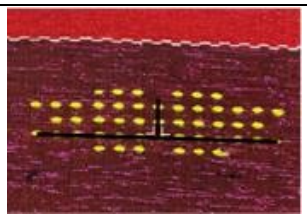
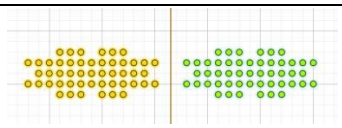
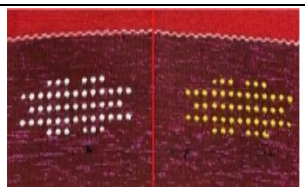
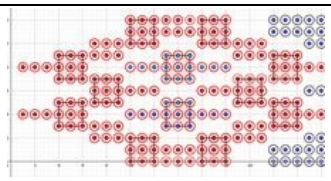
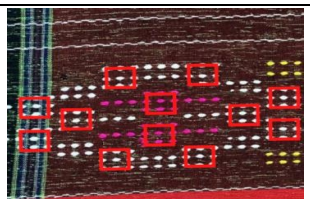
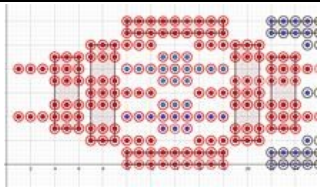
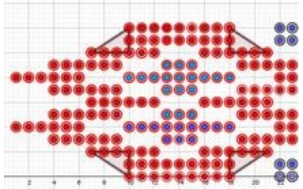
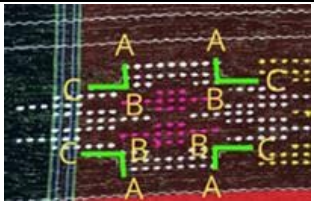
2. Development of the *Saddum Ulos* Motif with Geogebra

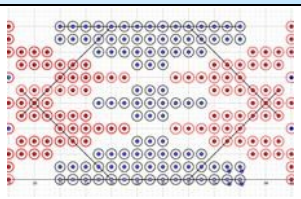
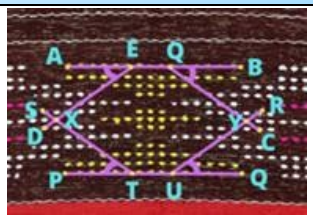
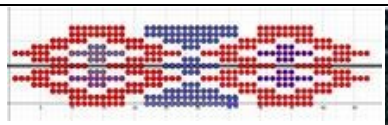
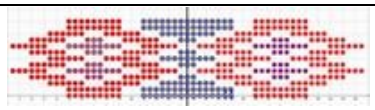
Motifs that are related to mathematics are implemented and further developed using Geogebra software, this allows better visualization and can clearly see the mathematical relationships contained in *Ulos Batak Saddum*. The following are the results of comparing mathematical concepts using Geogebra software with *Saddum Ulos*.

Tabel 3. Mathematical Concepts Designed by GeoGebra Software with *Saddum Ulos*

No	Mathematical Concepts in GeoGebra Software Design Results	Mathematical Concepts in *Saddum Ulos*	Description
1			There is a plane shape in the shape of an isosceles triangle.
2			There is a plane shape in the shape of a hexagon. The resulting difference is that in the GeoGebra software the hexagons formed are regular hexagons, whereas in the *Saddum Ulos* fabric the hexagons formed are irregular hexagons.
3			There is a plane shape in the form of an equilateral triangle.
4			There is a plane shape in the shape of an irregular hexagon.

5	 		There are plane shapes in the form of rectangles and trapezoids.
6			There is a concept of transformation geometry, namely reflection on the y-axis.
7			There is a plane shape in the shape of a trapezoid.
8			There is a plane shape in the shape of a rhombus.
9			There is a concept of transformation geometry, namely reflection on the x axis.

10		 	There are planes, rectangular shapes with different sizes.
11.			There is the concept of lines and angles, namely two lines that intersect each other
12			There is the concept of lines and angles, namely perpendicular lines.
13			There is a concept of transformation geometry, namely reflection on the y axis.
14			There is a plane, square shape.
15			There is a plane, rectangular shape.
16			There is a flat plane in the shape of a right triangle.

17			There is the concept of lines and angles, namely two pairs of lines that intersect each other.
18			There is a concept of transformation geometry, namely reflection on the x axis.
19			There is a concept of transformation geometry, namely reflection on the y-axis.

Based on Table 3 above, it can be concluded that the mathematical concepts in the design of the Geogebra software and the mathematical concepts in *Saddum Ulos* have similarities, but there is one motif that appears to be different, namely motif number 2 in the table above. The resulting difference is that in the Geogebra software the hexagons formed are regular hexagons, whereas in the *Saddum Ulos* fabric the hexagons formed are irregular hexagons. Apart from that, from the table it can also be seen that there is a geometric transformation process in the *Saddum Ulos* motif, such as mirroring. This is like the Minangkabau songket woven motif (Syahriannur, 2019), the Lunggi cloth woven motif (Purnama, et al, 2020), the Buna cloth motif (Natun, et al, 2021).

CONCLUSION

After observing and studying the *Saddum Ulos*, it can be concluded that the *Saddum Ulos* owned by the Batak people has its own history and meaning related to the daily life of the Batak people, both in relationships with fellow humans and the creator. There are 13 mathematical concepts contained in *Saddum Ulos* motifs, namely one-dimensional geometry in the form of intersecting lines and perpendicular lines. Then there are the mathematical concepts of two-dimensional geometry, namely square, rectangle, rhombus, trapezoid, hexagon, equilateral triangle and right triangle. Next there is a geometric transformation in the form of reflection, finally there is the concept of number patterns and arithmetic sequences contained in the *Saddum Ulos* motif. When making the *Saddum Ulos* motif using GeoGebra Software, it can be seen clearly in the algebra section, which displays the area of a flat shape that is formed. So that when the process of searching for the area of a flat shape is carried out manually, the results obtained are the same as those displayed on GeoGebra.

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