Study ethnomathematics: revealing mathematics ideas on minangkabau traditional weaving songkets in pandai sikek

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Abstract. This study aims to prove a mutual relationship between mathematics and culture. Due to an assumption that mathematics does not have any relationship with each kind of culture. However, a study about ethnomathematics scrutinizes a group of culture as mathematical. This research takes place in Pandai Sikek, Tanah Datar Regency, West Sumatera. People in Pandai Sikek are the biggest producers of songket in Minangkabau. Pandai sikek still keeps on their culture tightly, one of them is the women of pandai sikek do the weaving hereditary. This research focuses on revealing a mathematical idea beyond traditional songket Minangkabau at Pandai Sikek. This study of ethnomathematics uses a qualitative approaching of an ethnography method. The data were collected through observation, interview and study documentation. The result of the research is to reveal a mathematical idea that is used by Pandai Sikek people on manufacturing songket that there are mathematic activities and geometry patterns in traditional songket pattern of Minangkabau. This research enlights people that mathematics has relationship with culture.

1. Introduction
Mathematics in schools puts some benefits that is to develop the ability in counting and communicating ideas. The aim is to practice the reasoning-thinking to conclude, creative activities, problem-solving abilities, convey information, and have a rational objective attitude [1]. However, mathematics had been dominated by an absolute paradigm for more than 2000 years which viewed mathematics as a perfect science and objective truth (body of infallible and objective truth), far from human life [2].

An example taken from past that caused an absolute paradigm towards mathematics was the quote in Tempo Newspaper entitled Questioning the 2013 Curriculum “The curriculum, that put too much load on book manufacturers and national examinations, is dominated by the cognitive domain merely as a symbol of the highest achievement. Fields of study remain numerous, content standards are very heavy, deify mathematics-science, and ignore humanities-literature [3]. In the learning implementation, the 2013 curriculum deifies mathematics-science subject, while ignores humanities-literature fields. it is very clear that mathematics and culture are mutually independent and do not have a reciprocal relationship.

Meanwhile, the activities that we do on our each single of activity are inseparable from mathematics. Regardless of whether we realize the matter or not, we use mathematics in solving every problem in life. Likewise with a group and community that still maintains its culture.

Furthermore, the results of Ulum’s research [4] states that there are some cultural characteristics of mathematics through weaving activities of the Gajebo Village community in Baduy. In line with Ulum’s findings, Mustika's [5] research figures out that there are mathematical aspects toward the play of the Baduy community which indicates that mathematics has an important role in human life.

The public's view about mathematics and culture that has no reciprocal relationship is a mistake. One of the things that convinces the existence of errors beyond the view of the community according to Turmudi [4] in describing what is mathematics, as the following quote: Mathematics is an object found and created by humans; Mathematics is created and not dropped by itself but arises from activities for
which the object is available and from the needs of science and everyday life; and Once a mathematical object is created, it has well-defined properties.

Alangui states that if you look at social, historical, cultural, political and educational reasons, there is a necessity of transformation for looking what and how mathematics works. The form of transformation in viewing mathematics is known as ethnomathematics [6]. According to D'Ambrosio the idea of ethnomathematics in a broader view is on how mathematics relates to life. Mathematics is an intellectual instrument created by human to depict life and help in solving problems in daily life [7]. Begg argues that different cultural groups may have different ways in figuring out, that we might propose several improper questions and we might need to consider "ethno-education" [8]. Rossa & Orey assert that ethnomathematics use mathematical modeling to solve the real problems and translate them into the academic system of mathematical language [9].

Barton argues that Ethnomathematics can be seen as a realm of research studies that examines the way of a group of people in a particular culture in understanding, expressing, and using cultural concepts and practices that are described by researchers as a mathematical [10]. The reasons why the importance of ethnomathematics studies are as follows [6]: (1) Social reasons, through the study of Science and Technology the difficulty of finding knowledge systems originating from non-Western countries, (2) Historical reasons, the European scientific mathematics were forced to the colonial countries without regard to cultural conflicts. The birth of an idea to study the history of mathematics is one form of the colonialism rejections, (3) Cultural reasons, the results of documentation and investigation of cultural activities actually show that there are some other forms of mathematics that are different from the mathematics of Western countries' thinking and (4) Political and educational reasons, it involves social aspects in learning that is not sufficient for not doing a depth learning. Nevertheless, it also needs to provide a space for democracy in mathematics classes. So that a kind of critical and open dialogue takes place between the teacher and students in order to facilitate the development of the level of students' creativity to solve mathematical problems.

Indonesia is a multi-cultural country, each culture has its own characteristics. There are still many different kinds of ethnic or ethnic communities that still hold fast to their beliefs and culture. One of them is Minangkabau which has several traditions, traditional houses and different regional languages. One of the nagari who still upholds their culture is Pandai Sikek. In Pandai Sikek it still preserves the beauty and production of Minangkabau traditional songket weaving crafts. According to researchers, the Minangkabau community in Pandai Sikek is one of the right places for a study of ethnomathematics.

Songket is a kind of traditional Minangkabau woven fabric. Songket is well-woven by hands using gold and silver threads. Songket is generally used in official occasions, one of them is the traditional Minangkabau ceremony. According to Nanda Wirawan the old Minangkabau songket is one of the world's cultural heritages. Physically, Minangkabau songket is a work of art that is made by weaving metal macau threads on weft lungs with very fine and intricate patterns [11]. By observing the Minangkabau Traditional songket weaving activities in Pandai Sikek, it is expected that the community of society is able to show the relationship between culture and mathematics so that it can change the public's point of view upon the absence of a relationship between culture and mathematics. Thus, it can be useful in the improvement efforts of the quality in mathematics learning to be more meaningful and contextual.

2. Methods
This research was conducted to reveal several mathematical ideas that appears in the process of creating Minangkabau traditional songket by using qualitative research methods through ethnographic approaches.

2.1 research design
The research design that is applied in ethnomathematics research refers to the research design used by Alangui [6]. There are four questions used in the Alangui dissertation as follow: Where to start looking?, How to look?, How to recognize that you have found something significant?, and How to understand what it is?
2.2 participants and research sites
This research was conducted in Jorong Baruh, Pandai Sikek, X Koto District, Tanah Datar District, West Sumatra. The participants in this study were Pandai Sikek women who does a daily work as weavers who were considered to be knowledgeable about the process of making songket.

2.3 research instruments
In qualitative research, the main instrument is the researcher himself. However, after the focus of the research becomes clear, it is believed that a simple research instrument will be developed. It is expected to be able to complete and compare the data that has been collected through observation and interviews [12].

2.4 data collection
In this research, the techniques in the data collection are through the form of observation, study documentation, and interviews. There are three stages of observation; descriptive observation, focused, and selected.

2.5 data analysis
The data analysis in qualitative research were carried out at the time of data collection and after completing the data collection. The stages of data analysis are the data reduction, data presentation, and verification [12].

3. Result and Discussion
This section is going to elaborate mathematical ideas in the Minangkabau traditional woven songket that is in the process of making songket cloth and traditional Minangkabau songket fabric patterns in Pandai Sikek

3.1 mathematical idea in the process of manufacturing woven songket
The process of manufacturing songket is divided into six mathematical activities in accordance with what has been explained by Bishop, those are counting, measuring, locating, explaining, playing games, and designing [13].

3.1.1. counting. In the songket manufacturing process, there is a numerical activity, especially in the process of making patterns. The process of making patterns using pancukie by counting each piece of string. Count the strands of yarn by taking and closing the yarn in accordance with the division of yarn on the pattern that is going to be made.

3.1.2. measuring. In the songket manufacturing process, there is a measuring activity by measuring the distance between one pattern and another pattern. Measuring the size of the songket fabric that will be produced, such as the size for a sarong is 180 cm × 110 cm and the size for the salendang is 180 cm × 50 cm or 180 cm × 30 cm.

3.1.3. locating. In weaving activities, there is a mathematical activity that is locating some patterns that are going to be made on a songket cloth. Allocating patterns with the distance between the patterns that will be considered by the weaver in their use of songket fabric.

3.1.4. explaining. In weaving activities, there is a mathematical activity that is locating some patterns that are going to be made on a songket cloth. Allocating patterns with the distance between the patterns that will be considered by the weaver in their use of songket fabric. Pucuak rabuang pattern means that in this life it is always useful for others, Saik galamai pattern means that to always be thrifty in this life, Itiak pulang patang pattern means that in this life must follow a leader and be loyal to a leader, and Buah Palo pattern means that the results of human thought in creating weaver creativity ideas in making a pattern.

3.1.5. playing. In making songket, weaver’s ability is being important thing to play with the congket cloth to be when combining the repetition and symmetrical patterns. So as to produce a beautiful blend like every 5 cm makes the red dominant, and the next 5 cm being dominant golden. This creates songket fabric which has high artistic value and is very beautiful to look at.
3.1.6. designing. Before making songket, women in Pandai Sikek designs the forms and patterns of songket that is going to be made and designs the division of yarn. Next section, will be discussed about the mathematical model that might be built in the process of making songket fabric, which is to answer the question of how to determine how long the thread is needed in making songket fabric if the size of songket fabric \((p \times l) cm^2\).

In the research results section it has been explained that is every 1 cm wide of songket fabric has 18 threads or 36 strands of warp yarn and every 1 cm long songket fabric there are 28 threads or 56 strands of weft so that we can determine the length of thread needed in the size of 1 cm \(\times\) 1 cm.

\[
1 \text{ cm } \times 1 \text{ cm} = 56 \text{ strands of weft} + 36 \text{ strands of warp yarn}
\]

\[
= 56 \text{ cm} + 36 \text{ cm}
\]

\[
= 92 \text{ cm}
\]

From the explanation above, it is obtained that for each size of 1 cm \(\times\) 1 cm or 1 \(cm^2\) it takes 92 cm of yarn length, because it is obtained based on the number of threads that make it. Then what about the length of thread needed when the size of the songket fabric \((p \times l) cm^2\) is as follows:

\[
p \text{ cm } \times l \text{ cm} = (p \times l) cm^2,
\]

\[
= (p \times l) 92 \text{ cm}
\]

because for 1 \(cm^2\) requires 92 cm thread

\[
= 92 \text{ cm} \times (p \times l)
\]

Thus, it was obtained that to make songket cloth in size \((p \times l) cm^2\) required yarn length as follows.

\[
B = 92 cm \times p \times l \quad (1)
\]

With:

- \(B\) = thread length
- \(p\) = the length of the songket fabric
- \(l\) = width of songket fabric

Then how to determine how long weft yarn or length of warp yarn needed in making songket fabric. We can use the solution as follow:

\[
1 \text{ cm } \times 1 \text{ cm} = 56 \text{ cm weft yarn} + 36 \text{ cm warp yarn}
\]

Suppose \(p\) is a weft thread and \(l\) is a warp thread, then

\[
1 \text{ cm } \times 1 \text{ cm} = 56p + 36l
\]

So if asked how long the weft or thread length can be obtained with the following equation:

\[
N = 56x + 36y \quad (2)
\]

With:

- \(N\) = length of weft and thread length
- \(x\) = length of songket using a type of weft \((p)\)
- \(y\) = width of songket fabric using warp yarn \((l)\)

In this case, there is also the concepts of comparison of reverse value and the concept of comparison value.

The concept of comparison of reverse values is in the yarn density. The less (finer) the density of the yarn the longer the time of manufacture and the coarser the density of the feeding yarn the faster the time of manufacture.

The concept of comparable worth is found in the complexity of songket fabric patterns. The more complicated the songket fabric pattern, the longer the manufacturing time and the more expensive the selling price. The easier the complexity of the pattern, the faster the time needed and the cheaper of the selling price.

3.2. mathematical ideas on traditional minangkabau woven songket patterns in pandai sikek

In this section of the discussion, the author is going to explain what mathematical ideas are in the Minangkabau traditional songket woven pattern in Pandai Sikek. Disclosure of mathematical ideas in
this section is based on geometrical patterns with reference to previous relevant ethnomathematics research, namely research conducted by Ada Katsap and Fredrick L. Silverman entitled “Ethnomathematics of Negev Bedouins’ Existence in Forms, Symbols and Geometric Patterns” in year 2016 [14].

| No | Pattern Drawing | Symmetry group | IUC Notation |
|----|-----------------|---------------|-------------|
| 1  | Draw Pattern *itiak pulang patang* | Only Translation | p111 |
| 2  | Draw Pattern *pucuak rabuang (1)* | Translation, horizontal and vertical reflection, 2-fold rotation (180°) | pmm2 |
| 3  | Draw Pattern *bakamuak (1)* | Translation, and horizontal reflection | p1m1 |
| 4  | Draw Pattern *biku-biku (2)* | Translation and glide reflection | p1a1 |
| 5  | Draw Pattern *siriang* | Translation and horizontal reflection | p1m1 |
| 6  | Draw Pattern *cantik manis* | Translation, horizontal and vertical reflection, 2-fold rotation (180°) | pmm2 |
| 7  | Draw Pattern *saluak laka* | Only Translation | p111 |
| No | Pattern Drawing | Symmetry group | IUC Notation |
|----|-----------------|----------------|--------------|
| 8  | **Draw Pattern buah palo (6)** | Translation and horizontal reflection | p1m1 |
| 9  | **Draw Pattern buah palo (7)** | Translation, and vertical reflection | pm11 |

Based on the table above, in the *pucuak rabuang* pattern (1), *cantik manis* pattern is a symmetry of translation, horizontal reflection, vertical reflection, 2-fold rotation (180°) with IUC notation is *pmm2*. This means that there are two perpendicular lines in each pattern as vertical and horizontal symmetry axes. It is also either called the symmetry of the letter H [15]. This is due to the right side is a reflection of the left side (vertical symmetry) and the top side is also a reflection of the bottom side (horizontal symmetry), so that the right side is congruent with the left side and the top side also congruent with the underside. In the *buah palo* pattern (7) there is translational symmetry and vertical reflection called *pm11*. The existence of vertical lines as vertical symmetries. It is called either a symmetry letter *M* [15] where the left side is a reflection of the right side so that the left side is congruent with the right side. In the *bakaluak* pattern, *siriang* pattern, *buah palo* pattern (6) consists of translational symmetry and horizontal reflection called *p1m1*. The existence of horizontal lines as symmetrical horizontally. It is called either symmetrically the letter *B* [15] where the top side is a reflection of the bottom side so that the top side is congruent with the bottom side. In the *biku-biku* pattern, it has glide reflection called *p1a1*, consisting of a combination of glide reflection and translation along the line. In the *itiak pulang patang* pattern and *saluak laka* it only has translational symmetry called *p111*. The right side is not congruent with the left side and the top side is also not congruent with the bottom side.

4. **Conclusion**

Based on the research, it was found that there was a mathematical idea in the process of making songket fabricating and on the traditional Minangkabau woven songket pattern in Pandai Sikek. There is mathematical activity in accordance with what Bishop explained. Those are: counting, locating, measuring, designing, playing, and explaining. There is a mathematical model in determining the length of thread needed in making songket. The concept of comparison of reverse values is in the yarn density. The less (finer) the density of the yarn the longer the time of manufacture and the coarser the density of the feeding yarn the faster the time of manufacture. There are geometric patterns in the songket fabric pattern, namely *pmm2*, *p1m1*, *p111*, *pm11* and there are symmetries of letters H, B, M.

5. **References**

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