Journal of Research and Advances in Mathematics Education

Volume 8, Issue 1, January 2023, pp. 30 – 48
DOI: 10.23917/jramathedu.v8i1.2524
p-ISSN: 2503-3697, e-ISSN: 2541-2590

Mathematical ability of Bugis community in designing *Lipa' Sabbe of Sengkang*

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Citation: Busrah, Z., Aras, A., Buhaerah, B., & Pathuddin, H. (2023). Mathematical ability of Bugis community in designing Lipa' Sabbe of Sengkang. *JRAMathEdu (Journal of Research and Advances in Mathematics Education)*, 8(1), 30-48. https://doi.org/10.23917/jramathedu.v8i1.2524

ARTICLE HISTORY:
Received 10 October 2022
Revised 21 January 2023
Accepted 25 January 2023
Published 30 January 2023

KEYWORDS:
Ethnomathematics
Lipa' Sabbe motif
The number patterns
Geometric transformation
Algebraic models

ABSTRACT
This research is an ethnomathematical research that aims to explore the mathematical abilities of the Bugis people in weaving the *lipa' sabbe*. This study applies a qualitative method with an ethnographic approach. The data were collected through observation, interviews, and documentation. Based on the results, it can be explained that in the process of weaving silk, the craftsmen combine the techniques of counting, designing, placing, and measuring as mathematical activity to produce various motifs. The weaver's ability to count and design motifs produces geometric planes that are transformed through a combination of reflection, translation, and dilatation. In making visualized motifs resembling curved planes such as the *lagosi* motif, the *phinisi* or the *batumesang* motif, they are approximated by using a collection of rectangular pixels from the arrangement of warp, weft and other motif yarns such as gold or viscose. The redesign of the silk motif uses the the number patterns identified on the arrangement of the yarns. In algebra, the *lipa' sabbe* motif can be represented by a set of constant functions, parallel linear functions, or degree-n polynomial. The results of this study indicate that the mathematical concepts in *lipa' sabbe* motifs are not only in the form of geometric concepts, but also include the concepts of number pattern, and algebra. Based on the manufacturing process and the resulting motifs indicate that the craftsmen have uniq mathematical abilities.

INTRODUCTION

The advances in science and technology as a product of modernization create new patterns of behavior in various dimensions of life. Apart from bringing about positive changes, these developments also include new threats and challenges for both individuals and communities. This phenomenon is not intended as a pessimistic response to the progress of technological civilization but it can be said that technological progress must be able to maintain the existence of local culture. D'Ambrosio's criticisms encourage a new idea called ethnomathematics. In order to, at the 5th ICME in Australia in 1985, D'Ambrossio introduced the term ethnomathematics.

Ethnomathematics as a sub-study of mathematics can be a bridge in developing multicultural education in formal education. The term ethnomathematics was introduced by D'Ambrosio (D'Ambrosio, 1985) as a mathematical study obtained from deepening activities in a particular cultural group that can provide an overview of the mathematical thinking system by people in that community (Rosa & Orey, 2011). As Keith Devlin has argued that mathematics is a way of looking at the world, both the physical, biological, sociological world in which we live, and also a way of interpreting the inner world of ideas and thoughts (Haryono, 2014). With regard to local culture, it

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can be said that there are many cultural attributes that can indicate ways or techniques of thinking mathematically in a cultural society.

Local Wisdom products that have been passed down by ancestors should be recognized and respected through identification, exploration, documentation, and codification. Indonesia is a national gallery that has cultural pluralism as a legacy from its ancestors as well as Indonesia's identity as a pluralistic nation. Bugis, one of the largest ethnic group in Indonesia, has a variety of cultural heritages. Bugis people are scattered in various regions in Indonesia and most of them live in the province of South Sulawesi. Knowledge in the Bugis community that is enshrined through the *Lontara* manuscript is an indication of the existence of culture-based intelligence in transmitting knowledge or values in society (Koolhof, 1999). This gives an opportunity to take advantage of the existence of local culture in optimizing more contextual mathematics learning.

Presently, ethnomathematical studies that integrated elements of Bugis local culture with mathematical concepts in formal education is limited. Previous research found that Buginese traditional food provide mathematical concepts such as 2D, 3D, similarities, and congruences, that can be integrated with mathematics learning (Pathuddin et al., 2021; Pathuddin & Raehana, 2019). Further research modeled the volume model of a rotary object on a Bugis tradisional food (Busrah & Pathuddin, 2021). Furthermore, research that uses the context of traditional cakes in teaching mathematics in the classroom has been also conducted (Aras et al., 2022). However, there have been no studies that have explored mathematical concepts in silk weaving.

Silk woven fabric or in Bugis society known as *Lipa' sabbe* is a cultural heritage that is well known to foreign countries. *Lipa' sabbe* production can be found in Sengkang, the city of Wajo Regency, because it is one of the largest weaving producing areas in South Sulawesi (Wahyuni & Nahari, 2013). In this study, the concept of geometric transformation will be explored in *lipa' sabbe* ornaments. Apart from being a Bugis cultural heritage which has a symbolic meaning and philosophy of cultural values, *lipa' sabbe* also reflects a system of knowledge, skills and attitudes (Sulvinajayanti, 2020). In this study, *lipa' sabbe* will be used as a medium to explore the mathematical abilities of the craftsmen either through the manufacturing process or from the motifs produced. This is important because most people in Sengkang still preserve the tradition of weaving silk. It is shown by the fact that there are still many weavers who pass on their skills to the next generation. Weaving expertise and skills are inherited from the ancestors from generation to generation (Joharia, 2019). Some of the people of Sengkang, especially women, have learned to weave since childhood. Without realizing it, these skills not only preserve traditions and become a livelihood, but can also improve mathematical abilities.

Mathematical ability is defined as the ability to obtain, process, and store mathematical information (Vilkomir & O'Donoghue, 2009). In addition, mathematical ability can also be interpreted as an intrinsic potential to learn mathematics and utilize mathematical knowledge effectively, as well as master new mathematical ideas and skills (Koshy et al., 2009). Mathematical ability is not innate but something acquired in life (Krutet͡skiĭ, 1976). This suggests that some people will become more able to develop mathematical abilities through development and experience in life. In line with this, researchers conducted an exploration of the mathematical abilities developed by *lipa' sabbe* weavers in Sengkang district. Even though it has not yet reached the level of formal mathematics, the mathematical concepts found in the *lipa' sabbe* weaving process show that mathematical abilities always develop naturally in every activity of human life.

The variety of motifs on *lipa' sabbe* represents the mathematical abilities and skills of the craftsmen. To obtain description about mathematical abilities in the weaving process, an in-depth and comprehensive exploration is needed, not only on the motifs depicted, but also requires an understanding of the steps and techniques for making *lipa' sabbe*. Through an in-depth study of the weaving process and the *lipa' sabbe* motifs, it is hoped that it will provide more specific information about the description of the mathematical abilities of the silk sarong craftsmen.

Fundamentally, in ethnomathematical research there are two goal orientations. The first goal is oriented to the science of mathematics, namely to encourage the creation of new knowledge, with this it is hoped that it can spread the perspective that there are various mathematical activities that develop in a cultural group. In general, mathematical activities that can be found in a cultural community include: counting, placing, measuring, designing, playing, and explaining (Bishop, 1991). The second goal is oriented towards mathematics education, in this case ethnomathematical research

Figure 1. Weaving process by craftsmen

Figure 2. Lipa' sabbe Sengkang

seeks to uncover mathematical concepts that develop in society and integrate them in formal mathematics learning in schools (Risdiyanti & Prahmana, 2020). The process of weaving and an example of Sengkang's Lipa' sabbe can be seen in Figure 1 and Figure 2.

In mathematics, there are several topics that become basic studies and must be programmed for all mathematics students, such as sequences, algebra, and geometry. These concepts can be explored in various types of cultural properties produced by cultural societies. In various previous ethnomathematics studies that tried to explore geometric concepts in cultural ornaments such as *batik*, woven fabrics, as well as in other cultural properties, it was shown that there were mathematical concepts. However, generally the studies only focus on aspects of form that are associated with plane geometry or spatial geometry as well as geometric transformations. Geometric transformation concept such as translation, dilation and rotation were found in Javanese batik motifs (Prahmana & D'Ambrosio, 2020; Risdiyanti & Prahmana, 2018a, 2018b). Geometric transformation has also been applied in making Lampung and Kawung batik motif (Christanti & Sari, 2020; Fadila, 2017; Faiziyah et al., 2021). In addition, the concepts of triangle, rhombus, square, and rectangle were found in Ende Lio's tie weaving (Merdja & Restianim, 2022). The concepts of straight lines, parallel lines, folding symmetry, rhombuses and triangles have been identified in Balinese woven fabrics (Putra et al., 2022). Modelling activities on batik motifs has been carried out by designing an ellipse plane through its basic equation (Pradanti, 2016). Furthermore, geometry concept is also implemented in East Sumba woven fabrics (Wulandari, 2020). In this *lipa' sabbe* ethnomathematics research, it does not only focus on the geometrical aspects in the existing motifs, but also explores the tools, materials, thinking processes, and techniques applied by silk cloth craftsmen in the weaving process. In addition, this study also tries to identify algebraic models and number patterns that represent the counting techniques used by craftsmen to produce the *lipa' sabbe* motifs. Additional studies carried out were tracing motifs containing curves. Therefore, this research will try to integrate these mathematical topics in constructing a mathematical model through exploring the weaving process, and the various motifs on *lipa' sabbe*.

Based on the previous background description, this research will examine the integration between mathematics and local culture, in this case the woven sarong or *Lipa 'sabbe*. Therefore, there are two main objectives, namely to explore the mathematical intelligence possessed by craftsmen in the process of making *lipa' sabbe*. Meanwhile, the second objective is to explore the mathematical concepts contained in the *lipa' sabbe* motif. The mathematical concepts that are the focus of this research are geometric transformations, number patterns on ornaments, algebraic representations and plane curve approximation techniques using the Riemann concept. This research is expected to encourage the birth of a new mathematics by involving the cultural dimension.

METHODS

This research is qualitative research using ethnographic approaches in exploring and describing the intelligence possessed by silk sarong craftsmen. A qualitative research method or process with an ethnographic approach requires a researcher to use various methods to collect data through observation, interviews and documentary data to produce detailed and comprehensive reports of cultural phenomena (Hamidani, 2019). In ethnographic research, the stages of research implementation can be distinguished in several approaches. Singleton and Strait (2005), started with (1) formulating the problem, (2) selecting and determining the scope of the research, (3) formally obtaining research permits, (4) introducing the role and position of the research group, and finally (5) collecting and recording information in various ways. According to Anggrosino (2007), data collection in ethnographic research can be obtained through observation, interviews, and archival documentation. In the process, researchers must prepare themselves by understanding the character, customs and natural situations of the research subjects. Researchers must equip themselves with the ability to interact, communicate, and in particular must have language skills that exist in the cultural groups being observed. Another approach regarding the stages of ethnographic research was also introduced by Spradley (2007), starting from (1) determining the scope of the research, (2) determining the informants, (3) making ethnographic records or recordings which can be in the form of observations, interviews or documentation, (4) analyzing the results of interviews and documentation, (5) domain analysis, (6) conducting taxonomic analysis and (7) writing ethnography. By considering the characteristics of the research, the researcher adopted the research stage with the ethnographic approach introduced by Spradely because these stages best suited the research objectives.

Specific intelligence is explored in the form of creative thinking processes, manufacturing techniques and mathematical practices by craftsmen in the activity of weaving silk sarongs or *lipa' sabbe*. Data is collected through observations, interviews, and documentation. The instruments used were observation sheets and interview guides. Before the research was carried out, the instruments to be used were validated first. The observation sheet focuses on mathematical activities that are implemented in the weaving process directly. While the interview guidelines are categorized into 2 main aspects, namely primary aspects and secondary aspects. The primary aspect is related to ethnomathematics. In this primary aspect, the researcher wants to know whether there is a theoretical understanding of the elements of geometry, and the techniques used in the process of depicting silk motifs. While the secondary aspects include the identity of the weavers, history of weaving activities, aspects of understanding motifs including the names of motifs, considerations in selecting motifs, aspects of tools, materials and processes, and techniques in designing motifs. Validation was carried out by experts and experienced in the field of ethnomathematics. The data obtained is used in further in-depth study of the activities and mathematical concepts involved in the manufacturing process and the motives of *lipa' sabbe*.

The first stage of this procedure includes determining the scope of the research. In this stage, the objects, locations and informants are determined. The main object of this research is the technique of making silk sarongs and the motifs produced from the weaving process by craftsmen. In order to obtain efficient and effective research results, in this study, a regional boundary was determined, namely the Tanasitolo sub-district in Mappadaelo' Village and Pakkana Village, with the consideration that these two areas are known as the center of silk craftsmen in Sengkang. Furthermore, four informants were determined, each of which was the main informant, key informant, and two supporting informants. The four informants were selected through consideration of their direct role as the main actors, in this case as craftsmen who had understood and were directly involved in the manufacture of *lipa' sabbe*.

The next stage is data collection, which includes interviews with informants, recording the results of interviews, recording or documentation. Data was collected in October 2021, consisting of four visits to the research site. Furthermore, triangulation was carried out to ensure the validity of the data. Triangulation involves verification and validation of qualitative data analysis (Nurani, 2008). The triangulation carried out in this study was source triangulation. Researchers confirmed the data that had been obtained from one informant to another. In this study, there were four informants who were interviewed regarding the technique of making *lipa' sabbe*. Furthermore, to ensure data reliability, two methods were carried out, by extending the observation process and conducting an interview process until data or information was found that had not changed. Reliability is often defined as the consistency and stability of data or findings (Stainback & Stainback, 1988). From interviews with the four informants, data were obtained in the form of consistent interview results so that the researcher concluded that the data had reached a saturation point. Thus, it can be said that the data is reliable.

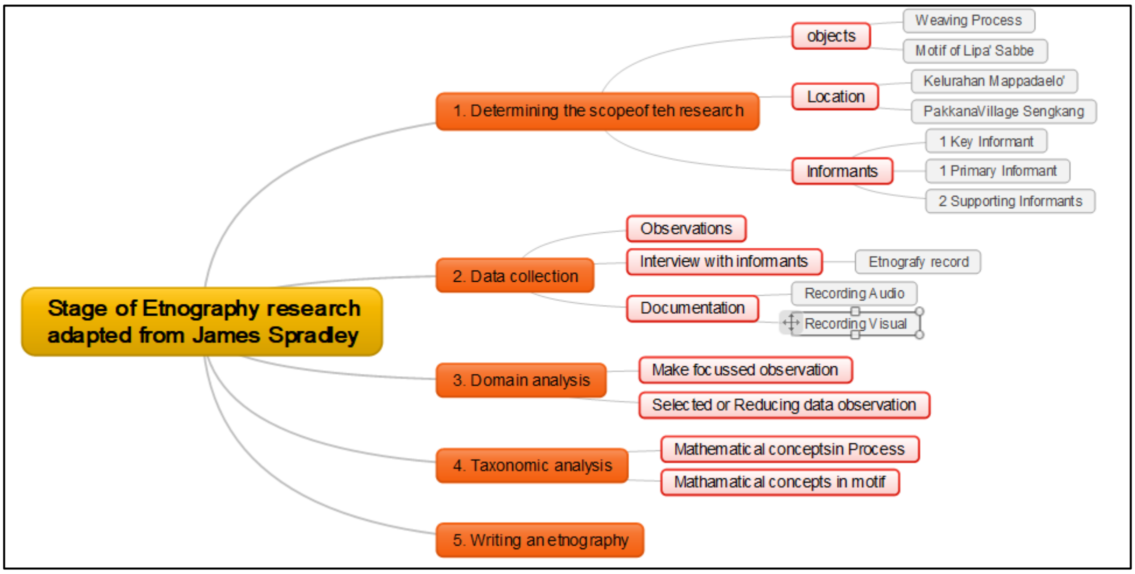

Figure 3. The stage of etnography research

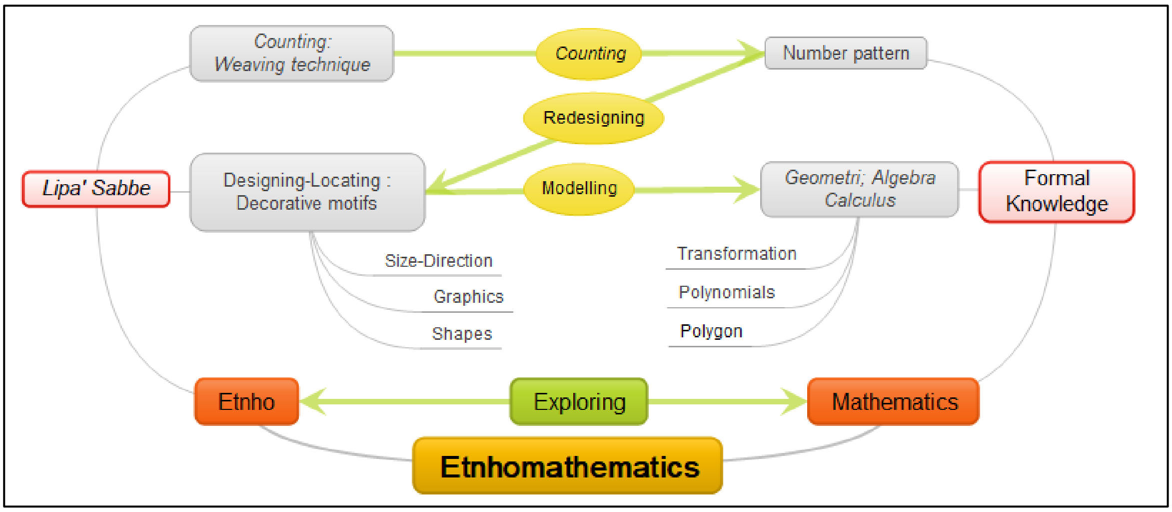

Figure 4. The scopes of research

The next step is to conduct a domain analysis, which is intended to build a correlation between the research objectives and the data obtained. Thus, at this stage, data reduction is carried out by selecting certain interview notes and the required documentation. The domain analysis is followed by a series of taxonomic analyses. In ethnomathematics research, taxonomic analysis is aimed at matching up mathematical concepts in formal education, to the observed cultural elements. Specifically, the cultural elements that are focused on in this research are the *lipa' sabbe* weaving process and the resulting geometric patterns. While the mathematical studies that are prioritized in taxonomic analysis include exploration of the integration of number patterns and the symmetry of geometric fields, geometric transformations, modeling of algebraic functions, and some calculus concepts on silk ornaments. From the whole procedure above, it is closed by writing an ethnography. In summary, the object, location, and stages of this research described above can be presented through the Figure 3. The ethnomathematical exploration in this study combines mathematical activities by a group of craftsmen with mathematical concepts in formal education as illustrated in the Figure 4.

FINDINGS

The discussion framework in this study is briefly described in Figure 5.

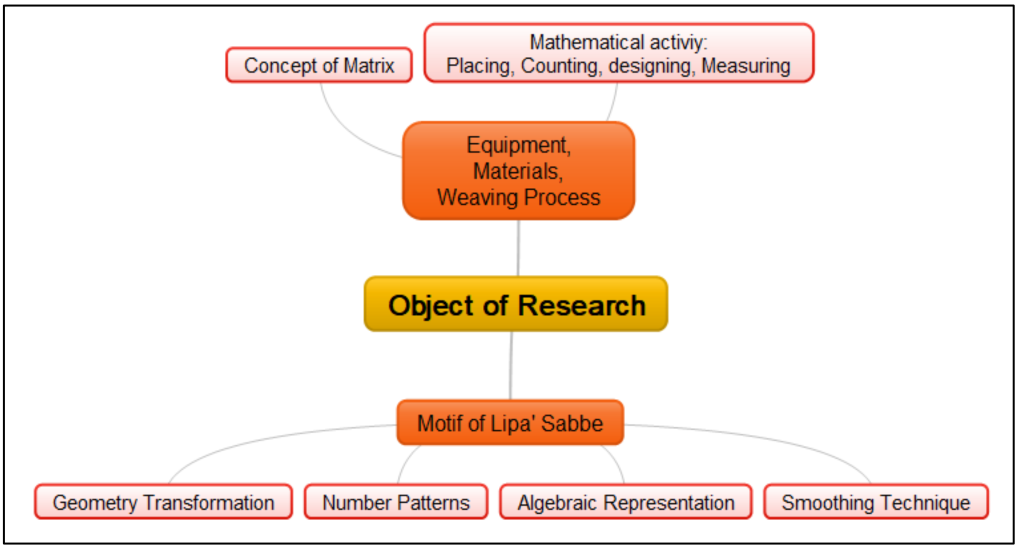

Figure 5. Object of research

Equipments and materials

In converting silk threads into silk cloth, craftsmen use two types of traditional looms, namely the *gedogan loom* or known as *walidah* and the other type is traditional ATBM, the Non-Machine Loom Tool or known as the *bola-bola* as shown in Figure 6. As for the ATBM, it is composed of several elements that have different functions including: *pessa, pedal, wakkangeeng, taropong, awereng, boko-boko, suru', jakka, pabbiccang are', tali-tali penenada, bum, dinamo, Jencara.* The parts of the ATBM above are constructed in such a way as to resemble a vehicle, for craftsmen in Sengkang call it with *Bola-bola* which means an artificial house. The construction of the balls or ATBM in Sengkang is the same as the construction of the weaving mechanism which is illustrated in the book Fundamentals of Fibrous Materials (Hu et al., 2020) as shown in Figure 7.

Furthermore, the basic materials used include warp threads, weft threads and motif threads in various colors and sizes. The warp thread is the silk thread which is the basic thread in the weaving process. In ATBM, the warp threads are attached to the gun and the combs are stretched out in front of the craftsman. The warp threads are moved up and down by the craftsmen by moving the pedals up and down. Simultaneously with the up and down movement of the thread following the pedal movement, the weft or motif thread will be clamped tightly and evenly between the warp threads perpendicularly. In the process, the weft is inserted into the warp threads which are carried by a cylindrical coil container known as *taropong* (shuttle).

Weaving process

The essence of the weaving process is to arrange the weft threads into the warp threads perpendicularly. The process is divided into three stages including preparing the thread, doing the weaving process and designing the motif. Based on the results of the interview, the craftsman explained that the thing that needs to be considered in tying the warp on the cloth winder, it should be tied by giving a certain count to each tie, for example every 10 warp threads then tied to the cloth roll. The informant explained that the total number of warp threads depended on the width of the fabric to be made. Based on the results of the interview, there were two types, namely 3600 strands for large sizes and 1800 for small sizes. Therefore, in this process the craftsmen must be thorough, careful, agile and patient in inserting the warp on the heddles and comb loom.

The process of weaving using ATBM should begin with adjusting the position of the gun and stepping on the pedal. After that, the weft yarn is inserted into the center of the criss-cross lip of the warp yarn. The weft yarn carried by the shuttle slips into the center of the warp yarn. This shuttle is the vehicle for the weft yarn or motif yarn to move left and right. The movement of the shuttle from left to right along with the up and down movement of the pedal that produces a knocking sound. To make the yarn durable, strong, and neat, it is necessary to wipe it with starch or lime water which is placed on the *pattasi*, then dry with a *jakka* comb.

Figure 6. Traditional looms *bola-bola* (ATBM)

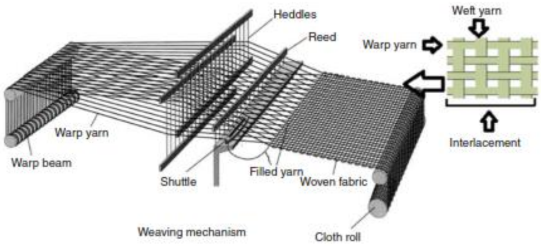

Figure 7. Weaving mecanism (Hu et al., 2020)

Figure 8. Color warp yarn attached to the ATBM

Figure 9. Black warp yarn attached to the ATBM

Figure 10. Gold motif yarn in *shuttle*

In general, motifs are distinguished into basic motifs and additional motifsThe basic motif is produced from a combination of colors on the warp yarn and color combinations on the weft yarn. There are many kinds of yarn can be used, for example color, black, and gold warp yarn such as shown in the Figure 8, 9, and 10, respectively Technically, designing a motif is distinguished by the *mattennung* or *mattete'* motif and the *sobbi'* technique. The matte'te' technique can be understood as a technique for creating motifs by adding motif yarn through the tweezers, similar with the way of weaving weft yarns into warp yarns. Of course, in this process the craftsmen have to adjust the stepping on the foot-pedal and the movement of the shuttle. The main thing to consider in adding motifs using the matte'te' method is how to choose the type of motif yarn and how to place the motif yarn. The characteristics that are considered in choosing motif yarn are color, thickness and type.

DISCUSSION

Based on the notes from the interviews, the informants explained that there are several mathematical skills needed in the weaving process, including the ability to calculate when inserting warp threads into heddles and combs. In addition, the activity of designing motifs, in this process the weavers combine counting, placing and measuring activities. Based on the mathematical activity proposed by Bishop (Bishop, 1991), it can be said that in the silk weaving process several mathematical activities are used by weavers.

Mathematical concepts in the weaving process and Lipa' sabbe motifs

The warp yarn are inserted into the heddles and combs vertically, then crossed with the weft horizontally to the craftsman's position, producing interlacements that are perpendicular to each other. The arrangement of the warp yarns in the eye of the bum consists of two arrangements, namely the upper warp yarn and the lower warp yarn which can be moved up and down alternately by stepping on the foot-pedal. With this, the interlacement is obtained from the weft thread which is tightly clamped by the upper (front) and lower (back) warp threads. The number of warp yarns inserted into the heddles varies, including 3600 strands, 2060 strands, and 1800 strands.

The perpendicular position of the warp and weft yarns results in a very tight arrangement of rows and columns. Mathematically, the interlacement of the warp and weft yarns is in accordance with the matrix concept. In the matrix, the warp yarn used can be denoted by index $l_i,; i = 1, 3, 5, n - 1$ for warp the top, while the lower warp is denoted by index $l_i,; i = 2, 4, 6, n$. Moreover, the

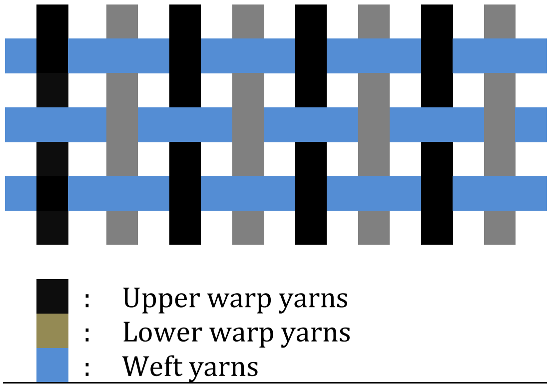

Figure 11. Illustration of warp and weft threads interweaving

$$S_i^j = \begin{bmatrix} S_1^1\ S_1^2\ S_1^3\ S_1^4\ \cdots\ S_1^n\ S_2^1\ S_2^2\ S_2^3\ S_2^4\ \cdots\ S_2^n\ S_3^1\ S_3^2\ S_3^3\ S_3^4\ \cdots\ S_3^n\ S_4^n \\ S_4^n\ S_4^n\ S_4^n\ \cdots\ S_4^n\ \vdots\ \vdots\ \vdots\ \vdots\ \ddots\ \vdots\ S_m^1\ S_m^2\ S_m^3\ S_m^4\ \cdots\ S_m^n \end{bmatrix}$$

Figure 12. Matrix representation illustration

Figure 13. Motif of *Balo Tettong*

Figure 14. Motif of Balo *Makkalu'*

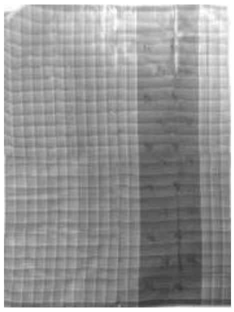

Figure 15. Motif of *Renni'*

Figure 16. *Lobang* Motif

arrangement of the weft strands inserted midway between the upper and lower warp threads can be denoted by the index : $p_j; j = 1, 2, 3, \ldots m$. Perpendicularly, the interlacement between the warp (vertical) and weft (horizontal) yarns result an arrangement of rows and columns which can be denoted by S_i^j. These warp yarn indices are used by craftsmen to mark through the *fitte* technique. Through certain counting activities, the weaver gives a sign where the weft yarn begins to be inserted or pulled out. Based on the results of the interview, the informant explained that the location markers of the warp threads are very helpful for weavers in designing motifs. The illustrations of warp and weft threads interweaving and the matrix representation can be seen in Figure 11 and 12 respectively

Mathematical concepts on Lipa' sabbe motif

The motifs on the Sengkang silk cloth are inseparable from a historical perspective and symbolic meaning. In its development, changes in silk motifs are influenced by changing times, creativity of craftsmen, community demands and efforts to conserve ancestral heritage. At first, the *lipa' sabbe* motif design was only made in two types, namely the vertical line pattern known as *balo tettong* and the horizontal line pattern known as *balo makkalu'* as shown in Figure 13 and Figure 14. Based on the results of observations and interviews, the horizontal line pattern is influenced by the combination of color and texture on the warp yarn, while the vertical pattern is influenced by the color and texture on the weft yarn or motif yarn. In order to be attached tightly and compactly, the weft or motif threads on the taropong move back and forth to the left and right of each row made tightly by the tette' technique. The combination of the *balo tettong* and *balo makkalu'* results motifs is a new style, namely *balo renni* or the small square pattern and *balo lobang* or the large square pattern as shown in Figure 15 and Figure 16.

The development of the *lipa' sabbe* pattern does not only consist of a collection of horizontal lines, vertical lines or squares from the intersection of lines. However, various kinds of motifs can be produced as additional motifs such as *balo cobo'* (sharp knife), *balo pucu'* (shoot), *balo bombang* (wave), with a smooth texture. There are also those with the same motif but with a rougher or embossed texture known as *cure' sobbi'*, including *pucuk rebbung* (bamboo shoots)*, cure' barong, mappagiling, batumesang* (tombstone), and *lagosi* (flowers). Based on the results of the interview, it can be explained that the creation of new motifs resulted from a process of imagination and deep reflection. As is the case with the development of *walasuji* motifs, *phinisi* motifs, *lontara* motifs and various other types of flower motifs. These patterns are produced from the weaver's visual experience of geometric objects on the natural surroundings and the socio-cultural environment.

Sobbi technique

Furthermore, apart from the tette' technique, the *lipa' sabbe* motif can also be made using the *sobbi'* or prying technique. The *sobbi'* technique, The sobbi' technique, which is also known as *the ikat process* (Buckley, 2017), is specifically designed to print motifs with relatively small sizes. The result of this sobbi' technique produces logo motifs, with various shapes. It can be said that the logo motif is above the intersection of the warp and weft threads.

Based on the results of interviews regarding the making of logo motifs, the informants explained that : *the creation of a logo motif must first be able to imagine the basic shape or pattern, then certain estimates and calculations are made so that the resulting motif is balanced, neat and proportional to the basic motif (not too big and not too small). Meanwhile, to create a new motif requires deep reflection, therefore the obtained motif has more meaning and selling value because of its novelty.*

Geometric transformation

Transformation geometry is one part of geometry which refers to changes in the location, size, direction of geometric objects such as points, polylines or polygons. The operations used in transformation geometry consist of mirroring (reflection),shifting (translation), resizing (dilation), rotation (Prahmana & D'Ambrosio, 2020). Several previous studies have explored the concept of geometric transformation in various cultural attributes, such as batik ornaments, traditional houses, or in bamboo handicrafts (Maryati & Prahmana, 2019). In research by Anggraeni et al (2018) revealed that the Surakarta batik pattern can be found the application of the concepts of reflection, translation, rotation and dilation. Disclosure of meaning and implementation of geometric transformation on batik motifs such as *Baboon Angreem*, *Parang* Barong, *Sidomukti*, *Sidoluhur*, *Soblog* and *Sidowirasat* can be used as learning resources (Prahmana & D'Ambrosio, 2020). In addition, the concepts of reflection, translation, dilation, rotation and tessellation have also been explored in *Solo* batik (Faiziyah et al., 2021) dan *Trusmi* Cirebon (Karimah et al., 2013).

In this study, the concepts of transformation geometry were also found in the observed *lipa' sabbe* motifs as shown in Figure 17, 18, 19, 20, and 21. The existence of a motif that contains the concept of geometric transformation, shows an intelligence and special ability possessed by lipa 'sabbe weavers. In this case, the ability to place color, change size, change direction, change shape and maintain symmetry produces a variety of decorations on *lipa' sabbe*.

Number pattern on Lipa' sabbe

Number patterns in formal mathematics learning can be found on the topic of sequences and series. In a simple concept, a sequence $a_1, a_2, a_3, \cdots, a_n$ can be understood as a regular arrangement of real numbers with a certain pattern. Thus, the sequence in real analysis is defined as a function that maps natural numbers to the set of real numbers. Changes in numbers from one term, to the next term, are determined by certain patterns. Commonly, the types of sequences include arithmetic sequences, multiple sequences, geometric sequences and Fibonacci sequences. However, number patterns in a more general view are often associated with a person's ability to read patterns through addition, subtraction, multiplication techniques on certain number sequences. Furthermore, number patterns are usually still used as topics in general intelligence instruments.

In making the *lipa' sabbe* motif, it is different in the process of making the motif on batik, the *lipa' sabbe* weaver applies counting techniques. In designing patterns or motifs on batik, it is still known as batik, which is the process of drawing on cloth that combines elements of points, polylines and polygons. Meanwhile, in designing the motif on *lipa' sabbe*, the depiction of the motif can be done through the usual weaving technique or known as the tette' technique, another technique is the sobbi' technique.

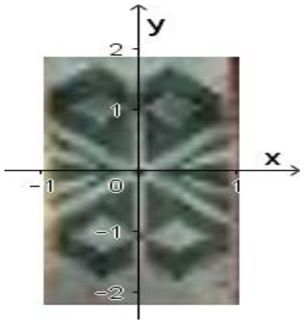

Figure 17. The concept of reflection

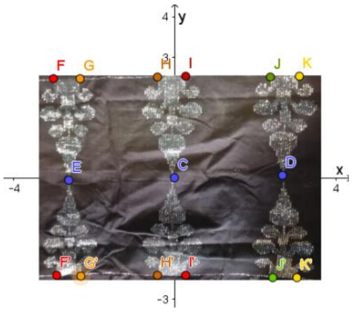

Figure 18. Vertical reflection on the tombstone motif

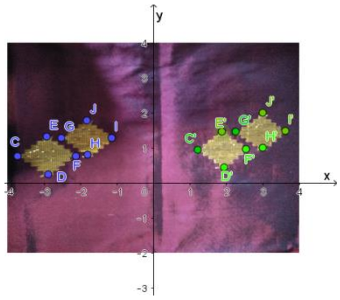

Figure 19. Concept of translation

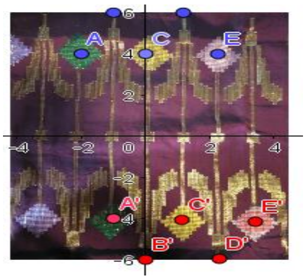

Figure 20. The concept of reflection and translation

Figure 21. Concepts of dilation and translation

Identification of number patterns on cultural objects can be found in several previous studies. Number patterns in the traditional game "Nasi Goreng Kecap" which is integrated in learning (Rosikhoh et al., 2020). In particular, the pattern of numbers on batik motifs has also been investigated. The results of the study indicate that in Adipurwo batik motifs, different arithmetic patterns can be found in the types of geblek and clanting motifs, bitter melon leaf motifs and clorot (Astuti et al., 2019). The different thing in this study, the number pattern is modeled based on the position of the motif thread against the basic thread. According to the results of the interview, the placement of the motif thread against the basic thread requires calculation, so that the resulting motif is balanced and proportional to the combination of other motifs.

Number pattern with weaving technique (tette' technique)

The tekte' technique is applied by setting the pakkarekeng and pabbicang are' at a certain position as a marker for the weft yarn limit for the motif to be inserted into the warp yarn. If the marker is lifted, then at this index the shuttle containing the motif thread is inserted into the open warp mouth. Next, the basic weft thread in the shuttle that moves back and forth is re-tightened by using the jakka as the tread or foot-pedal moves on the ATBM. The use of ma'tette technique can be seen in Figure 22.

In this process, the motif is obtained by combining the colors of the warp yarns, the basic weft yarns and the motif yarns that are coiled in the shuttle. The provision of color position boundaries has various lengths according to the pattern desired by the weaver. As in making the *balo pucuk* of *bamboo shoots* motif, combining the colors of gold viscose threads with warp threads that are inserted directly by hand. In order for the motif to be balanced and symmetrical, it is necessary to establish a long tier pattern. Figure 23 and 24 are the results of the identification of the number pattern generated on the *pucuk* motif and the *cobok* motif. In designing each motif, it maintains horizontal symmetry, resulting in a certain number pattern.

The results of the identification of the number pattern horizontally on the *pucuk* motif:

$$0, 0, 15, 15, 29, 29, 42, 42, 54, 54, 42, 42, 29, 29, 15, 15, 0, 0$$

The results of the identification of the numbers pattern vertically on the *pucuk* motif:

$$2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2\ (12\times)$$

Figure 22. Designing motifs with the ma'ttette technique

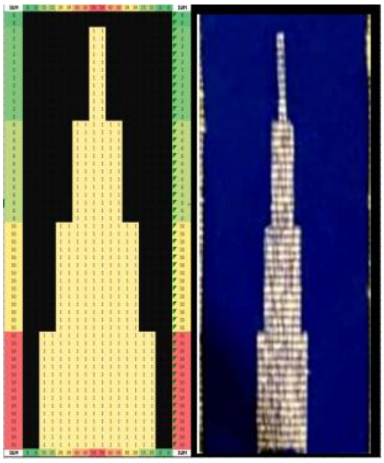

Figure 23. Identification of number patterns and redesign on the *pucuk* motif

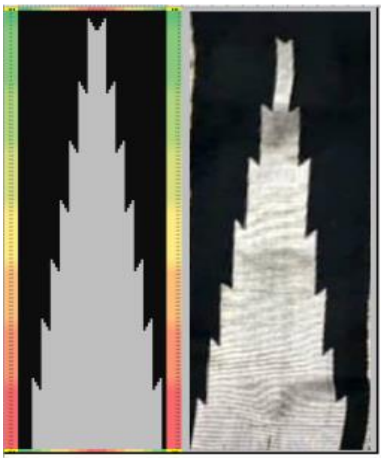

Figure 24. Identification of number patterns and redesign of the *cobo* motif

$$6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6 (13\ \times)$$

$$10, 10, 10, 10, 10, 10, 10, 10, 10, 10, 10, 10, 10, 10\ (14\times)$$

$$14, 14, 14, 14, 14, 14, 14, 14, 14, 14, 14, 14,14,14,14\ (15\times)$$

The results of the identification of the pattern of numbers horizontally on the cobo motif:

$$0, 0\ 0, 0, 18, 17, 16, 15, 33, 32, 31, 30, 48, 47, 46, 45, 63, 63, 61, 60$$

$$78, 77, 76, 75, 93, 92, 91, 90, 109, 108, 107, 106, 106, 107, 108, 109$$

$$90, 91, 92, 93, 75, 76, 77, 78, 60, 61, 63, 45, 46, 47, 58, 30$$

$$31, 32, 33, 34, \ldots\ , 0, 0, 0, 0$$

The pattern of numbers generated vertically on the cobo motif:

$$2, 4, 6, 8\ \ 12\times;\ \ 10, 12, 14, 16\ \ \ 12\ \times;\ \ 18, 20, 23, 24\ \ \ 12\ \times$$

$$34, 36, 38, 40\ \ \ 12\ \times;\ \ 42, 44, 46, 48\ \ \ 12\ \times;\ \ 50, 52, 54, 56\ \ \ 12\ \times$$

Number patterns on motifs from the Sobbi' technique

The *lipa' sabbe* motif can also be designed using the sobbi' technique or known as the prying technique. The sobbi' technique is carried out by inserting a motif thread that can be gold, or silver. In particular, in the sobbi' technique, a special term is known, namely mappitte wennang, namely the technique of selecting and separating the warp yarn that will be covered by the motif threads. Moreover, the warp yarn that will tie the motif threads are also selected. In this technique, the

Figure 25. Identification of number patterns and redesign of the Walasuji motif

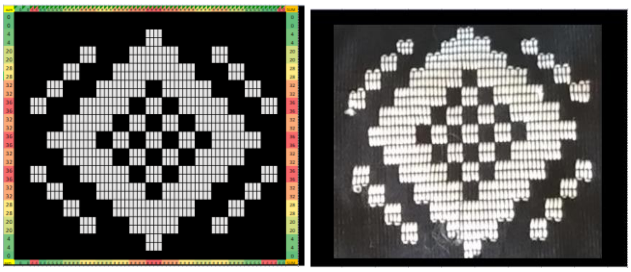

Figure 26. Identification of number patterns and redesign of the modified Walasuji motif

Figure 27. Modified Walasuji 2

Figure 28. Identification of number patterns and redesign modified Walasuji 2

counting process is carried out using the fitte formula, that is, if it is written 30f which shows the yarn counted from the left as many as 30 strands of yarn.

This sobbi' technique does not use a shuttle, but directly by hand with a lifting technique and insertion technique. This process produces symmetrical, wavy and asymmetrical patterns. The existence of a counting process in designing motifs produces a certain number pattern that represents the intersection of the warp and motif yarn. Visually, the motifs resulting from the color combination with the sobbi' technique resemble a digital *raster image*. In this case, the arrangement of existing motifs is represented by the color arrangement that occupies certain pixels.

Based on the results of the exploration of the *lipa' sabbe motif* by the sobbi' technique, it can be distinguished into symmetrical motifs and asymmetrical motifs. The following are some results of the exploration of number patterns and the redesign of logo motifs that represent the *lipa' sabbe*' motif from the sobbi' technique.

Symmetrical type of sobbi motif

Identification of number patterns is carried out using the help of Ms.office excel to count the number of threads that arise in each motif. There are three types of *walasuji* motifs obtained in this research. The identification of number pattern and redesign of each motif can be seen in Figure 25, 26, 27, and 28, respectively.

Figure 29. Embossed Lagosi motif

Figure 30. Soft Lagosi Motif

Figure 31. Lagosi motif with white background

Closed walasuji motif

The results of the identification of number patterns horizontally on the closed walasuji motif:

0, 0, 5, 5, 5, 5, 9,9, 9, 9, 13, 13, 13, 13, 17, 17, 17, 17, 13, 13, 13, … , 5, 5, 0, 0

The results of the identification of number patterns vertically on the closed *walasuji* motif:

0, 0, 4, 4, 12, 12, 20, 20, 28, 28, 28, 28, 28, 20, 20, 12, 12, 4, 4, 0, 0

Modified walasuji 1

The results of the identification of number patterns horizontally on the modified walasuji 1:

0, 0 0, 0, 4, 4, 4, 4, 6, 6, 6, 6, 10, 10, 10, 10, 14, 14, 14, 14, 16, 16, 16,16, 18, 18, 18, 18, 16, 16, 16, 16, 14, 14, 14, 14, 10, 10, 10, 10, 6, 6, 6, 6, , 4, 4, 4, 4, 0, 0, 0, 0

The results of the identification of number patterns vertically on the modified walasuji 1:

0, 0, 4, 4, 20, 20, 28, 28, 32, 32, 36, 36, 32, 32, 36, 36, 32, 32, 36, 36, 32, 32, 28, 28, 20,20, 4, 4, 0, 0

Modified walasuji 2

The results of the identification of number patterns horizontally on the modified walasuji 2:
6, 9, 11, 13, 15, 13, 15, 14, 15, 13, 11, 6, 9

The results of the identification of number patterns vertically on the modified walasuji 2:
1,3, 5, 6, 7, 9, 9, 9, 8, 8, 8, 9, 9, 9, 7, 6, 5, 3, 1

Calculus concepts on asymmetrical motifs

In this section, some lagosi motifs are visualized as flowers as shown in Figure 29, 30, and 31 . Geometrically, it can be said that the lagosi motifs in various colors are asymmetrical. Based on the results of the interview, the informant said that the lagosi flower motif is more difficult to design. The appearances that appear are generally in the form of flower stalks with branches, added with leaves and flower buds in various colors. The stalks look curved designed from a collection of yarn arrangements that are thicker than the base of the fabric. The thickness affects the texture of the silk fabric motif. The curvature of the stems and polygons of flowers and leaves is produced by the arrangement of the lengths of the rectangular yarns arranged in such a way that the ends look like they are curved.Based on the concept of calculus, this technique can be found in the technique of calculating the area of a curved area which is approximated by the area of a rectangle. As introduced more than 2000 years ago by Archimedes (Varberg et al., 2006). In the lagosi silk motif, rectangular

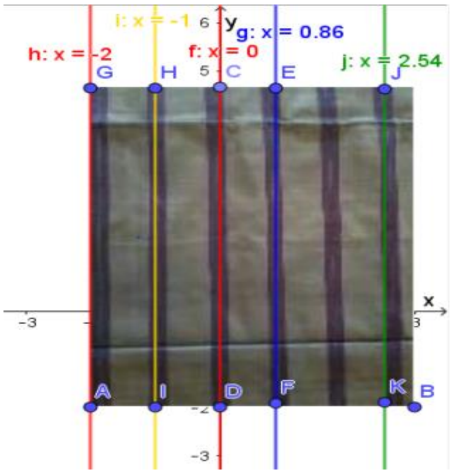

Figure 32. Perpendicular lines on the *balo tettong* motif

Figure 33. Making Balo Makkalu' Motif

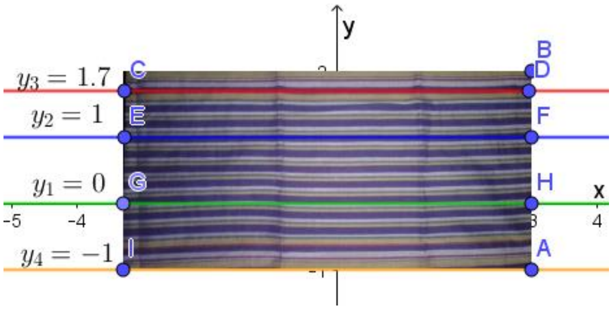

Figure 34. Representation of constant function on the line Motif makkalu'

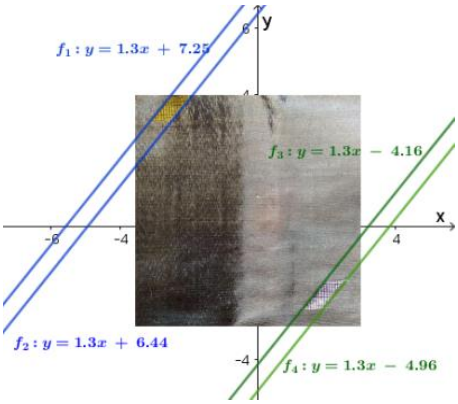

Figure 35. Representation of parallel straight lines on simple *serong* motifs

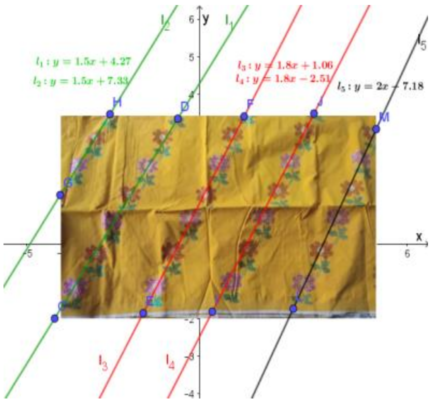

Figure 36. Oblique motif from the arrangement of floral motifs

shapes are arranged and form polygons with curved borders. This shows the skill and intelligence of silk craftsmen in making lagosi motifs from a collection of rectangular segments into curved areas that represent stalks, leaves and flowers.

Algebra Representation

Motif of Balo Tettong

The *balo tettong* is obtained from the presence of lines of a certain thickness that are perpendicular to the plain warp threads. Thus, the lines stand vertically or vertically to the mouth of the sarong as shown in the Figure 32. The mathematical representation of the balo tettong motifs is in the form of a collection of equations, in this case it can be written as

$$x_i = k_i \,; i = 1,2,3, \dots, n \tag{1}$$

These results can only be categorized as mapping but cannot be categorized as a function.

Motif of Balo Makkalu'

The next motif is the makkalu' motif, according to the results of interviews and direct observations, the makkalu' motif is obtained from a firm color compaction on the type of warp thread which is stretched towards the front of the craftsman. Thus, the resulting motif is only a line parallel to the top and bottom sides of the sarong. Figure 33 illustrates the process of making the motif.

Meanwhile, the makkalu' motif in a mathematical perspective can be seen as a collection of horizontal lines parallel to the slope value of 0. In particular, in algebraic studies, these lines can be viewed as a collection of constant functions

$$y_i(x) = k_i \,; i = 1,2,3, \dots, n \tag{2}$$

In general, as with the circular shape of the sarong, the lines will also run along the length of the fabric. In this case, the line motifs formed are parallel lines and do not intersect as shown in Figure 34.

The Serong motif

Several other motifs can also be represented by linear equation models. This model can be found in the *serong* motif. Based on the results of the interview, it was explained that the *serong* motif resulted from the counting and positioning accurately by considering the angle, length, slope, balance and alignment of the two lines. However, the alignment of the lines formed by the craftsmen does not consider the aspect of its algebraic representation. The craftsman revealed that the *serong* motif can be in the form of a collection of yarn positions that form a parallelogram through the sobbi' process and *serong* motifs resulting from the placement of ornaments that are made obliquely and parallel to each other's motifs. In this section, serong motifs are presented in a Cartesian coordinate system. In addition to simple serong motifs, there are also serong motifs composed of floral motifs as shown in Figure 35. These motifs form a linear line that is parallel to the other flower arrangements as shown in Figure 36.

In simple Serong motif, 4 parallel lines can be produced which are made on 2 separate serong motifs, each with an equation that can be written as:

$$f_1 \coloneqq y = 1.3x + 7.25 \tag{3}$$

$$f_2 \coloneqq y = 1.3x + 6.44 \tag{4}$$

$$f_3 \coloneqq y = 1.3x - 4.16 \tag{5}$$

$$f_4 \coloneqq y = 1.3x - 4.96 \tag{6}$$

Pucuk Motif

A set of polynomials can also be modeled from the *pucuk* motif, using the concept of interpolation as shown in Figure 37. This *pucuk* motif is the most common motif found in this study. From the results of the interpolation, the representation of polynomial functions with different orders is obtained:

$$\begin{aligned} f \coloneqq y = {} & -93.37x^6 - 1926.12x^5 - 16472.01\,x^4 - 74745.05x^3 - 189816.41x^2 \\ & + 255816.06x - 142965.36 \,; -4 \le x \le -3 \end{aligned} \tag{7}$$

$$\begin{aligned} g \coloneqq y = {} & 1171.52\,x^8 - 256.55x^7 - 976.63x^6 + 158.54x^5 + 288.58\,x^4 \\ & - 34.04x^3 - 43.94x^2 + 2.73x + 4.04 \,; -0.58 \le x \le 0.58 \end{aligned} \tag{8}$$

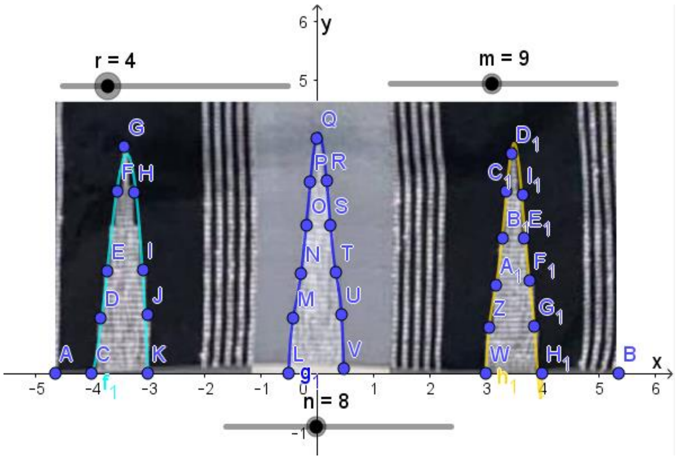

Figure 37. Interpolation of functions on pucuk motifs

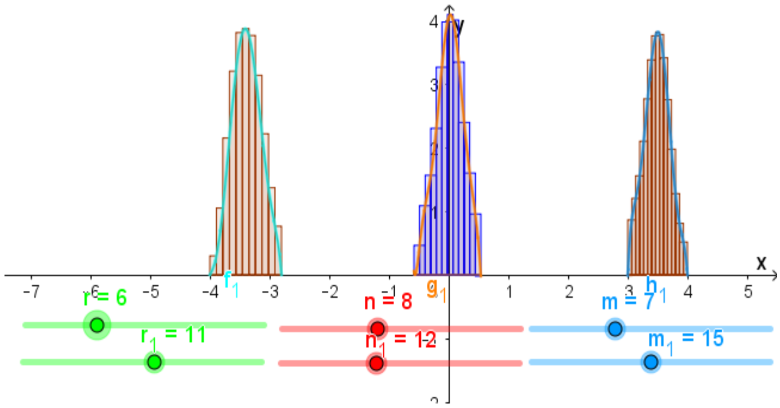

Figure 38. Riemann Sum and Trapezoidal Sum concept on pucuk motifs

$$h \coloneqq y = -43.16x^7 + 554.51x^6 - 482.15x^5 - 28446.98\,x^4 + 208492.59x^3 - 663785.02x^2 + 1032742.04x - 641941.48\,; 3 \le x \le 4 \quad (9)$$

Trough the implemetation of the concept of interpolation of functions, the representation of polynomial functions of degrees 6, 7 and 8 is obtained on the shoot motif. The use of interpolation techniques can approximate polynomials from a set of points (Busrah & Pathuddin, 2021) . The integral value of each function can be approximated by using the Rieman and Trapezoid Sum approach. Through the concept of Riemann sum in determining the definite integral value approach, physically it shows similarities to the pucu' motif on *lipa' sabbe* Sengkang. Figure 38 is the simulation results obtained using the Geogebra Application Program using the uppersum, lowersum and trapezoidsum commands (Hohenwarter & Hohenwarter, 2002; Hall & Lingefjard, 2017).

The concept of Riemann sum as a concept in approximating area by using rectangular segments that resemble pucuk motifs. While the use of a trapezoid sum produces trapezoidal segments that resemble the cobo' motif.

Contribution of research in the development of mathematics learning

The results and discussion show that there is a unique mathematical ability in the cultural community who are members of the silk craftsman group in the city of Sengkang. These results can be a relevant learning resource for students in the field of mathematics at various levels by utilizing the attributes of local wisdom. Number pattern problems in mathematics learning are usually in the form of continuing the sequence of numbers after the last term based on a certain pattern found in the previous term. The pattern can be an arithmetic sequence, a geometric sequence, or both. Through this research, identification of number patterns can be developed through figures on *lipa' sabbe* motifs.

In addition, geometry and algebra can also take advantage of the motifs found on silk sarongs. Geometry and algebra studies in this research include transformation geometry, straight line equations, straight line modeling and polynomial modeling through interpolation techniques. The results of this study can also be additional information in learning calculus, especially in learning integral applications. The craftsman's ability to make curved planes, such as the lagosi or flower motifs, is approximated by the arrangement of the combination of weft, warp and motif threads. With this motif can be used as a source of contextual learning in the calculation of the area and the calculation of the length of the curve on the topic of integral applications.

The results obtained in this study, have not been directly implemented in learning mathematics. Finally, for the next research, the implementation and measurement of the effectiveness and efficiency of the use of silk motifs in learning can be a research opportunity in the future, especially in ethnomathematical-based contextual learning.

CONCLUSIONS

The process of weaving silk fabrics of the *lipa' sabbe* type shows the existence of various ideas, creativity, methods, techniques and mathematical practices by silk craftsmen in the city of Sengkang. In the process of making *lipa' sabbe*', the craftsmen have a system of knowledge and mathematical skills that are contextualized in making a variety of *lipa' sabbe* motifs.

Among them, weavers have numeracy skills through the fitte technique in determining the index or position of making motifs. In addition, craftsmen also have the mathematical ability to produce certain number patterns to maintain the balance of the motifs so that they remain symmetrical, and still maintain their aesthetic elements and messages of meaning, either through the tette' technique, or through the sobbi' technique. Furthermore, from the aspect of the motif, various patterns of certain numbers and geometric elements in the motif can be identified. The resulting number pattern has a unique structure. In addition to the ability to count and form number patterns, weavers also have the ability to approximate curved planes in the form of curves or polygons through recatngular yarn segments. Some *lipa' sabbe* motifs can be modeled into constant functions, linear functions, and n-degree polynomial functions. This research is expected to contribute as a learning resource that integrates formal mathematics learning with elements of local culture.

ACKNOWLEDGMENT

Thanks and appreciation to the parties involved for the moral and material support. Especially to the Institute of the Ministry of Religion of the Republic of Indonesia which has launched a Research Program for lecturers, which was followed by the provision of research funding assistance. Second, to LP2M of IAIN Pare-Pare who have supported us in our research administration efforts. We also extend our deep gratitude to the Head of the Tadris Mathematics Study Program at IAIN Parepare who has supported and provided technical direction related to the implementation of the research.

AUTHOR'S DECLARATION

Authors' contributions	All author's contributed to the design and implementation of the research, to the analysis of the results and to the writing of the manuscript.
Funding Statement	This research was funded by Ministry of Religion of the Republic of Indonesia
Availability of data and materials	All data are available from the authors.
Competing interests	The authors declare that the publishing of this paper does not involve any conflicts of interest. This work has never been published or offered for publication elsewhere, and it is completely original.

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