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The Exploration of Mathematics Through the Different Cultures in Sarawak, Malaysia

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Abstract

Sarawak is the largest state in Malaysia and a home to 27 ethnic groups. With 45 different dialects, each group has their own unique stories, beliefs, traditions and cultures that makes Sarawak a great potential for the ethnomathematics studies. Ethnomathematics is defined as the relationship between culture and mathematics. This study explores on how mathematics is used in the daily life application among several ethnics in Sarawak. The research was conducted in Sarawak Cultural Village and Borneo Cultures Museum using a qualitative descriptive method such as observation, interview, collecting data and documentation from the fieldwork and ethnographic approach. The data collected is validated using triangulation method and data verification process is run in term of credibility, transferability, dependability and confirmability before summarizing the conclusion. Researchers try to connect the mathematical values contained in these ethnic groups. The mathematical concepts found in the *Bumai* calendar, the architecture of *Baruk* and Iban long house, weaving and plaiting techniques.

Keywords: ethnomathematics, culture, exploration, Sarawak

Introduction

Mathematics is closely related to every aspect of social life (Rosa & Orey, 2016; Irfan, Slamet Setiana, Fitria Ningsih, Kusumaningtyas, & Adi Widodo, 2019; D'Ambrosio, 2001) and all societies have developed mathematical practices that are considered most appropriate to their daily lives and cultures. This connection between culture and mathematics is called ethnomathematics. These cultural practices include jargons, codes, symbols, myths and specific ways of reasoning and inferring (D'Ambrosio, 1997) and may involve one or more of the universal mathematical activities such as counting, locating, measuring, designing and explaining (Bishop, 1988).

Ethnomathematics research in Malaysia offers a captivating lens through which to explore the unique mathematical traditions and cultural practices that have evolved within the diverse communities of this Southeast Asian nation. Malaysia's rich cultural tapestry, comprising Malay, Chinese, Indian, and indigenous populations, contributes to a multifaceted landscape of mathematical knowledge and practices. In Malaysia, ethnomathematics research delves into the

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traditional mathematical systems embedded in various communities, examining how cultural, historical, and social contexts shape mathematical thinking and application.

However, research on ethnomathematics in Malaysia especially in Sarawak is still deficient. The exploration study of culture-based mathematics in Sarawak is fascinating to conduct. It is because Sarawak, a Malaysian state on Borneo, stretches along the island's northwest coast, including many beaches on the South China Sea and is home to 27 ethnic groups. The Iban dominate and rank first, making up about 50.8% of the total population, followed by the Malay at around 19.3%. The Chinese come third with 18.7%, followed by the Bidayuh at 6.5%, the Orang Ulu at 4.9%, and the Melanau at 3.1%. Based on the 2021 statistics, there are more than 40 sub-ethnic groups, each with its own distinct language, culture and lifestyle. This data illustrates the challenges of studying ethnomathematics in Sarawak, which has a very distinct and unique demography.

This exploration extends to indigenous knowledge systems, folk practices, and the ways in which mathematical reasoning is woven into everyday life. The multicultural nature of Sarawak provides a fertile ground for ethnomathematics scholars to investigate the intersections between different cultural influences on mathematical cognition. Every culture has its own way of mathematical measuring and thinking which is part of its inheritance and the results of the struggle for its survival (Balamurugan, 2015).

Literature Review

Ethnomathematics is the field of study explaining the relationship between mathematics and culture. It is a way for ethnic groups to deal with problems related to measuring, classifying, sorting, concluding and then solve them in their own way, style and technique (D'Ambrosio, 2018). The study of mathematics considers culture and appears to understand the reasoning of the mathematical system used by an ethnicity (Septiadi, Hartoyo, & Bistari, 2017).

Research in terms of ethnomathematics has been widely carried out in many countries. The thought of mathematics as a culture continues to roll from language (Reigner, Bello, & Kuznetsova, 2016), buildings (Hardiati, 2017; Nursyeli & Puspitasari, 2021), musical instruments (Lubis et al., 2018) to games (Wahyuni, Nuraida, & Husna, 2018; 2021). These findings showcase the dynamic interplay between culture and mathematics.

In Indonesia, exploring mathematical concepts has been carried out by some researchers. Abdullah (2017) studied ethnomathematics in Sundanese culture. Risdiyanti and Prahmana (2017) explored ethnomathematics of batik in Javanese culture. Furthermore, researchers studied the concept of geometry in Sasaknese architecture (Supiyati & Hanum, 2019), the idea of geometry in Lionese traditional house (Wondo, Mei, & Naja, 2020), ethnomathematics is calculating an auspicious day in Javanese society (Imswatama & Setiadi, 2017) and mathematical concepts in Balinese calendar system (Suarjana, Suharta, & Japa, 2014).

In the Phillipines, ethnomathematics research on the Kabihug tribe has showed that the community applies many mathematical concepts in daily life which were classified into counting patterns, coding, measuring, classifying, sorting, inferring, and modelling (Rubio, 2016).

A study conducted among the *Boti* tribe in East Timor has a distinctive culture that maintain the customs and beliefs of their ancestors which incorporates various mathematical concepts. The concepts of geometry transformation represented by the shapes, colors and motifs on the *Boti*'s

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woven fabric and the concept of infinite limit can be found in *Lopo Boti,* a traditional home architecture (Dosinaeng, Lakapu, & Leton, 2020).

Few studies on ethnomathematics have been conducted in Malaysia. Long and Chik (2020) stated that the Melanau people in Tellian Mukah, Sarawak highly valued mathematics applications in their daily life which practiced in social ranking, house construction, food preparation, weaving and silver, and gold measurement. Wan Muhamad Fauzan, Wan Muhammad Afiq, Said Husain, Sharifah Kartini, Abdul Wahab, and Mohd Rohaizat (2020) discovered that Malay traditional dance such as *Zapin, Inang,* and *Joget* dance can be mapped to a graph theory by using certain graph definitions such as eccentricity, diameter, radius, degree of edges, and chromatic number.

Methodology

This study uses a qualitative descriptive methodology with an ethnographic approach (Roudsari, 2019). The descriptive data is collected in the form of words and pictures (Mohajan, 2018), meanwhile the ethnographic methods were used in this study to discover mathematical idea practices by the ethnic groups in Sarawak. Ethnomathematics research studies the cultural practice, mutual interrogation, interview and collecting information from the society (Vidal, 2020). The fieldwork of this study will do the observation, interview, collecting and documentation of the data. The data collected were validated using triangulation method. This technique checks data through several relevant sources (informants). Data verification is a step used to confirm the conclusions from the collected data (Creswell & Creswell, 2017). The verification process is run in terms of credibility, transferability, dependability, and confirmability before summarizing the conclusion.

Findings

Iban's Annual Calendar for Paddy Planting

The Iban life centres on the paddy planting activity every year. The Iban has their own year-long calendar with 12 consecutive months which are one month later than the Gregorian calendar. The months are named in accordance with the paddy farming activities or *bumai* and the activities in between. The Iban calendar starts in the fifth month or April for the Gregorian calendar (Philip, 2013). The fifth month is the month to start *bumai*.

Table 1: The Iban's annual calendar for paddy planting

Tusun Bulan Iban	Month in English calendar	*Bumai* Month
1	June	*Bulan Manggul* The paddy farming begins from the rites of *manggul* which marks the inauguration of the farming year.
2	July	*Bulan Nasau* The Iban start to clear (*nasau)* the small trees and shrubs at the land of selection.
3	August	*Bulan Nebang* Felling commences at the land of selection.

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4	September	*Bulan Belanggang Reban* The drying season. The timber logs are dried to facilitate the process of burning.
5	October	*Bulan Ngelabuhka Benih* The sowing of the rice seed (*ngelabuh benih*) before season for dibbling (*nugal*).
6	November	*Bulan Mantun* The weeding month (*mantun).*
7	December	*Bulan Begantung Senduk* The Iban waits for the paddy to ripen. Some Iban may facing a problem with rice supply if they harvested less paddy in the previous year.
8	January	*Bulan Matah* The Iban prepares a ritual before the process of harvesting the paddy. The purpose of the ritual is to hope for a bountiful harvest.
9	February	*Bulan Ngetau* *Harvesting month.*
10	March	*Bulan Empalai Rubai* *The harvesting month is over. The Iban will fill their time to plant vegetables or taya. Taya is a plant that can be used as a dye in the making of pua kumbu.*
11	April	*Bulan Berangkut* *The Iban will help each other (berduruk) to carry the harvested paddy back to the house.*
12	May	*Bulan Lelang/Kelelang* *Month of celebration after bumai activities have been completed.*

Source: Author (2023)

Iban's Counting System

Table 2: The Iban's Counting System is Called *Sistem Tunggu*

Type of counting system	Equivalent or estimated
Sepikul	$ 100 or *100 kati* ~ 165 kg
Sepengendang (half hand raised)	$ 10 or *10 kati* ~ 16.5 kg
Rusa	$ 8
Alas (for small tajau*)*	$ 4
Sigi panding	$ 2
Sigi jabir	$ 1
Mungkul	$ 1
Seuta	$ 0.25
Sigi menukul	$ 0.50
Alas ngerang	$ 5
Alas berejang	$ 6
Alas betanduk	$ 7
Sigi menaga	$ 16
Sigi ningka	$ 32

Source: Author (2023)

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Table 3: The Iban's Time System

Time	Equivalent or estimated
Dini hari dalam	1 am – 3 am
Dini hari	4 am – 5 am
Pagi	6 am – 11 am
Tengah hari	12 noon – 1 pm
Ngalih hari	2 pm – 3 pm
Lemai	4 pm – 5 pm
Sabung petang	6 pm – 7 pm
Salah kelala	7.30 pm – 8 pm
Malam	8 pm – 11 pm
Tengah malam	12 midnight

Source: Author (2023)

Table 4: The Iban's Day System

Day	Equivalent or estimated
Sehari tu	Today
Pegila/ila	Tomorrow
Lusa	The day after tomorrow
Tulat	4 days to come
Lupat	5 days to come
Lanat	6 days to come
Ladi	More than 7 days to come
Kemari	Yesterday
Ensana/ensanus	The day before yesterday
Kilah ensana	4 days ago
Kilah ensana jauh	5 days ago
Rekutai	6 days ago
Suba	More than 7 days ago
Kelia munya	Long time ago

Source: Author (2023)

Bidayuh's House (Baruk)

The Bidayuh headhouse is called *Baruk*. The *Baruk* functions as a venue for courthouse, a meeting place and a residence for the male adolescents (Zaini, Karsono, & Awang Sulong, 2018). It is a structure elevated on stilts and shaped like a circle and the floor is octagon (Guntur, 2020). To adapt the circular wall design, the roof must be designed with conical formation. It connotes as a cosmological define where the cone roof model as a village orientation endorsed by their limited space and orientation (Guntur, 2020). The wall is 1 to 1.5 meters height over the floor that allows someone to sit and not for standing. The wall of *Baruk* has a vertical slope around 80 degrees to provide the possibility for leaning and allow the wind to pass through its interior. The wall circularly covering the floor forces occupant orientation to the center where fireplace state. It is like giving an honour attitude to the leader who led the ritual.

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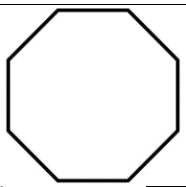
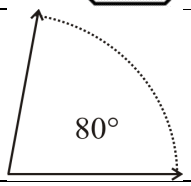
Figure 1: The *Baruk*
Source: Author (2023)

Structure of *Baruk*	**Result**
Roof (Conical shape)	
Base (Octagon)	
Wall (80 degree tilted)	

Beads Crafts, Basketry, and Plaiting

Figure 2 showed the examples of beads crafts made by the Orang Ulu in Sarawak. The bead-worker work the beads on a set of descending strings, crossing and re-crossing the string in every second row of beads. The pattern is made by selecting beads of different colours. A skilled bead-worker can make any design from traditional to modern, including lettering and motifs. A bead-worker can shape the patterns by increasing or decreasing the number of strings.

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Figure 2 is a baby carrier, the *ba*'. The *ba'* is used to carry baby at the back or in front of the bearer. The *ba*' features heirloom beads and beadwork with the motif of human figurine to symbolize the wealth and status of the baby and the *ba*' maker. However, the study conducted by Faridah and Hasan (2016) showed that the *ba*' also has gone through several transformation in its variation of design. Diagram 2 showed that the pattern of the *ba*' consist of a combination of spirals and diamond shape motif (or rhombus). The design consists of a combination of congruent parallelograms.

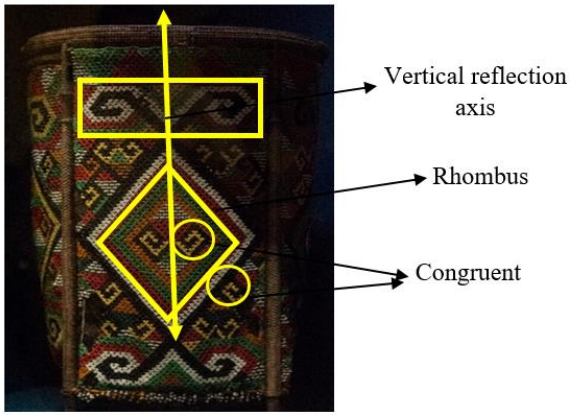

Figure 2: baby carrier, the *ba*'
Source: Author (2023)

Figure 3(a) and 3(b) are sun-hat normally wear by a "middle class" Orang Ulu. The circumference has a curvy repetitive triangles design. The white parallelograms have congruent shapes while the red geometry pattern ensembles quadrilateral kite shape. A 180-degree rotation about the origin either in the clockwise or counterclockwise direction, each vertex of an object has to be changed from (x,y) to $(-x,-y)$ and graph the rotated object. The movement of object P (the quadrilateral kite shape) to P' is associated with 180-degree rotation.

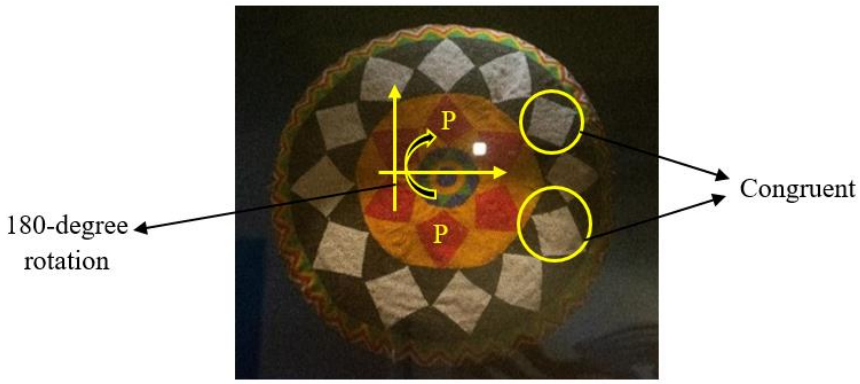

Figure 3(a)
Source: Author (2023)

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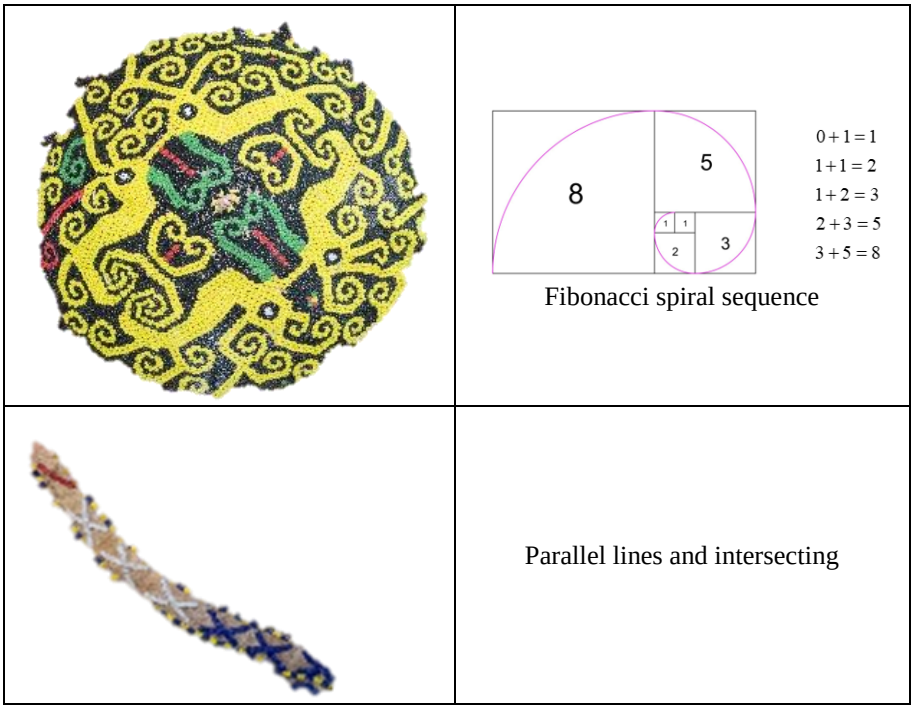
Figure 3(b)
Source: Author (2023)



The abundant weaving and basketry are the most widespread craft among the different ethnic groups. It is a traditional skill among the indigenous people in Sarawak who utilised everything that nature provided to produce useful items like baskets, hats, mats, trays and hunting gear. A variety of materials sourced from the jungle such as rattan, *nipah*, pandanus, *bemban* reed, bamboo, and tree barks are weaved into all kinds of products, either of functional or aesthetic value.

Figure 4(a) to 4(c) show different types of winnowing trays made from bamboo strips which are traditionally used for sifting grain, paddy or dry stuff. Figure 4(a) is an example of a circular winnowing tray with a diameter of 60 – 85 cm. It is associated with learning mathematics, namely flat shapes which is circle. The bamboo strips are place into overlapping columns or rows (a basic shape of a rectangle) in a grid pattern until the weave finished at a diagonal angle. This

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process is called a tessellation where a shape is repeated covering a plane without any gaps or overlaps.

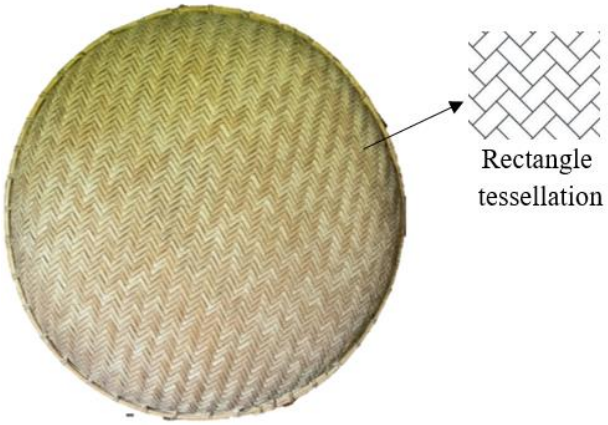

Figure 4(a)
Source: Author (2023)

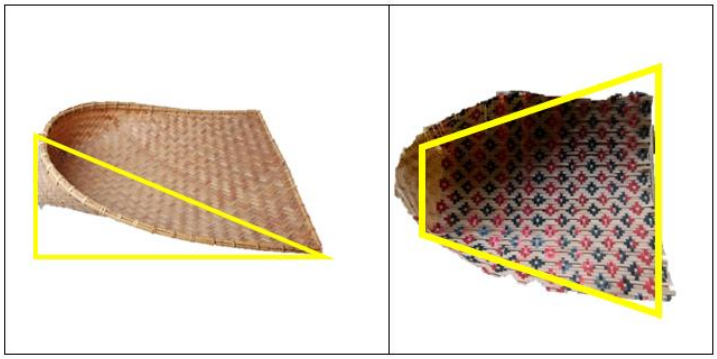

Figure 4(b)
Source: Author (2023)

Figure 4(c)
Source: Author (2023)

From the side view Figure 4(b) and 4(c), it has a triangle shape and from the top view it has a trapezoid shape as the base. The aim of the shapes is to keep more grains or paddy as well as to avoid air resistance during the winnowing process.

In mathematics, a reflection in geometry is the transformation of an object where the final figure will be an equal distance from the reflection line as the image but on the opposite side. Figure 5 shows the reflection of human figure motif on *Pua Kumbu* satisfies the properties of reflection.

Pua Kumbu is the Iban equivalent of a "blanket" – meaning "to cover". It refers to a tie and natural dye resist textile hand-woven exclusively by Iban women. The sacred tradition carries rich allegorical symbols, legends, stories and rhymes that are typical to Iban beliefs and origins. The Iban believe that nature and living things in the form of human figure motif, birds, animals, insects, plants are closely related to the spirit world were embedded into the design of *Pua Kumbu*.

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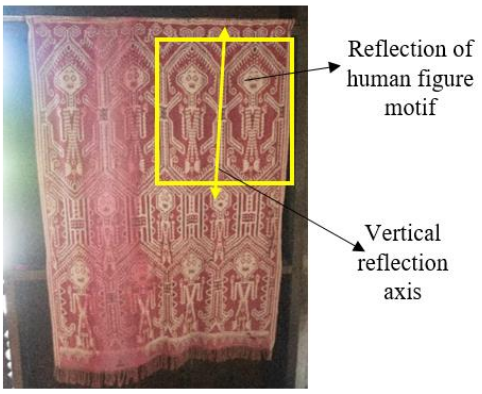

Figure 5: Human Figure Motif on *Pua Kumbu*

Discussion

The discussion should thoroughly explain the results or findings from the study and to be interpreted with the support of evidence or data and suitable references. The results from this exploration study shows the indigenous people in Sarawak have known mathematics for a long time ago. It is interesting to see the Ibans own their own Bumai calendar, counting system and time and day system which they practically use until today. The previous study conducted in Kampung Tellian, Sarawak shows that the Melanau community use the calendar as their guide for their daily works such as agriculture includes planning activities since they still belief in guardian spirits that guide them on the calculation of the constellation, rise and set of the sun, moon and stars (Long & Chik, 2020).

The integration of mathematics is visible through the architecture of the Baruk to present a functioning and beautiful building that contain noble values. The shape and model of the building which has the pattern, angle, building space, triangle, square, cylinder, prism and circle. This is supported by an ethnomathematics exploration at the Great Wall of China in the form of stones of plane geometry, such as rectangles, triangles, squares, circles and various geometric spaces (Dwidayati, Zaenuri, & Suyitno, 2019).

The elements of geometry patterns principles can be seen through the handicraft that they made which requires a mathematical ability that they learned by themselves is good enough for the weaver or craftsman in determining the forms of the motif. The exploration of ethnomathematics in Javanese society on batik motifs have found out that the batik motifs of Lereng, ceplok, and Jlamprang are related to lines and angles, triangles, quadrilaterals and circles (Pramudita & Rosnawati, 2019) and geometric transformation such as rotation and translation (Prahmana & D'Ambrosio, 2020).

The results of this study can motivate teachers to develop a mathematics learning model in the classroom. It can be one of the transformative efforts to bridge mathematics with the reality and perception of students in learning mathematics. Thus, the students can see that mathematics is close to the culture around them, and students can finally take on the meaning of the mathematical concepts they learn to apply in their daily lives (Abdullah, 2017; Risdiyanti & Prahmana, 2020). Mathematics learning using an ethnomathematics approach will make the learning more innovative and meaningful for students who live in rural and urban areas.

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Limitation/Implications/Conclusion

Based on the discussion, ethnomathematics has proven to be a platform to connect culture and mathematics. The Iban has their own *bumai* calendar and counting system for time and days. The architecture aspect of *baruk* by the Bidayuh ethnic contains several geometric shapes such as cones, octagon and circle. As for the handicrafts made by the Iban and Orang Ulu tends to use various variations of motifs and several types of flat shapes were found such as rhombuses, parallelograms, triangles, circles and trapezoids. The design of the motifs shows geometric transformations have been applied such as rotation and translation. In general, ethnomathematics can be integrated into learning if they are being designed properly. Further research is needed to design and apply it to the learning process in school. The teacher can use ethnomathematics objects around us to be used to carry out innovative and meaningful learning materials as well as to preserve local culture.

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