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Ethnomathematics on the *Saluang*: Analysis of mathematical concepts in Minangkabau musical instruments

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Abstract

Saluang musical instruments are unique during manufacturing because they contain mathematical concepts. However, no one has further realized and studied the mathematical concepts of musical instruments. This study aims to explore the relationship between mathematics and Saluang. The results of the exploration are fascinating because mathematical concepts such as arithmetic and geometric series are the most important ones applied during the Saluang manufacturing process. It will also be fascinating to apply in learning to motivate students to learn. The research method used is ethnography. Data were obtained from direct observation, interviews, literature reviews, and documentation. The results obtained from this study are that during the Saluang manufacturing process, there are cultural values and mathematical concepts that include geometry and arithmetic series. Using leaves, cloth, and fingers to determine the distance between holes in making Saluang is a unique mathematical concept. This research can be used as a guideline for teachers in compiling learning devices by paying attention to activities that are very close to students.

Keywords: arithmetic sequence; circumference; ethnomathematics; Saluang

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Introduction

Mathematics is tedious and scary (Amir, 2015; Annisa et al., 2021). Many think mathematics is separate from human life (Tanujaya et al., 2017). Mathematics is applied in everyday life, and of course, it is fun. It is strengthened by the opinion of Karnilah and Juandi (2013), who explained that the rational reason why society considers mathematics irrelevant to culture comes from the habits of students who do not understand how to use mathematics to solve everyday problems. Rahmi et al. (2021) also stated that students do not focus on the concept but only on using formulas. Most of the time, taking notes and never explaining the material being taught results in the learning and teaching process becoming unconducive, uninteresting, and boring for students (Ardiansyah, 2020). Many things make learning mathematics uninteresting to learn.

Overcoming this requires an approach that connects mathematics with everyday contexts to increase study motivation (Zhang & Zheng, 2023). It was also confirmed by Hartoyo (2012) that learning needs to begin by exploring informal knowledge that students have previously absorbed from their surroundings. Mathematics material in schools must be able to be transmitted as a human activity (Febrian et al., 2023). One innovative approach, such as ethnomathematics, offers a potential solution to overcome this problem by integrating local cultural context in mathematics learning so that student motivation also increases during learning

One of the current learning innovations is culture-based mathematics, commonly called ethnomathematics. Ethnomathematics is a study that explains the relationship between mathematics and culture (Laukum et al., 2024; Muhtadi et al., 2017; Muyassaroh & Dewi, 2021). Ethnomathematics learning is contextual learning related to culture. Ethnomathematics-based learning, in addition to learning mathematics contextually, can motivate students to be active in class, understand the culture, and foster character values (Andriyani & Kuntarto, 2017). Rosa et al. (2016) said that knowing and connecting values, ideas, understandings, procedures, and practices using contextual environments is one of the initial foundations of ethnomathematics learning. Critical mathematics education is concerned with addressing mathematics in its many different forms of applications and practices (Ernest et al., 2016). Of course, this is an effort so that students understand, comprehend, articulate, process, and ultimately use mathematical ideas, concepts, procedures, and practices to solve problems related to their daily activities.

Bishop emphasized that connecting mathematics to local culture can deepen students' conceptual understanding (Bishop, 2022). Ethnomathematics helps students understand mathematical concepts through cultural contexts that are familiar to the students. Culture plays an essential role in the emergence and development of mathematics; hence, both are inseparable (Pathuddin et al., 2023). Culture is human life and cannot be separated from culture itself, so humans are surrounded by their culture (Aslan & Yunaldi, 2018). Culture and humans are an inseparable unity, meaning that the supporters of culture are humans themselves (Normina, 2017). Likewise, in the world of education, culture is something that cannot be separated from learning, especially mathematics.

Researchers in mathematics education have widely conducted ethnomathematics research to help students understand mathematical concepts. The following are some studies, such as geometry, namely two-dimensional and three-dimensional figures, sets, and arithmetic number patterns on the Angklung musical instrument (Sari et al., 2022). Based on the results of research conducted by Sari et al. (2022), arithmetic and geometry can be applied to the traditional Kenong musical instrument. That gamelan artifacts can enrich the teaching of sets and numbers with their various types, shapes, and sizes) (Oktaviyani et al., 2023). Besides that, cultural contexts impact students' problem-posing performance (Peng & Zhou, 2024). Many other ethnomathematics studies have been conducted in various parts of the world to help improve students' understanding and motivate students to learn by connecting cultures, including Indonesia.

One area with a variety of cultural forms is West Sumatra (Minangkabau). Through a historical process, Minangkabau has various forms of culture that then gave birth to various forms of cultural arts that developed amid its supporting community (Nursyam & Supriando, 2018). One of the Minangkabau cultural arts is the traditional music "Saluang." Saluang culture is an essential musical and cultural tradition in Minangkabau, West Sumatra, Indonesia. Traditional musical instruments have various sizes, specialties, and shapes. If seen at a glance, the Saluang musical instrument resembles a Bansi (a Minangkabau wind instrument) with seven tone holes but is more significant (Purnomo & Aulia, 2020). In the history of its development, there are four types of Saluang spread across various regions in Minangkabau, namely Saluang Darek, Saluang Sirompak, Saluang Pauah, and Saluang Panjang (Radendri & Marzam, 2024). Each musical instrument has a different form in organological studies (Ediwar et al., 2019). Likewise, the four Saluang have different aspects of organological studies, so they are interesting to study.

Although ethnomathematics has been widely applied in various cultures, no research has examined how mathematical concepts are contained in traditional arts such as Saluang in West Sumatra. Not many people know how elements such as patterns or structures in Saluang can relate to broader mathematical concepts, such as geometry and arithmetic sequences. How are mathematical concepts applied to make and form Saluang in West Sumatra? Therefore, this study aims to raise the ethnomathematics element of Saluang, the reason for wanting to know the mathematical aspects, and how the mathematical thinking process of the community is in the process of making Saluang.

Methods

This research used ethnographic methods. Ethnography is a part of historical science that studies culture in a society, group, or ethnicity (Rezhi et al., 2023). Ethnography is one of the approaches in qualitative research methods that seek to explore a community's culture. A study will not be considered ethnographic if it ignores the context and conditions in which people's actions and statements are observed and recorded (Windiani & Nurul R, 2016). This research method was chosen because it aligns with the objectives of ethnomathematics; namely, data collection is carried out through field studies and interviews with purposively selected sources and artisan families from Lima Puluh Kota and Solok Selatan. The researcher selected three informants, namely Saluang Craftsmen (Lima Puluh Kota and South Solok), as key informants and one community member who can communicate and use Saluang in everyday life as additional informants.

The main focus of this research is how the organology of the Saluang instrument. The researcher will observe the organology form of a Saluang to find the mathematical and cultural values contained in the Saluang. Data collection was carried out through field studies and interviews with informants. Interviews were conducted systematically based on the informant type to ensure the data's validity. Literature reviews on Saluang complement the results of the observations and interviews. All data are documented in photos, videos, and field notes.

The data collection results were analyzed using source triangulation techniques to comprehensively explore the relationship between the mathematical concept and the Saluang musical instrument. The data analysis techniques used in this study are content analysis, triangulation, and pattern search techniques. Researchers can guarantee the validity and reliability of research data based on these three analysis techniques. Triangulation techniques were used to determine the validity of an ethnographer's observations, including examining what a person hears and sees (Umbara, 2024). It is done by comparing sources of information through cross-examining sources of information.

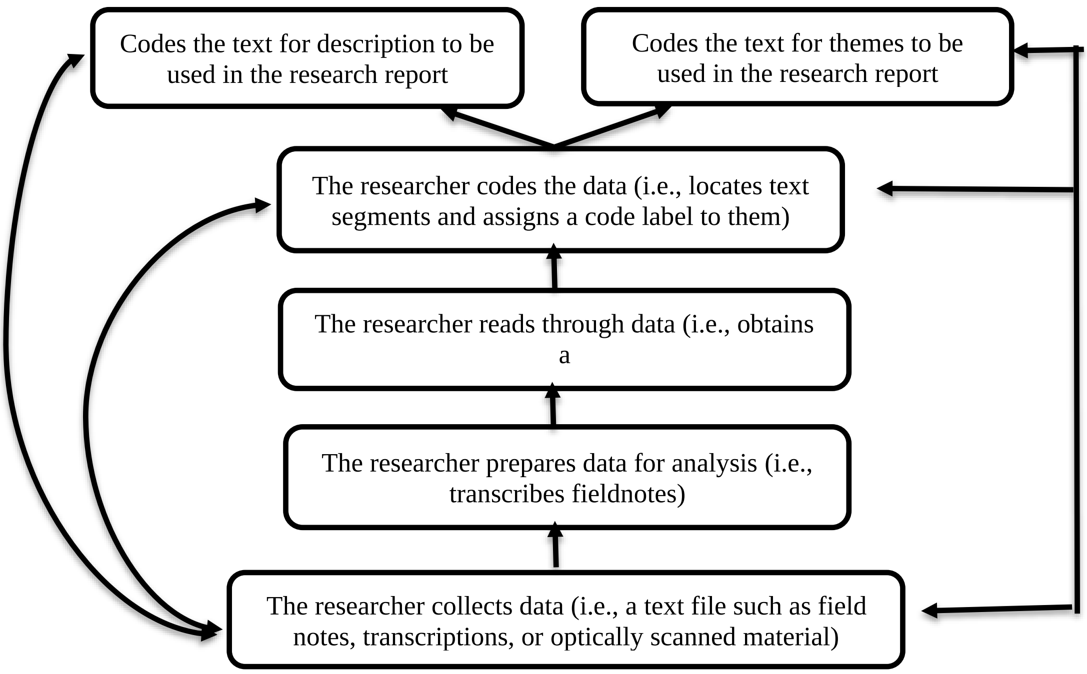

Figure 1. The process of data analysis (Umbara, 2024)

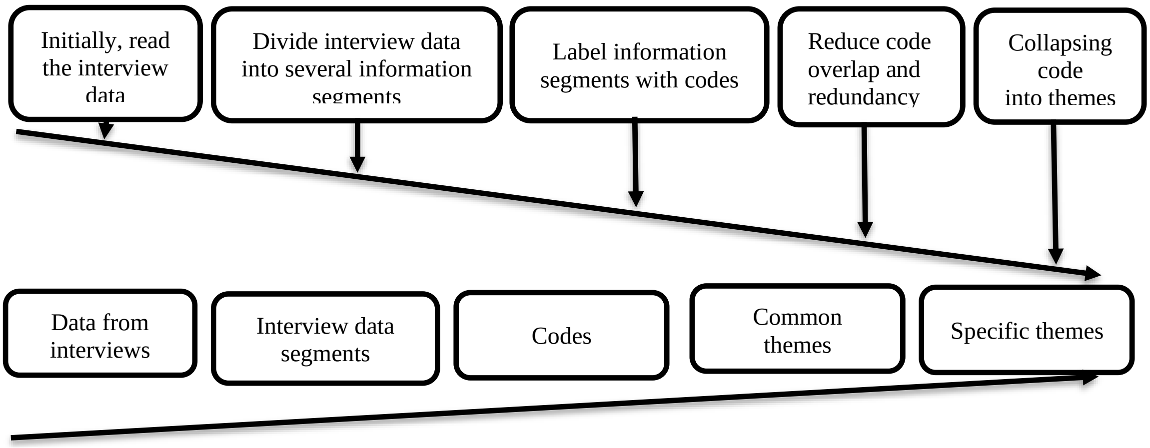

Figure 2. The Process of data analysis (Umbara, 2024)

Based on Figures 1 and 2, the data analysis process is shown in Figure 1. The interview results were transcribed and analyzed by following the coding process in Figure 2. In this coding process, when the researcher found differences in mathematical ideas and activities from the three types of informants, the researcher cross-checked the data based on other sources of information using triangulation techniques. Finally, the researcher was able to compile categories by finding patterns (themes).

Results

Saluang is a typical Minangkabau musical instrument made of bamboo or talang. Saluang in Minangkabau consists of four Saluang: Saluang Darek, Saluang Sirompak, Saluang Pauah, and Saluang Panjang. The four Saluang have almost the same shape. Each Saluang has a different shape, structure, sound color, and playing technique. These differences are the characteristics of each instrument according to the character of the area where the musical instrument grew and developed.

After researching the Saluang musical instrument, we found several geometric shapes of two-dimensional figure shapes. In addition, the concept of rows was also found in the Saluang.

Saluang Darek

Saluang Darek is a musical instrument originating from Luhak nan tigo which developed in the Singgalang area near the foot of Mount Singgalang. This instrument is used to accompany Minangkabau singing or chanting. The shape of Saluang Darek can be seen in Figure 3.

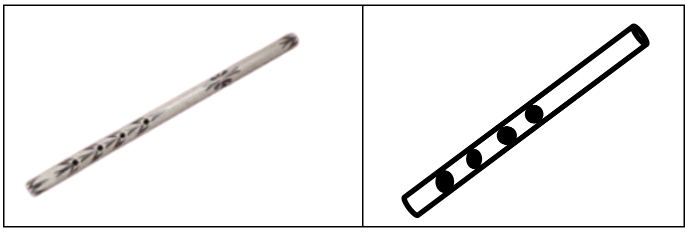

Figure 3. The shape of *Saluang Darek*

The construction of the Saluang Darek wind instrument body consists of a body, tip, base, suai, and tone holes. At the base, there are four tone holes. Traditionally, the part of the Saluang that leads to the blowing area is called suai, while the part of the Saluang that leads to the tone holes is called pangka (base) (Ediwar et al., 2019). So, Saluang Darek comes from luhak nan tigo and has four tone holes.

Circle concept

When making the Saluang Darek, the circumference of a circle is used to determine the distance between the tone holes in the Saluang. The following is shown in Figure 1: the shape of the Saluang Darek, which consists of several small circles. Based on the research that has been carried out, the process of making the length of the Saluang and determining the first mark can be explained as follows (Ediwar et al., 2019):

(1) The length is equal to six times the circle of the tip cross-section (the lower bamboo cross-section). The temporary marking for this measurement is measured at half the length (six times the circle of the cross-section) with the marking position located in the middle of the length of the Saluang, but this marking only functions as a guideline for determining the position of the next marking which is related to the position of the tone hole of the Saluang.

(2) The distance from the base to mark 1 is one cross-section circle, then the tone hole 1 is made above mark 1, because the size of the base of the Saluang becomes the base tone (first tone) of the Saluang.

(3) The distance from mark 1 to the temporary mark is divided into 4 and each division is given a mark, namely mark 2, mark 3 and mark 4, where each mark is positioned to place three tone holes, namely tone hole 2 (second), tone hole 3 (third), and tone hole 4 (fourth) as a continuation of tone hole 1 (first).

Based on the data found in the field, the length and cross-section of the tip are different and uncertain from 2.5 - 3.5 cm. So, variations in making Saluang can be seen by utilizing variations in data obtained with the formula for the circumference of a circle, namely $K = \pi d$ as in Table 1.

Table 1. Calculation results for making the distance from the base to the first note mark and the length of the saluang using the circumference concept

No	End Cross Section Diameter	Perimeter of End Cross Section or Distance from Base to First Mark (πd) cm	Length of Saluang (6 πd) cm
1	2.6 cm	8.164 cm	48.984 cm
2	2.7 cm	8.478 cm	50.868 cm
3	2.8 cm	8.792 cm	52.752 cm
:	:	:	:
:	:	:	:
9	3.4 cm	10.676 cm	64.506 cm

Based on Table 1, it can be seen that in determining the distance and length of the Saluang using the formula from the circumference of the circle. In addition, it is also seen that the size of each circle where the Saluang maker uses cloth in calculating the circumference of the circle and calculating the distance. It can be concluded that when making Saluang Darek is very closely related to the concept of a circle and also the larger the diameter of the end cross-section, the greater the length of the Saluang.

The concept of arithmetic sequences

(1) Distance Between Tone Holes

Based on the research that has been conducted for the process of making the second to third marks for the second, third and fourth tone holes, it can be explained that the distance from mark 1 to the temporary mark is divided into 4 and each division is given a mark, namely mark 2, mark 3 and mark 4, where each mark is simultaneously positioned to place three tone holes, namely tone hole 2 (second), tone hole 3 (third), and tone hole 4 (fourth) as a continuation of tone hole 1 (first) (Ediwar et al., 2019). Based on this, it can be seen in the process of making tone holes on the Saluang Darek using the concept of arithmetic sequences. This can be seen in Table 2 related to the making of the first sign, the second sign and the third sign.

Table 2. Calculation results for making mark 2, mark 3 and mark 4 in the process of making note holes 1, 2, 3 and 4

No	**Mark 1 (cm)**	**Temporary Mark (cm) (half the length of the Saluang)**	***x* = (Temporary Mark – Mark 1) / 4 (cm)**	***y* = Distance from Base to Mark 2 (cm) (Mark 1 + *x*)**	***z* = Distance from Base to Mark 3 (cm) (*x*+ *y*)**	**Distance from Base to Mark 4 (cm) (*x* + *z*)**
1	8.164 cm	24.492 cm	4.082 cm	12.244 cm	16.326 cm	20.408 cm
2	8.478 cm	25.434 cm	4.239 cm	12.717 cm	16.956 cm	21.195 cm
3	8.792 cm	26.376 cm	4.396 cm	13.188 cm	17.584 cm	21.98 cm
:	:	:	:	:	:	:
:	:	:	:	:	:	:
9	10.676 cm	32.253 cm	5.39425 cm	16.07025 cm	21.46448 cm	26.85873 cm

Based on Table 2, it can be seen that in determining the distance from mark 1 to the fourth mark, the concept of arithmetic sequence is used. For example, we take the size of the tip cross-section diameter of 2.7 cm with mark 1, which is 8.478 from the base, then it can be seen in the arithmetic concept as follows:

The distance from the base to mark *n* with *a* is mark 1 and *b* is the temporary mark - mark divided by 4:

$$\begin{aligned} Un &= a + (n-1)b \\ &= 8.478 + (n-1)4.239 \\ &= 8.478 + 4.239\,n - 4.239 \\ &= 4.239\,n + 4.239 \\ &= 4.239\,(n+1) \end{aligned}$$

If formulated in general for different Saluang lengths, the formula obtained when determining the tone holes will be as follows:

$$Un = \frac{1}{2}\pi \mathrm{d}(n+1)$$

Note:

n = Sign 1,2 ... and so on

Based on Table 2, it can be seen that in determining the distance between holes, you can use the formula from the arithmetic sequence.

(2) Tone Hole Size

In addition, each tone hole on the Saluang Darek has the same diameter difference (0.5 mm). In detail, the size of the holes is tone hole one (12 mm), tone hole two (11.5 mm), tone hole three (11 mm) and tone hole four (10.5 mm).

Table 3. Results of hole diameter making calculations

Hole	Hole Diameter (mm)	Hole Circumference (mm)
Hole One	12 mm	37.68 mm
Hole Two	11.5 mm	36.11 mm
Hole Three	11 mm	34.54 mm
Hole Four	10.5 mm	32.97 mm

Based on Table 3, it can be seen that in determining the diameter of the tone holes 1 to 4, the concept of arithmetic series is used because each hole has a different diameter with a difference of 0.5 according to the data obtained in the field. The formula for the tone hole diameter is as follows:

$$Un = a + (n-1)b$$
$$= a + (n-1) - 0.5$$
$$= a - 0.5n + 0.5$$

If formulated in general, the formula obtained when determining the diameter of the tone holes 2, 3 and 4 is as follows:

$$Un = a - 0.5\,(n-1)$$

Note:
n = Hole 1,2,3 dan 4
a = Hole 1

It can be concluded that when making the diameter of the tone holes of the Saluang, it is also very closely related to the concept of the row.

Saluang Pauah

Saluang Pauah is one of the musical instruments that grew and developed in Pauah Padang. Inspired by the Bansi wind instrument from the south coast with Saluang from the Darek area, so it is still named Saluang, even though its shape is the same as Bansi, while the name Pauah is taken from the name of the area where the musical instrument grew, so it is called Saluang Pauah (Desmawardi et al., 2022). The shape of Saluang Pauah can be seen in Figure 4.

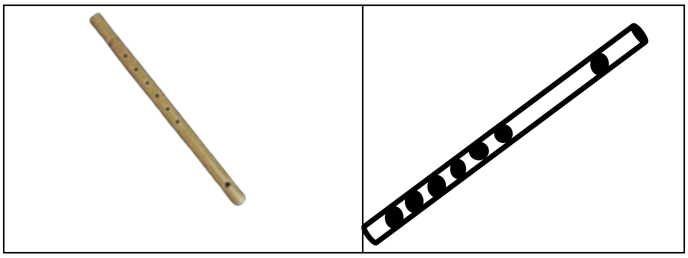

Figure 4. The shape of *Saluang Pauah*

Saluang Pauah serves as an accompaniment to kaba or Saluang will not appear alone. Kaba is one of the narrative arts that tells various patterns of life of the Minangkabau people. At the top there are six melody holes and one air hole called Rakuak parian (Purnomo & Aulia, 2020). So, the Saluang Pauah comes from the Padang Pauah and has six tone holes.

Circle concept

During the process of making Saluang Pauah, it turns out that the concept of circumference of a circle is used when determining the distance on the Saluang. The following is shown in Figure 3, the shape of the Saluang Pauah which consists of several small circles.

Based on the research that has been carried out, the process of making the length of the Saluang and determining the distance between the holes can be explained as follows (Purnomo & Aulia, 2020) :

(1) For the length of the Saluang Pauah, the usual size used is 5 circles of the trunk, 5 ½ circles, or 6 circles of the diameter of the Saluang with a range of 3 – 4 cm.
(2) The distance from the base to the sound source hole or Rakuak Parian is made at a distance of 1/3 of a circle from the base of the Saluang Pauah.

Variations in making Saluang can be seen by utilizing variations in data obtained using the formula for the circumference of a circle, namely $K = \pi d$ as in Table 4.

Table 4. Results of calculations for making saluang length, distance in saluang holes using the circumference concept

No	Diameter of the Saluang (cm)	Distance from Base to Rakuak Parian (cm) (1/3 πd)	Length of Saluang (5 πd) cm	Length of Saluang (5,5 πd) cm	Length of Saluang (6 πd) cm
1	3.1 cm	3.24467 cm	48.67 cm	53.537 cm	58.404 cm
2	3.2 cm	3.34933 cm	50.24 cm	55.264 cm	60.288 cm
3	3.3 cm	3.454 cm	51.81 cm	56.991 cm	62.172 cm
:	:	:	:	:	:
:	:	:	:	:	:
9	3.9 cm	4.082 cm	61.23 cm	67.353 cm	73.476 cm

Based on Table 1, it can be seen that in determining the distance and length of the Saluang, the formula for the circumference of a circle is used. In addition, it can also be seen that the Saluang maker uses coconut leaves to calculate the circumference of a circle and the distance. It can be concluded that there is a close relationship between the concept of a circle when making Saluang Pauah and also the larger the diameter of the circle, the larger the length of the Saluang.

The concept of arithmetic sequences

The manufacturing process is continued by making the next six tone holes. Each tone hole has the same distance, which is 1/3 of a circle with the distance from the rakuak parian to the first hole being 2 circles. So, based on this, it can be seen that the process of making tone holes on the Saluang Pauah also uses the concept of arithmetic sequences. This can be seen in Table 5 regarding the making of the first mark, the second mark and the third mark.

Table 5. Calculation results for making tone holes 1, 2, 3, 4, 5 and 6 on the Saluang Pauah

No	x = Distance from Base to Rakuak Parian (cm)	a = Distance from Base to Hole 1 (x + 2 circumference) cm	b = *Hole 2* (a+1/3 πd) cm	c = *Hole 3* (b+1/3 πd) cm	d = *Hole 4* (c+1/3 πd) cm	e = *Hole* 5 (d+1/3 πd) cm	f = *Hole* 6 (3+1/3 πd) cm
1	3.24467 cm	22.71267 cm	25.95734 cm	29.20201 cm	32.44668 cm	35.69135 cm	38.93602 cm
2	3.34933 cm	23.44533 cm	26.79466 cm	30.14399 cm	33.49332 cm	36.84265 cm	40.19198 cm
3	3.454 cm	24.178 cm	27.632 cm	31.086 cm	34.54 cm	37.994 cm	41.448 cm
:	:	:	:	:	:	:	:
:	:	:	:	:	:	:	:
9	4.082 cm	28.574 cm	32.656 cm	36.738 cm	40.82 cm	44.902 cm	48.984 cm

Based on Table 5, it can be seen that in determining the distance from hole 1 to the sixth, the concept of arithmetic sequence is used. For example, the diameter is 3.5 with a being the distance from hole 1 to the base and b being 1/3 of the circle, then:

$$
\begin{aligned}
Un &= a + (n-1)b \\
&= 25.67 + (n-1)\ 3.67 \\
&= 25.67 + 3.67\,n - 3.67 \\
&= 3.67\,n + 22
\end{aligned}
$$

If formulated in general for the length of the Saluang with different diameters, the formula obtained when determining the tone holes will be as follows:

$$
\begin{aligned}
Un &= bn + 2\pi \mathrm{d} \\
&= \frac{1}{3}\pi \mathrm{dn} + 2\pi \mathrm{d} \\
&= \pi \mathrm{d}\ (\frac{1}{3}n + 2)
\end{aligned}
$$

Note:
n = Hole 1,2….. dst
d = Bottom diameter

It can be concluded that when making the distance between the tone holes of the Saluang, it is also very closely related to the concept of rows.

Saluang Sirompak

Saluang Sirompak is one of the musical instruments originating from Limo Puluh Kota, West Sumatra. Saluang and Dendang Sirompak are an inseparable part of the Sirompa performance. Bairompak performance is in the form of a presentation of vocal music, called sengdang in Minangkabau. The presentation of the sengdang vocal music is accompanied by a wind instrument called Saluang Sirompak. The traditional musical instrument Saluang Sirompak accompanies the vocal melody by a singer. In practice, one person is added to the gasiang tangkurak maker, namely a top made of human skull material. This explanation shows its relationship with magical properties (Ediwar et al., 2020). The shape of Saluang Pauah can be seen in Figure 5.

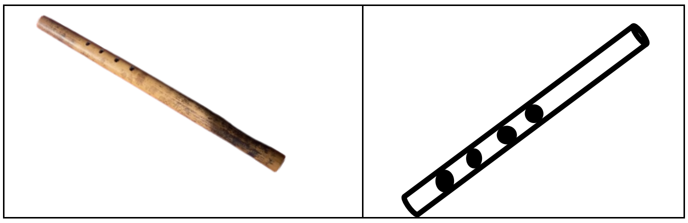

Figure 5. The Shape of Saluang Sirompak

The parts of the Saluang Sirompak consist of four tone holes on the top and one tone hole on the back (parallel or right under the fourth tone hole). So, the Saluang Sirompak comes from fifty cities and has four tone holes on the top and one on the back.

Circle concept

During the process of making the Saluang Sirompak, it turns out that the concept of the circumference of a circle is used when determining the distance between holes. Based on the research that has been done for the process of determining the distance on the hole can be explained that the distance between the first hole is 2/3 of the length of the bamboo, measured from the top end. And for the second, third and fourth holes, each in sequence down with the same distance. That is, approximately half a circle of the lower Saluang. The fifth hole is made right behind the first hole. For each hole diameter made 0.5 cm. The length of the Saluang is about 70 cm, has a diameter of 2 - 2.5 cm.

Variations in making Saluang can be seen by utilizing variations in data obtained using the formula for the circumference of a circle, namely $K = \pi d$ as in Table 6.

Table 6. Results of calculation of making distance in the front saluang hole using the circumference concept

No	Diameter of the Saluang (cm)	Length of Saluang (cm)	*a* = Distance between Hole 1 and the Upper Ends (2/3 length of Saluang) cm	*b* = Distance from Top End to 2 ($a + \frac{1}{2}\pi d$) cm	*c* = Distance from Top End to 3 ($b + \frac{1}{2}\pi d$) cm	*d* = Distance from Top End to 4 ($c + \frac{1}{2}\pi d$) cm
1	2.1 cm	70 cm	46.67 cm	49.97 cm	53.27 cm	56.57 cm
2	2.2 cm	70 cm	46.67 cm	50.124 cm	53.578 cm	57.032 cm
3	2.3 cm	70 cm	46.67 cm	50.281 cm	53.892 cm	57.503 cm
4	2.4 cm	70 cm	46.67 cm	50.438 cm	54.206 cm	57.974 cm

Based on Table 6, it can be seen that in determining the distance using the formula from the circumference of the circle. In addition, it is also seen that the maker of the Saluang is only estimated as big as an adult's thumb in the process of calculating the distance. It can be concluded that there is a close relationship between the concept of a circle when making the Saluang Sirompak.

The concept of arithmetic sequences

The Saluang hole must be round, not square or other. If the hole is square, it will result in the sound coming out of the Saluang not being good. Based on Table 6 in the process of making the distance between the tone holes on the Sirompak Saluang also uses the concept of arithmetic sequence. Based on Table 6, it can be seen that in determining the distance from hole 1 to 4, the concept of arithmetic sequence is used. For example, the diameter is 2.1 with a being hole 1 to the base (2/3 of the length of the Saluang Sirompak) and b being 1/2 circle, then:

$$Un = a + (n-1)b$$
$$= 46.67 + (n-1)\frac{1}{2}\pi d$$
$$= 46.67 + \frac{1}{2}\pi dn - \frac{1}{2}\pi d$$
$$= 46.67 + \frac{1}{2}\pi d\,(n-1)$$

Note:
n = Holee 1,2….. dst
d = Bottom diameter

It can be concluded that the creation of the distance between the tone holes of the Saluang is also closely related to the concept of rows.

Saluang Panjang

Saluang Panjang is one of the musical instruments that grew and developed in Luak Kapau Village, Pauah Duo District, South Solok. Saluang Panjang is performed as an accompaniment to dance music, randai music, entertainment at gotong royong activities and at the Seribu Rumah Gadang festival (Saputra et al., 2022). The shape of Saluang Panjang can be seen in Figure 6.

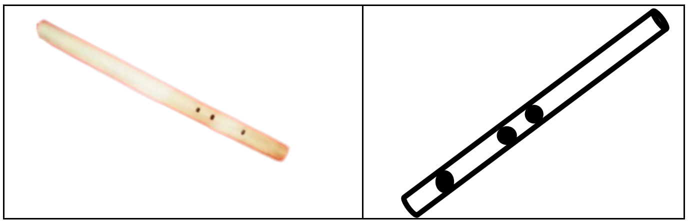

Figure 6. The shape of Saluang Panjang

This instrument has three tone holes and is a type of wind instrument called a wistle flute (has a tongue). So, the long Saluang comes from South Solok and has three tone holes. The Saluang Panjang is usually called the patik tigo Saluang because it consists of three holes. The longer the Saluang, the better the sound. \

In the past, our parents made the Saluang Panjang wind instrument using traditional measuring methods, namely by referring to the length of the user's cubit and the size of the grip of the fingers or palm to make the distance between the holes of the Saluang Panjang (Saputra et al., 2022). The following are the results of interviews conducted regarding the making of long Saluang in detail:

(1) The length can be adjusted to the needs of the Saluang maker or artist.
(2) The diameter of the long Saluang is 2.5-3 cm.
(3) The distance between the holes is two finger joints of the Saluang maker or artist.
(4) The diameter of each hole is adjusted to the finger of the Saluang maker or artist, at least the little finger of the Saluang maker or artist.

Variations can be seen in the making of the Saluang for the circumference of each tone hole and Saluang by utilizing variations in the data obtained as in table 7.

Table 7. Calculation results for the distance of each tone hole

No	Diame-ter of an Adult Little Finger (mm) (15-15,8)	*x* = Distance from End of Saluang Hole to Hole 1 (2d) (mm)	*y* = Distance from End of Saluang Hole to Hole 2 (2d+ *x*) (mm)	Distance from End of Saluang Hole to Hole 3 (cm) (2d+*y*) (mm)
1	15.2 mm	30.4 mm	60.8 mm	91.2 mm
2	15.4 mm	30.8 mm	61.6 mm	92.4 mm
3	15.6 mm	31.2 mm	62.4 mm	93.6 mm
4	15.8 mm	31.6 mm	63.2 mm	94.8 mm

Based on Table 7, it can be seen that in determining the distance from hole 1 to 3, the concept of arithmetic sequence is used because the distance is the same, namely the size of an adult human finger joint (for example, the little finger). Suppose a is hole 1 (the distance from the end of the hole to the note hole 1) and b is the size of the two joints of an adult human little finger, then:

$$\begin{aligned} Un &= a + (n-1)b \\ &= 2d + (n-1)2d \\ &= 2d + 2dn - 2d \\ &= 2dn \end{aligned}$$

Note:
n = Hole 1,2….. dst
d = The size of two human finger joints (adjust to the needs of the Saluang maker)

It can be concluded that the creation of the distance between the tone holes of the Saluang is also closely related to the concept of rows.

Discussion

Based on the research results, namely related to measurements in making the four Saluang, it can be seen that there is the use of geometric concepts such as circles when measuring the distance between Saluang holes. Mathematical activities are activities in which there is a process of abstracting real experiences in everyday life into mathematics or vice versa, including activities such as grouping, calculating, measuring, designing buildings or tools, making patterns, counting, determining locations, playing, explaining, and so on (Rakhmawati M, 2016). One of them is the geometric material that is visible during the process of making and forming the saluang.

Geometry is a branch of mathematics that teaches the concept of two-dimensional figure and three-dimensional figure. Geometry is mathematics that studies two-dimensional figure and three-dimensional figure (Hanan & Alim, 2023). Geometry is a branch of mathematics that focuses on three-dimensional figure, measurements, composite properties, and their associations with each other (Nurhayati et al., 2022). Mu'asaroh & Noor (2021) in their research results find that here is a geometric concept in the shape of the tambourine musical instrument especially related to three-dimensional geometry material, namely cylinders and cones. Besides that, the results of research Pasaribu & Sukirwan (2022) that there are mathematical concepts in Pantun Bambu, namely plane geometry, solid geometry, and arithmetic sequence. Many ethnomathematics studies related to traditional musical instruments have found mathematical concepts related to geometry. However, there has been no ethnomathematics study related to Saluang discussing geometry. The geometric concept found in Saluang is the circle. The concept can be found during the process of making Saluang, meaning that Saluang also has a mathematical concept, especially geometry. Of course, it is very interesting when to find the use of the concept of the circumference of a circle used by craftsmen when making saluang using leaves and clothing.

In addition, the concept of arithmetic sequences was also found during the manufacturing process and on the shape of the saluang. Arithmetic is a sequence of numbers whose difference (difference) between two consecutive terms is the same or constant (Ge'e et al., 2023). The discussion of sequences and series includes patterns of regularity, order, and series (Trisnawati, 2022). In addition to geometry, in ethnomathematics also found the concept of arithmetic. Many researchers of mathematics education conducted research on traditional musical instruments related to arithmetic. One of them is (Nursanti et al., 2024), the research show that the implementation of ethnomathematics with angklung musical instruments to instill the concepts of number patterns. Other research results on the Kecapi Siter musical instrument also show that there are concepts of geometry, arithmetic series, and trigonometry (Soedarbe et al., 2022). Likewise in this research, during the process of making saluang, the community had already applied the concept of arithmetic. The use of leaves, fingers and also clothing is used by the Minangkabau people during the process of making Saluang as a substitute for measurement. The use of these three objects is also to maintain the consistency of the distance between holes so that the concept of arithmetic sequence is found when making the distance between holes in the saluang. Unconsciously, the concept of mathematics and community activities are connected during the process of making Saluang. Of course, this activity is very close to students and can be used as a guideline by teachers in creating learning tools using an ethnomathematics approach.

The ethnomathematics approach will really help teachers and students in the learning process. Ethnomathematics has been proven to improve learning outcomes as proven by research related to ethnomathematics. Ethnomathematics can be used by teachers in conducting effective and enjoyable learning and can increase students' love for understanding their own culture (Soebagyo et al., 2021). In addition, ethnomathematics exploration of traditional musical instruments can increase enthusiasm in learning and the ability to understand mathematical concepts and have a positive impact on increasing the effectiveness of student learning. Students can also learn mathematics and art in a more fun and interesting way (Astria & Kusno, 2023). According to direct observation, making this Saluang requires precision and good skills. The process of making this Saluang requires a certain strategy to produce the desired sound. This is also in line with research that when making this traditional musical instrument requires counting skills, precision and emotional control (Desmawardi et al., 2022; Ediwar et al., 2019; Minawati & Yulika, 2019; Purnomo & Aulia, 2020; Saputra et al., 2022). Saluang musical instruments, especially the process of making them, can be developed during the learning process, especially when introducing mathematical concepts, especially circles and arithmetic sequences. In addition to students understanding the process of making Saluang, learning will also be very enjoyable and students' ability to understand mathematical concepts will be even better.

Conclusion

Ethnomathematics in Indonesia does not only stop at cultural exploration and experimentation in mathematics learning in several schools, but can also be introduced in the mathematics education curriculum in Indonesia. One of them is Saluang, which can be used during the learning process. In addition to introducing culture, teachers can also introduce it as a mathematical concept. When measuring the distance between holes on the saluang using the concept of the circumference of a circle using leaves and clothes that are adjusted to the size of the holes on the saluang. The use of fingers and hands in making the length of the saluang is also unique. In addition, measuring consistency in making the distance between holes also contains the concept of arithmetic sequences. Of course, this can be used as a guide for teachers in planning mathematics teaching and learning activities using the Saluang context.

This research has limitations in time, so the research is limited only to the process of making and the shape of the Saluang. There are still many mathematical concepts that can be observed in the Saluang such as the rhythm of the sound produced. Furthermore, this research did not develop mathematics learning materials or learning assessments in the Saluang context. Therefore, future research opportunities are future concept mathematic concepts from sound produced on saluang and developing mathematic learning material or learning assessments using the Saluang as the context.

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Conflicts of Interest

The authors declare no conflict of interest regarding the publication of this manuscript. In addition, the authors have completed the ethical issues, including plagiarism, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies.

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