

MATHEMATICAL STRUCTURES IN THE TRADITIONAL WIND INSTRUMENT SULING POMPANG OF MAMASA

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Abstrak. Penelitian ini mengkaji etnomatematika pada *Suling Pompang* dari Kabupaten Mamasa dengan mengintegrasikan analisis geometri dan pemodelan akustik matematis. Selain berfungsi sebagai alat musik tradisional, *Suling Pompang* merepresentasikan kearifan lokal yang mengandung prinsip-prinsip matematika secara implisit. Penelitian ini bertujuan untuk: (1) mengidentifikasi konsep geometri yang terdapat pada *Suling Pompang*; (2) menentukan parameter model akustik Joly (ϵ , δ , α , dan $\alpha\delta$) berdasarkan dimensi fisik suling; (3) menghitung spektrum frekuensi resonansi pada setiap konfigurasi lubang; dan (4) menganalisis deviasi harmonisitas nada atas yang dihasilkan. Penelitian menggunakan pendekatan etnomatematika eksploratif yang dipadukan dengan analisis kuantitatif menggunakan model akustik Joly. Data diperoleh melalui observasi, dokumentasi, dan pengukuran langsung dimensi fisik instrumen menggunakan penggaris dan jangka sorong. Analisis data dilakukan melalui identifikasi bentuk geometri dan perhitungan spektrum frekuensi resonansi. Hasil penelitian menunjukkan bahwa *Suling Pompang* merepresentasikan bangun ruang tabung dengan volume sebesar 77,715 cm³ dan luas permukaan 210,77 cm², sedangkan lubang-lubangnya berbentuk lingkaran. Parameter model Joly yang diperoleh adalah $\epsilon = 1,5\text{cm}$, $\delta = 0,349$, $\alpha \approx 0,6$, dan $\alpha\delta = 0,209$. Spektrum frekuensi resonansi menghasilkan rentang nada dasar 310–437 Hz dengan deviasi harmonisitas yang signifikan pada lubang yang berada dekat lubang tiup, mencapai –49,8 sen. Temuan ini menunjukkan bahwa para pengrajin tradisional telah menerapkan prinsip-prinsip geometri dan akustik secara empiris dalam proses konstruksi instrumen. Penelitian ini berkontribusi pada pengembangan kajian Etnomatematika melalui dokumentasi pengetahuan matematika lokal serta menegaskan potensi *Suling Pompang* sebagai sumber pembelajaran matematika kontekstual berbasis budaya.

Kata Kunci: Etnomatematika; Suling Pompang; Geometri; Model Akustik; Frekuensi Resonansi; Pengetahuan Lokal.

Abstract. This study investigates the ethnomathematics embedded in the *Suling Pompang*, a traditional wind instrument from Mamasa Regency, by integrating geometric analysis and mathematical acoustic modeling. Beyond its musical function, the instrument embodies local knowledge that reflects implicit mathematical principles. The objectives of this study were to: (1) identify the geometric concepts represented in the *Suling Pompang*; (2) determine the parameters of the Joly acoustic model (ϵ , δ , α , and $\alpha\delta$) based on the flute's physical dimensions; (3) calculate the resonance frequency spectrum for each finger-hole configuration; and (4) analyze the harmonic deviation of the resulting overtones. This research employed an exploratory ethnomathematical approach combined with quantitative acoustic analysis using the Joly model. Data were collected through observation, documentation, and direct measurement of the instrument using rulers and calipers. The data analysis involved geometric identification and resonance frequency computations. The findings reveal that the *Suling Pompang* geometrically represents a cylindrical structure with a volume of 77.715 cm³ and a surface area of 210.77 cm², while its finger holes exhibit circular geometric forms. The calculated Joly model parameters were $\epsilon = 1.5\text{cm}$, $\delta = 0.349$, $\alpha \approx 0.6$, and $\alpha\delta = 0.209$. The resonance frequency spectrum produced a fundamental pitch range of 310–437 Hz, with significant harmonic deviations occurring in holes located near the embouchure, reaching up to –49.8 cents. These findings demonstrate that traditional craftsmen have empirically applied geometric and acoustic principles in the construction of the instrument. The study contributes to the growing body of Ethnomathematics research by documenting indigenous mathematical knowledge and highlighting the potential of the *Suling Pompang* as a contextual resource for culturally responsive mathematics education.

Keywords: Ethnomathematics; Suling Pompang; Geometry; Acoustic Modeling; Resonance Frequency; Indigenous Knowledge.



A. Introduction

1. Ethnomathematics and Local Cultural Knowledge

Mathematics and culture are deeply interconnected entities that evolve simultaneously within human civilization. Mathematical practices do not emerge solely from formal educational systems but are also embedded in cultural activities, traditional technologies, architecture, art, and indigenous knowledge systems. This relationship between mathematics and culture is widely recognized within the field of Ethnomathematics, which investigates how particular cultural groups conceptualize, develop, and apply mathematical ideas in their daily lives (Rawani & Fitra, 2022). From this perspective, mathematics is understood as a socio-cultural construct shaped by empirical experiences and communal practices.

As a multicultural nation with extensive ethnic diversity, Indonesia provides a rich context for ethnomathematical studies. Numerous cultural artifacts, including traditional houses, woven fabrics, dances, games, and musical instruments, contain implicit mathematical concepts that reflect local wisdom and indigenous cognition (Serepinah et al., 2023). Ethnomathematical research therefore serves not only as a form of cultural documentation but also as a pedagogical approach that promotes contextual and culturally responsive mathematics education.

Recent studies have increasingly explored ethnomathematical elements in traditional musical instruments. Kristiyasari and Sukoco (2022) identified mathematical concepts such as geometric patterns, proportional reasoning, and measurement systems in ten Indonesian traditional musical instruments. Similarly, Bano and Bunga (2020) demonstrated that musical instruments used in the Ja'i traditional dance embody mathematical activities related to counting systems, spatial patterns, and symmetry. Rosadi et al. (2024) further revealed that the construction of the Papua Tambur flute incorporates indigenous numerical systems, traditional measurement techniques, and geometric motifs such as circles, triangles, and rhombuses.

Comparable findings have also been reported in studies on Sasando and Saluang traditional instruments. Deda et al. (2025) showed that the Sasando instrument contains sophisticated spatial geometry and numerical regularities in its structural design, while Rahmawati et al. (2023) highlighted the relationship between the physical dimensions of Saluang and the tonal characteristics produced. These studies collectively indicate that traditional musical instruments are not merely artistic artifacts but also repositories of embedded mathematical knowledge that can be scientifically investigated.

The Suling Pompang of Mamasa Regency

In Mamasa Regency, the traditional Pompang musical ensemble represents an important component of local cultural identity, with the flute (*Suling Pompang*) functioning as one of its principal instruments. The instrument has long been utilized in ceremonial events, traditional rituals, wedding celebrations, religious activities, cultural festivals, and official welcoming ceremonies. Consequently, the Suling Pompang functions not only as a musical instrument but also as a symbolic representation of the social and cultural identity of the Mamasa community.

Research conducted by Ihsan (2022) examined the musical structure and compositional forms of the Pompang ensemble, describing the functions and arrangements of its constituent instruments. Although the study successfully documented the musical characteristics of the ensemble, it primarily focused on ethnomusicological aspects and did not investigate the mathematical structures embedded within the physical construction of the flute itself. This limitation reveals an important research gap, particularly concerning the geometric configurations, dimensional proportions, and acoustic characteristics of the Suling Pompang.

From an ethnomathematical perspective, the Suling Pompang possesses significant research potential because its construction reflects implicit applications of measurement



systems, geometric reasoning, proportional relationships, and spatial organization developed through empirical craftsmanship. Investigating these mathematical aspects is therefore essential not only for scientific inquiry but also for preserving indigenous knowledge systems that are increasingly threatened by cultural modernization.

2. Mathematical Acoustic Modeling of Wind Instruments

Parallel to developments in ethnomathematics, mathematical modeling of wind instruments has also advanced considerably within the field of acoustics. One influential framework is the acoustic model developed by Joly (2011), which explains how side holes in a flute affect the sound produced by the instrument. The model employs a one-dimensional mathematical approach based on the Laplace operator under Dirichlet and Neumann boundary conditions to analyze wave resonance within cylindrical air columns.

In wind instruments, resonance frequencies are strongly influenced by tube length, hole diameter, hole position, and boundary conditions at the tube ends. Mathematically, these resonance systems can be described using wave differential equations governing air vibration inside cylindrical structures. This relationship demonstrates that traditional musical instruments embody complex mathematical and acoustic principles, even though their construction was historically achieved through empirical experimentation rather than formal scientific theory.

Several previous studies have emphasized the importance of integrating mathematical analysis with cultural artifacts. Wahyuni (2024) demonstrated that geometric concepts embedded in local cultural practices can support contextual mathematics learning, while Putri et al. (2024) argued that mathematical exploration of traditional arts enriches the interdisciplinary integration of culture and mathematics education. Nevertheless, few studies have quantitatively examined the relationship between the physical dimensions of traditional musical instruments and their acoustic resonance properties.

3. State of the Art and Research Novelty

Existing studies on ethnomathematics in traditional musical instruments have primarily focused on identifying geometric forms, numerical patterns, and their applications in mathematics education. Kristiyasari and Sukoco (2022), Rosadi et al. (2024), and Deda et al. (2025), for example, concentrated on exploring geometric concepts and mathematical activities associated with the construction and use of traditional instruments. However, these studies generally remain descriptive and rarely integrate ethnomathematical analysis with quantitative acoustic modeling.

Moreover, research examining the relationship between the physical dimensions of traditional instruments and their resonance characteristics remains limited, particularly for indigenous musical instruments originating from Eastern Indonesia. Consequently, there is still insufficient understanding of how traditional craftsmanship implicitly incorporates acoustic and mathematical optimization principles.

This study addresses these limitations through several contributions. First, it explores the ethnomathematical concepts embedded in the geometric structure of the Suling Pompang. Second, it integrates Joly's (2011) mathematical acoustic model to analyze the relationship between the flute's physical dimensions and its resonance frequencies. Third, the study provides quantitative validation through resonance spectrum calculations for multiple hole configurations. By combining ethnomathematics and acoustic modeling within a single interdisciplinary framework, this research contributes both to the preservation of indigenous knowledge and to the scientific understanding of traditional musical instrument design.

4. Research Objectives

Based on the preceding discussion, this study aims to:

1. Identify and analyze the geometric concepts embedded in the Suling Pompang from Mamasa Regency.



2. Determine the parameters of Joly's acoustic model based on the physical dimensions of the instrument.
3. Calculate the resonance frequency spectrum for each flute-hole configuration.
4. Analyze the harmonic deviation of the resulting overtones.
5. Integrate ethnomathematical findings and acoustic analysis to develop a holistic understanding of the Suling Pompang as both a cultural and mathematical artifact.

B. Methodology

1. Research Design

This study employed an exploratory qualitative design within the framework of Ethnomathematics, integrated with quantitative acoustic analysis based on the mathematical model proposed by Joly (2011). The qualitative component focused on identifying and interpreting the geometric concepts embedded in the construction of the *Suling Pompang*, while the quantitative component aimed to analyze its acoustic characteristics through mathematical modeling and resonance-frequency calculations.

The interdisciplinary approach adopted in this study enabled the integration of cultural interpretation, geometric analysis, and acoustic mathematics in order to develop a comprehensive understanding of the traditional instrument. This combination of ethnomathematical exploration and acoustic modeling was considered appropriate because the *Suling Pompang* simultaneously functions as a cultural artifact and a physical acoustic system.

2. Research Object and Data Source

The primary research object was a traditional *Suling Pompang* originating from Mamasa Regency. The instrument belonged to the researcher and constituted a family heritage item inherited from the researcher's grandmother. Historically, the flute had been used as a practice instrument for bamboo music activities in a local educational setting.

The instrument was selected purposively because it represents an authentic example of the traditional *Suling Pompang* still preserved within the local community. The study focused on examining the instrument's physical structure, geometric dimensions, hole configuration, and acoustic properties.

3. Data Collection Procedures

Data collection was conducted through four systematic stages:

a. Direct Observation

Direct observation was carried out to examine the physical characteristics of the flute, including the tube structure, embouchure hole, finger holes, and spatial arrangement of each component. Particular attention was given to identifying geometric forms and proportional relationships embedded in the instrument's design.

b. Documentation

The instrument was documented using high-resolution photographs captured from multiple perspectives, including front, side, and detailed views of each hole configuration. This documentation was intended to support geometric interpretation and preserve visual evidence of the traditional instrument's structural characteristics.

c. Dimensional Measurement

Physical measurements were conducted using a ruler and digital caliper to obtain accurate dimensional data. The measured variables included:

- Total flute length
- Internal and external tube diameter
- Wall thickness
- Distance from the embouchure hole to each finger hole
- Distance between adjacent finger holes
- Diameter of the embouchure hole and each finger hole



These measurements served as the primary input for both geometric calculations and acoustic modeling.

d. Data Recording

All observational findings, measurement results, and photographic documentation were systematically recorded in written field notes and digital archives to ensure data traceability and analytical consistency.

4. Data Analysis

Data analysis was conducted in two integrated stages involving ethnomathematical geometry analysis and mathematical acoustic analysis.

a. Ethnomathematical Geometry Analysis

The first stage focused on identifying and interpreting the geometric concepts represented in the *Suling Pompong*. The analysis included:

- Identification of geometric forms such as cylinders and circles
- Calculation of geometric properties, including volume, surface area, circumference, and circular area
- Interpretation of these geometric structures within the framework of formal mathematical concepts
- Comparison of findings with previous ethnomathematical studies on traditional flutes and musical instruments from other regions of Indonesia

The geometric analysis aimed to demonstrate how traditional craftsmanship implicitly embodies mathematical reasoning and spatial knowledge. The cylindrical structure of the flute was analyzed using the geometric relation:

$$V = \pi r^2 h$$

while the surface area analysis employed:

$$A = 2\pi r(r + h)$$

These formulations were used to quantify the geometric characteristics of the instrument.

Acoustic Analysis Using the Joly Model

The second stage involved quantitative acoustic analysis based on the one-dimensional flute model developed by Joly (2011). Several acoustic parameters were determined from the physical dimensions of the instrument, including:

- ε : tube diameter parameter
- δ : ratio between hole dimensions and ε^2
- α : geometric parameter associated with hole position and configuration
- $\alpha\delta$: combined acoustic interaction parameter

Resonance frequencies were subsequently calculated using Joly's transcendental resonance equations to determine the acoustic spectrum generated by different finger-hole configurations. The analysis also evaluated overtone harmonicity and pitch deviations in order to identify the extent to which the instrument approximates harmonic resonance behavior.

The resonance phenomenon in the cylindrical air column was conceptually represented through the wave relationship:

$$f_n = \frac{nv}{2L}$$

for open cylindrical resonance systems, where f_n denotes resonance frequency, v represents sound velocity, and L corresponds to the effective tube length.

Through this integrated analytical framework, the study connected ethnomathematical interpretation with quantitative acoustic modeling, enabling a holistic understanding of the *Suling Pompong* as both a cultural artifact and a mathematical-acoustic system.



C. RESULTS AND DISCUSSION

1. Physical Description of the Suling Pompang

The *Suling Pompang* analyzed in this study represents a traditional bamboo wind instrument originating from Mamasa Regency. The instrument is constructed from mature bamboo characterized by a rigid cylindrical structure and relatively uniform wall thickness. As a traditional musical artifact, the flute demonstrates the integration of craftsmanship, cultural aesthetics, and empirical acoustic knowledge inherited across generations. The observational findings indicate that the instrument consists of several principal components, namely the cylindrical air tube, embouchure hole, finger holes, upper end, and lower resonance end.



Figure 1: Traditional Suling Pompang Instrument

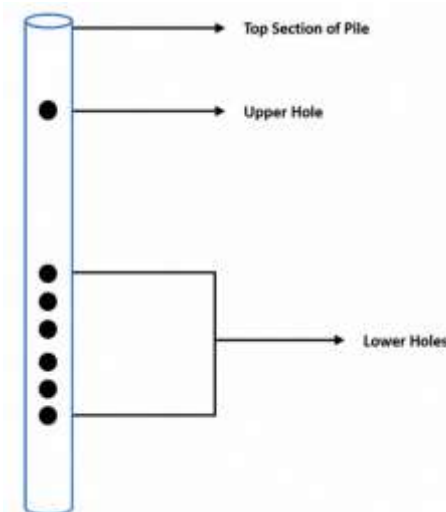


Figure 2 : Identification of Suling Pompang Components

The visual structure of the instrument reveals a high degree of geometric regularity. The cylindrical tube exhibits proportional spatial organization, while the arrangement of the finger holes follows a systematic interval pattern associated with tonal production. This structural consistency suggests that traditional instrument makers implicitly applied geometric and proportional reasoning during the construction process.

2. Dimensional Measurement Results

Dimensional measurements were conducted to obtain quantitative data regarding the flute's geometric structure and acoustic configuration. The measurement results are summarized in Tables 3.1–3.3.

Table 1. General Dimensions of the Suling Pompang

Parameter	Measurement
Total length	44 cm
Tube diameter	1.5 cm
Wall thickness	2 mm
Distance from embouchure to Do hole	15 cm
Distance from embouchure to La hole	17.5 cm
Distance from embouchure to Sol hole	20 cm
Distance from embouchure to Fa hole	22.5 cm
Distance from embouchure to Mi hole	25 cm
Distance from embouchure to Re hole	27.5 cm

Table 2 Distance Between Finger Holes

Configuration	Distance
Upper end to embouchure	7 cm
Embouchure to Do hole	15.5 cm
Do to La	1 cm
La to Sol	1 cm
Sol to Fa	2 cm
Fa to Mi	1 cm
Mi to Re	1 cm
Re to lower end	8 cm

Table 3 Diameter of Each Hole

Hole Type	Diameter
Embouchure hole	1 cm
Finger holes	1 cm

The measurement results demonstrate that the flute was constructed with relatively symmetrical dimensions and consistent spacing patterns. Such proportional regularity reflects an empirical understanding of spatial measurement systems among traditional craftsmen. Similar findings were also reported by Rosadi et al. (2024) and Deda et al. (2025), who observed that indigenous musical instruments frequently embody implicit mathematical structures through traditional fabrication techniques.

3. Ethnomathematical Geometry Analysis

The geometric analysis revealed that the *Suling Pompang* predominantly represents two fundamental geometric forms: cylinders and circles. The main body of the flute corresponds to a cylindrical structure, whereas the embouchure and finger holes correspond to circular geometries.

Table 4. Geometric Concepts Embedded in the Suling Pompang

Instrument Component	Geometric Representation	Mathematical Concept
Main flute body	Cylinder	Volume, surface area
Finger holes	Circle	Area, circumference
Upper and lower ends	Circle	Circular geometry



The cylindrical volume of the flute was determined using:

$$V = \pi r^2 h$$

$$A_{\text{base}} = \pi r^2 \approx 28.27$$

$$V = \pi r^2 h \approx 226.19$$

$$r = 3.0h = 8.0$$

while the total surface area was calculated using:

$$A = 2\pi r(r + h)$$

Table 5 Geometric Calculation Results

Component	Diameter (cm)	Circumference (cm)	Volume (cm ³)	Area (cm ²)	Surface Area (cm ²)
Main flute body	1.5	4.71	77.715	1.766	210.773
Finger holes	1	3.14	–	0.785	–
Upper/lower ends	1.5	4.71	–	1.766	–

The results indicate strong geometric consistency between the cylindrical tube and the circular end sections. This regularity suggests that the flute was constructed according to stable proportional principles rather than arbitrary dimensions. Such findings support previous ethnomathematical studies showing that traditional musical instruments often contain embedded geometric reasoning and spatial logic (Kristiyasari & Sukoco, 2022; Rahmawati et al., 2023).

From an ethnomathematical perspective, the geometric organization of the *Suling Pampang* reflects the practical mathematical knowledge of the Mamasa community. Although the craftsmen may not formally express their work through mathematical equations, the structural precision demonstrates an empirical understanding of geometry developed through long-term cultural practice.

4. Acoustic Analysis Using the Joly Model

a. Geometric Parameters of the Joly Model

Based on the physical measurements, the primary acoustic parameter of the flute tube was determined as:

$$\varepsilon = 1.5 \text{ cm}$$

The hole parameter ratio δ was calculated from the relationship between the hole dimensions and the squared tube diameter, producing:

$$\delta = 0.349$$

The geometric coefficient associated with the cylindrical hole configuration was estimated as:

$$\alpha \approx 0.6$$

Thus, the combined interaction parameter became:

$$\alpha\delta = 0.209$$

These parameters represent the geometric-acoustic interaction governing resonance behavior in the flute system.

b. Normalized Hole Positions

To analyze resonance behavior, each finger-hole position was normalized relative to the effective acoustic length of the flute.

Table 6. Normalized Hole Positions



Hole	Distance from Embouchure (cm)	Normalized Position a
Do	15.5	0.419
La	16.5	0.446
Sol	17.5	0.473
Fa	19.5	0.527
Mi	20.5	0.554
Re	21.5	0.581

The normalized positions demonstrate a progressive spatial arrangement corresponding to tonal intervals. This systematic organization indicates that traditional instrument makers employed an empirical acoustic logic in positioning the holes.

5. Resonance Frequency Analysis

The resonance frequencies for each finger-hole configuration were calculated using the Joly acoustic model. The resonance phenomenon in the cylindrical air column follows:

$$f_n = \frac{nv}{2L}$$

where f_n denotes resonance frequency, v represents sound velocity, and L corresponds to the effective tube length.

Table 7. Resonance Frequencies Without Open Holes

Mode	Frequency (Hz)	Reference Pitch
1	464	B \flat 4
2	928	B \flat 5
3	1392	F6
4	1856	B \flat 6

The results indicate that the flute behaves acoustically as an open cylindrical resonance system when no side holes are activated.

Table 8. Resonance Frequencies for the Do Hole Configuration

Mode	Frequency (Hz)	Reference Pitch	Deviation (cents)
1	310.5	E \flat 4	-5.6
2	785.5	G5	+2.2
3	1241.6	D6	-4.2
4	1710.0	A \flat 6	-49.8
5	2178.0	C7	+68.4

Table 9. Resonance Frequencies for the La Hole Configuration

Mode	Frequency (Hz)	Reference Pitch	Deviation (cents)
1	330.9	E4	+5.2
2	804.7	G5	-52.3
3	1257.5	D6	+18.0
4	1727.3	A \flat 6	-32.7



Table 10. Resonance Frequencies for the Sol Hole Configuration

Mode	Frequency (Hz)	Reference Pitch	Deviation (cents)
1	352.6	F4	+19.7
2	823.9	G5	-12.5
3	1273.5	D6	+39.8
4	1745.0	Ab6	-14.8

Table 11. Resonance Frequencies for the Fa Hole Configuration

Mode	Frequency (Hz)	Reference Pitch	Deviation (cents)
1	392.6	G4	+4.4
2	852.0	G5	+45.1
3	1298.0	E6	-27.7
4	1769.0	Ab6	+8.8

Table 12. Resonance Frequencies for the Mi Hole Configuration

Mode	Frequency (Hz)	Reference Pitch	Deviation (cents)
1	415.0	G4	0.0
2	871.2	F5	+372
3	1315.5	E6	-5.3
4	1786.5	Ab6	+25.3

Table 13. Resonance Frequencies for the Re Hole Configuration

Mode	Frequency (Hz)	Reference Pitch	Deviation (cents)
1	436.7	A4	-11.8
2	889.9	F5	+414
3	1333.2	E6	+18.3
4	1803.6	Ab6	+42.8

6. Harmonic Overtone Analysis

Table 14. Harmonic Ratio Comparison

Configuration	2nd Harmonic	3rd Harmonic	4th Harmonic
Perfect harmonic	2.000	3.000	4.000
No open hole	2.000	3.000	4.000
Do	2.533	4.005	5.514
La	2.433	3.804	5.223
Sol	2.335	3.611	4.946
Fa	2.169	3.304	4.504
Mi	2.100	3.171	4.306
Re	2.037	3.051	4.128

The overtone analysis demonstrates that harmonic deviation increases when the open hole is positioned closer to the embouchure. This phenomenon indicates that the interruption of the air column becomes more significant near the upper resonance region of the flute. The findings are consistent with Joly's (2011) acoustic theory, which predicts stronger perturbation effects for holes located near critical pressure nodes.

Interestingly, the Re-hole configuration exhibited harmonic ratios closest to ideal harmonic resonance, whereas the Do-hole configuration showed the largest deviations. These results suggest that traditional craftsmen may have intuitively optimized certain tonal positions while accepting non-harmonic behavior in others to achieve culturally preferred sound characteristics.



Overall, the findings confirm that the *Suling Pompang* embodies both geometric regularity and sophisticated acoustic behavior. The instrument therefore represents not merely a cultural artifact but also an empirical manifestation of indigenous mathematical and acoustic knowledge developed through generations of traditional craftsmanship.

D. Conclusion

This study demonstrates that the *Ei Ledo* woven textile of the Hubi Iki clan embodies a highly sophisticated form of indigenous mathematical cognition integrating numerical algorithms, binary logic, geometric precision, and algebraic symmetry within traditional weaving practices. The findings reveal that the weaving process is governed by a systematic computational structure, including the calculation of 144 thread strands through the *Mane* algorithm, the application of Boolean-based dyeing logic, and the construction of geometric motifs modeled as periodic triangular wave functions and higher-degree polynomial curves.

Furthermore, the identification of the C_{2v} symmetry group confirms that the microstructural composition of the motifs follows formal principles of transformational geometry and abstract algebra. The use of rotational and reflective operations derived from a single fundamental domain indicates the presence of advanced cognitive efficiency and recursive spatial reasoning among traditional Sabu weavers, despite the absence of modern measuring instruments or formal mathematical notation.

These findings challenge the conventional assumption that advanced mathematical reasoning is exclusively associated with formal scientific institutions. Instead, the study demonstrates that indigenous cultural practices preserve complex systems of mathematical knowledge embedded within artistic production and collective memory. From an academic perspective, this research contributes to the advancement of Ethnomathematics by bridging indigenous knowledge systems with computational modeling, geometry, and algebraic theory.

Future research should extend comparative analyses to other Sabu weaving traditions, particularly the Hubi Ae clan motifs, in order to investigate broader variations in mathematical structure and symbolic representation. Additionally, the findings provide a strong foundation for the development of culturally responsive mathematics curricula that integrate local wisdom into contemporary numeracy and mathematical literacy education.

REFERENCES

- Ely Goro Leba. (2024) *Makna Motif Sarung Sabu dan Sejarah Ada Hubi Ae dan Hubi Iki di Kalangan Wanita Suku Sbu Raijua*.
<https://www.kompasiana.com/pegiatliterasi9661/65f7cc111470936e6719b212/makna-motif-sarung-sabu-dan-sejarah-ada-hubi-ae-dan-hubi-iki-di-kalangan-wanita-suku-sbu-raijua>
- Armstrong, M. A. (1988). *Groups and symmetry*. Springer-Verlag.
- D'Ambrosio, U. (1985). Ethnomathematics and its place in the history and pedagogy of mathematics. *For the Learning of Mathematics*, 5(1), 44–48.
- Gallian, J. A. (2016). *Contemporary abstract algebra* (9th ed.). Cengage Learning.
- Gerdes, P. (1999). *Geometry from Africa: Mathematical and educational explorations*. Mathematical Association of America.



- Gittinger, M. (1990). *Splendid symbols: Textiles and tradition in Indonesia*. The Textile Museum.
- Kreyszig, E. (2011). *Advanced engineering mathematics* (10th ed.). Wiley.
- Maxwell, R. (1990). *Textiles of Southeast Asia: Tradition, trade and transformation*. Periplus Editions.
- Museum Negeri Propinsi NTT. (1995). *Koleksi tenun ikat Museum Negeri Propinsi Nusa Tenggara Timur*. Repositori Kementerian Pendidikan dan Kebudayaan.
- Stewart, J. (2015). *Calculus: Early transcendentals* (8th ed.). Cengage Learning.
- Talo, D. D. (2004). *Pergeseran kebudayaan orang Sawu pada fungsi kain tenun ikat di Desa Limaggu-Kupang NTT* (Master's thesis). Universitas Indonesia
- Washburn, D. K., & Crowe, D. W. (1988). *Symmetries of culture: Theory and practice of plane pattern analysis*. University of Washington Press.
- Weyl, H. (1952). *Symmetry*. Princeton University Press.
- Zill, D. G. (2018). *Advanced engineering mathematics* (7th ed.). Jones & Bartlett Learning.

