Journal of Mathematics and Mathematics Education
https://jurnal.uns.ac.id/jmme
p-ISSN 2089-8878; e-ISSN 2715-8276
Vol. 14, No. 01, June 2024

ETHNOMATHEMATICS IN JAVANESE GAMELAN (KENONG AND GONG)

Divia Virda Kurnia[1*)]
[1]Mathematic Education Department, Teacher and Training Faculty, Muhammadiyah Purwokerto University, Purwokerto, Indonesia

*Correspondence purposes, email: dvirdakurnia@gmail.com

Abstrak: Etnomatematika merupakan studi lintas-budaya tentang praktik matematika yang bertujuan untuk mengungkap, memahami, dan menghargai keberagaman konseptualisasi dan aplikasi matematika dalam berbagai latar budaya. Salah satu aspek budaya yang memiliki keterkaitan erat dengan matematika adalah gamelan, alat musik tradisional yang kompleks dan beragam. Gamelan tidak hanya sekadar seni pertunjukan, tetapi juga mengandung unsur-unsur matematika yang mendalam. Penelitian ini bertujuan untuk mengeksplorasi etnomatematika yang terkandung dalam dua instrumen gamelan Jawa, yaitu kenong dan gong, serta memahami bagaimana matematika tertanam dalam tradisi dan pembuatan instrumen tersebut. Penelitian ini menggunakan pendekatan kualitatif dengan metode etnografi. Data dikumpulkan dari penelitian langsung ke lapangan terkait gamelan Jawa, khususnya kenong dan gong. Hasil penelitian ini menemukan bahwa kenong dan gong, sebagai bagian dari ansambel gamelan Jawa, tidak hanya menghasilkan melodi yang memukau, tetapi juga mengungkapkan rahasia tersembunyi dalam pola-pola geometris dan aritmatika yang menjadi dasar pembuatan instrumen tersebut. Matematika tertanam dalam aspek-aspek seperti bentuk, ukuran, dan pengaturan nada pada kenong dan gong, mencerminkan kearifan dan pemahaman mendalam masyarakat Jawa tentang struktur matematika. Gamelan Jawa, khususnya kenong dan gong, merupakan contoh nyata dari etnomatematika, di mana matematika tertanam dalam tradisi seni musik tradisional yang menjadi warisan budaya masyarakat Jawa. Penelitian ini memberikan wawasan baru tentang keterkaitan erat antara seni, budaya, dan matematika dalam konteks gamelan.

Kata kunci : *Etnomatematika, Gamelan Jawa, Kenong, Gong*

Abstract: *Ethnomathematics is a cross-cultural study of mathematical practices aimed at revealing, understanding, and appreciating the diversity of mathematical conceptualizations and applications across various cultural contexts. One cultural aspect that is closely linked to mathematics is the gamelan, a complex and diverse traditional musical ensemble. Gamelan is not merely a performing art but also contains profound mathematical elements. This research aims to explore the ethnomathematics embedded in two Javanese gamelan instruments, the kenong and the gong, and to understand how mathematics is integrated into the tradition and construction of these instruments. A qualitative approach with ethnographic methods was employed in this study. Data were collected through direct field research on Javanese gamelan, specifically focusing on the kenong and the gong. The findings of this research reveal that the kenong and the gong, as parts of the Javanese gamelan ensemble, not only produce captivating melodies but also unveil hidden secrets within the geometric and arithmetic patterns that underpin the construction of these instruments. Mathematics is embedded in aspects such as the shape, size, and tuning arrangement of the kenong and the gong, reflecting the deep wisdom and understanding of mathematical structures possessed by the Javanese community. Javanese gamelan, particularly*

Accepted: december 28, 2023 Approved: June 01, 2024 Published: June 31, 2024
DOI: https://doi.org/10.20961/jmme.v14i1.89158

the kenong and the gong, serves as a tangible example of ethnomathematics, where mathematics is interwoven with the traditional musical art that constitutes the cultural heritage of the Javanese people. This research provides new insights into the close relationship between art, culture, and mathematics in the context of gamelan.

Keywords: *Ethnomathematics, Javanese Gamelan, Kenong, Gong*

INTRODUCTION

Ethnomathematics is a cross-cultural study of mathematical practices that aims to uncover, understand, and appreciate the diversity of conceptualizations and applications of mathematics in various cultural settings. According to D'Ambrosio (1985), ethnomathematics is a branch of study that examines the application and practice of mathematics by various cultural groups. This includes diverse communities, ranging from urban and rural societies to working groups, children of different age ranges, as well as indigenous peoples. Ethnomathematics explores how each of these groups develops and applies mathematical concepts in the context of their daily lives, reflecting their unique ways of understanding and using mathematics. As such, ethnomathematics sees mathematics not only as a universal discipline but also as a practice influenced by each group's cultural and social background.

One aspect of culture that is closely related to mathematics is gamelan. Gamelan, with its complex and diverse traditional musical instruments, is not only a performing art, but also contains deep mathematical elements. Each instrument in a gamelan ensemble has a specific role and rhythmic pattern, which must be precisely harmonized to create harmony. Rhythmic patterns or gendhing in gamelan often rely on a meticulous system of calculation, where mathematization of notation, rhythm and time intervals is essential to produce harmony of sound. As such, gamelan not only represents a rich culture, but is also a reflection of the complex and structured application of mathematical principles in a musical tradition that has been passed down through the generations.

The word “gamelan” itself comes from the word “gamel”, which means to beat or strike, and the suffix “-an” is added to turn it into a noun. The term refers to a traditional musical ensemble consisting of various instruments played by beating or drumming, creating a distinctive and complex harmony. There are several kinds of gamelan that have developed in different regions of Indonesia, each with unique characteristics and nuances. For example, Javanese gamelan is known for its soft and meditative sound; Balinese gamelan is known for its fast and dynamic tempo; Sundanese gamelan has a lighter and more melodic tone; and Madurese gamelan has a distinct rhythm and style. Each type of gamelan reflects the richness of local cultures and traditions, and demonstrates how this musical art continues to adapt and evolve over time.

Javanese gamelan, as a rich and deep cultural heritage, represents a close interweaving of artistic beauty, cultural wisdom and mathematical complexity. Javanese gamelan is even internationally renowned. For centuries, Gamelan music has been a symbol of pride for the Javanese people, not only as a form of entertainment or performance art, but also as a reflection of the deep understanding of mathematical structure and geometry embedded in the culture.

In the domain of Gamelan music, the kenong and gong instruments take center stage. Not only do they produce a mesmerizing array of melodies, but they also reveal secrets hidden in the geometric and arithmetic patterns upon which they are built. As an extension of the wisdom of our ancestors, the kenong and gong teach us that every sound they make is also a manifestation of the mathematical order hidden within the Javanese cultural heritage. Kenong is one of the most important gamelan instruments in Javanese and Balinese traditional music. Its physical form resembles a large bowl with a flat surface at the top, which serves as a beating platform. Kenongs are placed on a string or wood set in a wooden frame, and played by striking them with a special beater called a tabuh. Kenongs are usually arranged in a set containing several units with different tones, thus creating a variety of tones in gamelan music compositions. Its function is to mark certain parts of the gamelan song structure, emphasize rhythms and help maintain the tempo of the ensemble as a whole.

Gong, on the other hand, is a gamelan instrument that also has a vital role in this ensemble. Unlike the kenong, the gong is larger and simpler, a large metal disk suspended vertically. The gong is usually made of bronze or brass and is played by striking it with a beater covered with a thick cloth to produce a deep, resonant sound. The gong not only functions as a rhythmic marker like the kenong, but is also often used to mark the end of a musical phrase or section of a composition, giving it a dramatic feel and emphasizing transitions in song structure.

In general, kenong and gong have complementary roles in gamelan. The kenong with its high notes provides faster rhythms and detail in the music, while the gong with its low notes provides the foundation and sense of depth in the composition. The combination of these two instruments helps create harmony and dynamics in gamelan playing, creating a rich and complex listening experience. They also demonstrate how gamelan as an ensemble utilizes different types of sounds and rhythms to create layered and structured pieces of music.

As well as their function in music, kenong and gong also have cultural and symbolic value in Javanese and Balinese society. In traditional ceremonies, these two instruments are often played to accompany dances and rituals, and are used in various celebrations and important events. They are not only seen as musical instruments, but also as symbols of rich tradition and cultural identity. The presence of kenong and gong in various aspects of people's lives reflects the importance of gamelan music as part of a living and evolving cultural heritage.

However, so far research specifically examining the mathematical aspects of Javanese Gamelan kenongs and gongs is still limited. Therefore, this article will take the reader on an exploratory journey into the world of Javanese Gamelan ethnomathematics, where we will deepen the understanding of how Javanese people use and understand mathematical concepts in their musical context, with a particular focus on the role played by geometry and arithmetic patterns in the process of creation, maintenance and interpretation of Gamelan music, particularly on the kenong and gong instruments.

In this article, the author will take the reader on an exploratory journey into the world of Javanese Gamelan ethnomathematics, where we will deepen our understanding of how Javanese people use and understand mathematical concepts in the context of their music. Our primary focus will be on the role that geometry and arithmetic patterns play in the process of creation, maintenance, and interpretation of Gamelan music, with kenong and gong as the center of our attention.

Furthermore, by deepening our knowledge of the geometric structures and arithmetic patterns inherent in Javanese Gamelan, we can not only better appreciate the beauty of the music, but also gain deeper insight into the cultural and intellectual heritage passed down by our ancestors. Through this journey, we will unearth the wealth of knowledge contained within the melodies and rhythms, while also reinforcing the connections between math, art and culture in this fascinating context.

METHOD

A qualitative approach with ethnographic methods was used in this research. The qualitative approach was chosen because the focus of this research is to understand complex social and cultural phenomena, which cannot be measured by quantitative methods. Qualitative methods allow researchers to gain a deep understanding of how mathematical concepts are applied in the cultural practices of Javanese society, especially in the making and playing of saron musical instruments on Javanese gamelan.

The ethnographic method was chosen because it is suitable for studying cultural practices and mathematical understanding in traditional communities. Ethnography is a research method that aims to describe and interpret the social life of a group or community from the perspective of members of that community. Through ethnography, researchers can observe and be directly involved in the daily life of the community under study, thus gaining richer and more authentic insights into the cultural and mathematical practices applied.

An in-depth study of ethnomathematical practices in Javanese gamelan music was conducted from May 18 to May 19, 2024. Mr. Rasmo, an experienced player of gamelan instruments, was the main subject of the interview. The focus was on the two main instruments in Javanese gamelan music, the kenong and gong. In the article entitled "Ethnomathematics in Javanese Gamelan (Kenong and Gong)", an in-depth analysis is made of the mathematical roles and structures involved in the use of these two instruments in the context of Javanese traditional music.

RESULT AND DISCUSSION

In ethnomathematics view, both gong and kenong also have mathematical concepts, including the concepts of geometry and arithmetic. The following is an analysis of the geometry concept of the Javanese gamelan kenong and gong:

The concept of geometry in "Gong"

Figure 1. Front view of "Gong"

In Figure 1, we can observe several spatial figures, including a circle and a rectangle that serves as the gong's hanger. In math concepts, circles have some important formulas. To calculate the area of a circle, the formula is used:

$$\textit{Area of the Circle} = \pi r^2$$

where, π is a constant that is 22/7 or 3.14, and r is the radius of the circle.

$$\textit{Circumference of the circle} = 2\pi r$$

where, π is a constant that is 22/7 or 3.14, and r is the radius of the circle.

Beside the circle, the rectangle in the picture also has its own math formula. The area of a rectangle can be calculated with the formula:

$$Area = Length \times Width$$

Where length is one of the long sides of the rectangle, width is one of the short sides of the rectangle. Meanwhile, the perimeter of a rectangle is calculated by the formula:

$$Perimeter = 2 \times (length + width)$$

Where length is one of the long sides of the rectangle, width is one of the short sides of the rectangle.

Figure 2. side view of the "Gong"

In Figure 2, there are two geometric figures, namely a hemisphere and a pointed cone. In mathematical concepts, the surface area of a hemisphere consists of two parts: the curved surface area (the part of the sphere) and the base surface area (the circle formed by cutting the sphere). So, the formula for the total surface area of a hemisphere is:

$$\textit{Half-sphere surface area} = 2\pi r + \pi r^2 = 3\pi r^2$$

Where,

r = radius of the ball

$2\pi r^2$ = the curved surface area

πr^2 = surface area of the base (circle)

Secondly, there is a truncated cone space, as for the illustration of the truncated cone space is as follows:

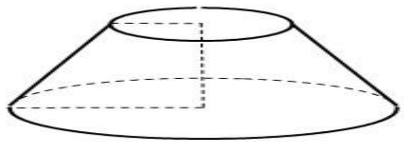
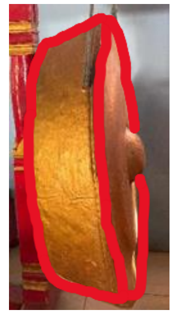



Figure 3. Illustration of a conical cone

In mathematical concepts, the formula for a truncated cone is as follows:

Volume formula of a truncated cone = *1/3 πh (r21 + r22+ r1r2)*

Where,

π = constanta (22/7 atau 3,14)

h = height of the conical cone (perpendicular distance between the two bases)

r1 = radius of the bottom base

r2 = radius of the top base

Then, there is the surface area of a conical cone. The surface area of a truncated cone consists of three parts: the surface area of the curved side, the surface area of the bottom base (circle with radius r1), the surface area of the top base (circle with radius r2). To calculate the surface area of the curved side, we use the length of the painter's line (s), which is calculated by:

$$s = \sqrt{(r1-r2)^2+h^2}$$

The surface area of a curved side is as follows:

Area of the curved side = π (r1+r2) s

so, the formula for the total surface area of a truncated cone is:

$$Surface\ area = \pi\ (r1+r2)s + \pi r21 + \pi r22$$

or, it could be simplified to:

$$Surface\ area = \pi\ ((r1 + r2)\ s + r21 + r22)$$

The Concept of Geometry in "Kenong"

The actual shape of the kenong and gong are almost similar, except that the kenong is smaller and thicker like a bowl, while the gong is flatter. Here is the concept of geometry contained in the kenong which is almost similar to the gong.

Figure 4. Kenong

In the picture, researchers can analyze some geometry concepts on the kenong, namely:

Figure 5. Constructing a hemispherical space in a "kenong"

The first one is the half-sphere that is located on the small part of the top of the kenong. In mathematical concepts, to find the half-sphere formula, it is known that

The surface area of a hemisphere consists of two parts: the area of the curved surface (the spherical part) and the area of the base surface (the circle formed by cutting the sphere). So, the formula for the total surface area of a half sphere is:

$$\textit{Half-sphere surface area} = 2\pi r + \pi r2 = 3\pi r2$$

Where,

r = the radius of the sphere

$2\pi r^2$ = the curved surface area

πr^2 = the surface area of the base (circle)

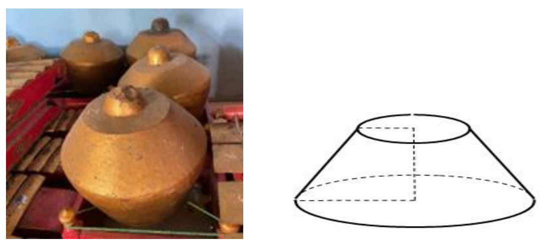


Figure 6. Illustration of a conical cone in a "kenong"

Likewise with the gong, the kenong also has a concave cone in the center, as for the concept of mathematical formulas, the formula for a concave cone is as follows:

$$\textit{The volume formula of a conical cone} = 1/3\ \pi h\ (r21 + r22 + r1r2)$$

Where,

π = a constant (22/7 or 3.14)

h = the height of the conical cone (perpendicular distance between the two bases)

r1 = the radius of the bottom base

r2 = the radius of the top base

Then, there is the surface area of a conical cone. The surface area of a truncated cone consists of three parts: the surface area of the curved side, the surface area of the bottom base (circle with radius r1), the surface area of the top base (circle with radius r2). In order to calculate the surface area of the curved side, we use the length of the painter's line (s), which is calculated by:

$$s = \sqrt{(r1-r2)^2 + h^2}$$

Also, the surface area of the curved side is as follows:

$$Curved\ side\ area = \pi\ (r1+r2)\ s$$

Hence, the formula for the total surface area of a truncated cone is:

$$Surface\ area = \pi\ (r1+r2)s + \pi r21 + \pi r22$$

or, it can be simplified into:

$$Surface\ area = \pi\ ((r1 + r2)\ s + r21 + r22)$$

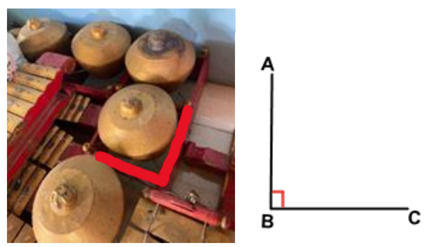


Figure 7. The use of angles in a kenong holder

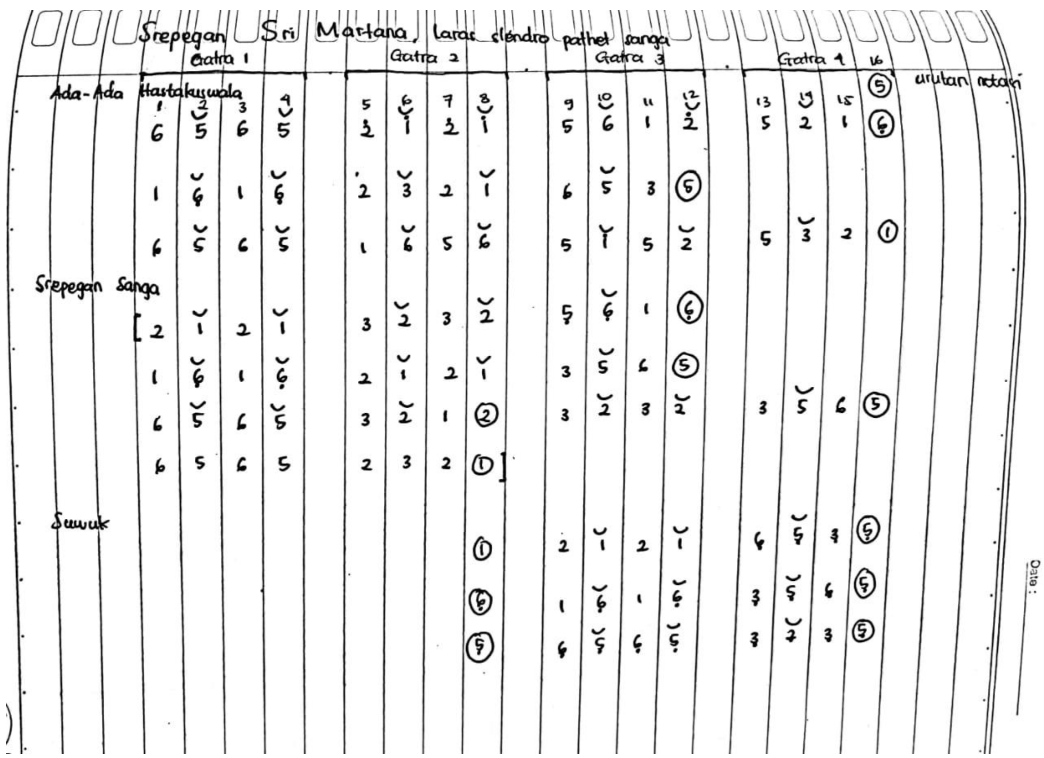
Based on Figure 7, the arrangement of Javanese gamelan instruments, specifically the kenong, creates a unique geometric configuration in one dimension, namely the angle. In this context, the angle formed by the kenong arrangement is a right angle. The right angle, which measures 90 degrees, plays an important role in the placement of the kenong. This angle ensures that the kenong is positioned precisely and symmetrically, which not only affects the visual aesthetics but also the comfort and efficiency in playing the instrument. Proper arrangement allows gamelan players to easily reach each kenong without excessive movement, leading to smoother and more coordinated performance.

The Arithmetic Concept In Javanese Gamelan, Particularly "Gong And Kenong"

Application in Javanese traditional music, particularly in gamelan instruments such as the gong and kenong. In Javanese gamelan, there is a complex rhythmic structure and mathematical patterns. For instance, in a gendhing (a gamelan musical composition), the large gong is typically played on the final count of a specific cycle, known as the gongan. This cycle is often divided into smaller sections, with the kenong marking the end of each sub-section. This rhythmic pattern is organized in a system called balungan, which can be compared to the mathematical concept of an arithmetic series. For example, if a gongan consists of 16 beats, the kenong will sound on the 4th, 8th, and 12th beats before the large gong is struck on the 16th beat. This pattern creates a repetitive and predictable rhythmic structure, similar to the nature of patterns in arithmetic series.

Moreover, the frequency and intervals of pitches in gamelan can also be analyzed using arithmetic principles. Each instrument in the gamelan has specific pitches that, when arranged mathematically, create a distinctive harmony. Therefore, understanding arithmetic concepts can provide deeper insights into studying and playing Javanese gamelan, enriching one's appreciation for the complexity and beauty of this traditional music.

Here is the arithmetic concept that researchers analyzed from Javanese gamelan, particularly the gong and kenong.

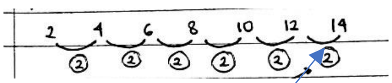


ᴗ = kenong

( ) / O = Gong

The kenong punch in the song:

In every gatra (1,2,3,4)



Diketahui bahwa:

$a = 2$

$b = 4-2 = 2$

$U_n = a + (n-1)\,b$

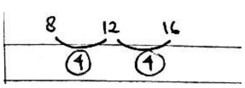
$= 2 + (n-1)\,2$

$= 2 + 2n-2$

$U_n = 2n$

The formula for finding the nth term of an arithmetic series in Kenong is $U_n=2n$

So, the kenong player hits the kenong after the 2nd count and the beat is every multiple of two. Gong strikes in the song:



$a = 8$

$b = 12-8 = 4$

$U_n = a + (n-1)\,b$

$= 8 + (n-1)\,4$

$= 8 + 4n-4$

$U_n = 4n + 4$

It can be seen that the gong beater hits the gong after the 8th count and the subsequent beats are multiples of 4. However, in the Sri Martana song, the beats only occur in the 2nd, 3rd, and 4th gatra so it is true that the gong is hit on the 8th count.

CONCLUSION

In this research, Javanese gamelan such as gongs and kenongs are analyzed through an ethnomathematics lens, revealing geometric and arithmetic concepts contained in the shapes and playing patterns of these musical instruments. In gongs, geometric shapes such as circles and rectangles are identified, with related mathematical formulas such as the area and circumference of circles and rectangles. Likewise, in kenongs, half-sphere and truncated cone shapes are found which also have certain mathematical formulas. Arithmetic concepts are seen in the rhythmic structure of gamelan, where the striking patterns of gongs and kenongs reflect arithmetic sequences that ensure proper harmony and rhythm in musical compositions. A deeper understanding of mathematical concepts in gamelan can be an effective tool to enrich learning and appreciation of traditional Javanese music. Therefore, the introduction of ethnomathematics in music and mathematics education curricula can increase cultural awareness and interdisciplinary knowledge among students. In addition, further research on the application of mathematical concepts in other traditional musical instruments could be an interesting topic for further exploration, which not only preserves cultural heritage but also strengthens analytical skills and creativity.

REFERENCES

Ardana, I Ketut. (2020). Representasi Konsep Patet Dalam Tradisi Garap Gamelan Bali. *Resital Vol. 21 (1).* Hal 11-28

Dewi, Agatha Feviari Kristina Dewi, dkk. (2020). Pola Barisan Aritmatika pada Pukulan Ketukan Dalam Gending Ketawang di Gamelan Yogyakarta. *Seminar Nasional Pendidikan Matematika, Vol. 1 (1).* Hal 7-14

Hananto, Paris. (2020). Gamelan sebagai Simbol Estetis Kebudayaan Masyarakat Jawa. *Jurnal Representamen, Vol 6 (01).* Hal 9-19

Harista, Adhidarma, dkk. (2022). Learning Application for Introduction of Javanese Gamelan Musical Instruments Based on Android Platform. *Jurnal Teknik Informatika, Vol. 17 (1)*. Hal 35-42

Isrok'atun. (2015). Menemukan Kembali Rumus Luas Persegi Panjang dengan Konstruktivisme. *Mimbar Sekolah Dasar, Vol. 2(1).* Hal 36-45

Iswantoro, Gatot. (2017). Kesenian Musik Tradisional Gamelan Jawa Sebagai Kekayaan Budaya Bangsa Indonesia. *Jurnal Sains Terapan Pariwisata, Vol 3 (1).* Hal 129-143

Lubis, Sofia Indriani. (2018). Eksplorasi Etnomatematika pada Alat Musik Gordang Sambilan. *Edumatika Jurnal Riset Pendidikan Matematika Vol. 1(2).* Hal 1-10

Nur, Rezky Juniarsih, dkk. Studi Etnografi pada Suku To Balo di Desa Bulo-Bulo Kecamatan Pujananting Kabupaten Barru Sulawesi Selatan. *Jurnal PENA, Vol.3 (2).* Hal 503-515

Nursulistyo, Eko. (2019). Pemanfaatan Siter, Kendang, Saron, Kenong, dan Gender Sebagai Media Pembelajaran Fisika. *JRKPF UAD Vol 6 (1).* Hal 5-9

Sarwoedi, dkk. (2018). Efektifitas Etnomatematika dalam Meningkatkan Kemampuan Pemahaman Matematika Siswa. *Jurnal Pendidikan Matematika Raflesia, Vol. 03 (02).* Hal 171-176

Wahyudin. Etnomatematika Dan Pendidikan Matematika Multikultural. *Prosiding Seminar Nasional Etnomatnesia* ISBN:978-602-6258-07-6. Hal 1-19

Widiawati,dkk. (2018). Desain Pembelajaran Garis dan Sudut dengan Konteks Pagar Buluh di Kelas VII. *Journal of Mathematics Science and Education, Vol. 1 (1).* Hal 118-130

Wiyati, Sri Wahyu, dkk. (2023). Gong Dalam Budaya Masyarakat di Indonesia. *Journal of Music Science, Technology, and Industry Vol. 6 (1).* Hal 19-30