



Learning Geometry From the Value of Life on The Traditional Musical Instrument

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Abstract

Many people believe that mathematics is unrelated to human existence. However, mathematics is, in reality, inextricably linked to human culture and life. For example, Ponorogo, a city in Indonesia, is known for its culture and art, particularly Reyog Ponorogo. Therefore, mathematical principles that bring mathematics closer to human life can be investigated using existing civilizations. Furthermore, culture can be used as a basis for math education in schools. This study seeks to investigate geometric concepts and the value of life in gamelan Reyog Ponorogo. The research question is, what are the values and concepts of geometry in gamelan reyog Ponorogo?. This research is an ethnography research. The data is collected through observations, literature reviews, and interviews with ponorogo elders. The results showed that gamelan reyog Ponorogo uses the concept of geometry (field geometry, spatial geometry, transformation geometry, angular concepts, and the concept of two parallel lines cut by a line). In addition, each gamelan instrument contains traditional values, such as self-control, accountability, self-improvement, and so on. Therefore, it can be concluded that the gamelan reyog ponorogo is full of geometry concepts and the value of life

Keywords: ethnomathematics; gamelan; geometry; reyog ponorogo; value of life

Abstrak

Banyak orang yang beranggapan bahwa matematika tidak ada hubungannya dengan keberadaan manusia. Namun, matematika pada kenyataannya terkait erat dengan budaya dan kehidupan manusia. Misalnya saja Ponorogo, sebuah kota di Indonesia yang terkenal dengan budaya dan seninya, khususnya Reyog Ponorogo. Oleh karena itu, prinsip-prinsip matematika yang mendekatkan matematika dengan kehidupan manusia dapat diselidiki dengan menggunakan peradaban yang ada. Selanjutnya budaya dapat dijadikan landasan pendidikan matematika di sekolah. Penelitian ini bertujuan untuk mengetahui konsep geometri dan nilai kehidupan dalam gamelan Reyog Ponorogo. Pertanyaan penelitiannya adalah, apa saja nilai dan konsep geometri dalam gamelan reyog Ponorogo?. Penelitian ini merupakan penelitian etnografi. Pengumpulan data dilakukan melalui observasi, studi pustaka, dan wawancara dengan sesepuh ponorogo. Hasil penelitian menunjukkan bahwa gamelan reyog Ponorogo menggunakan konsep geometri (geometri bidang, geometri ruang, geometri transformasi, konsep sudut, dan konsep dua garis sejajar yang dipotong oleh sebuah garis). Selain itu, setiap instrumen gamelan mengandung nilai-nilai tradisional, seperti pengendalian diri, akuntabilitas, pengembangan diri, dan lain sebagainya. Oleh karena itu, dapat disimpulkan bahwa gamelan reyog ponorogo sarat dengan konsep geometri dan nilai kehidupan

Kata Kunci: etnomatematika; gamelan; geometri; nilai kehidupan; reog ponorogo

BACKGROUND

Mathematics evolved from human responses to their environments, such as seeking explanations, understanding, experiences, and solutions to observed phenomena (D'Ambrosio, 2007, 2016; Freudenthal, 2006; Rosa et al., 2016). Thus, mathematics does not exist in isolation; it is influenced by historical, environmental, social, and geographical factors, or what we refer to as a culture in which humans evolve through life processes (D'Ambrosio, 2016; Risdiyanti and Prahmana, 2018; Utami et al., 2019). However, mathematics becomes formal when applied to formal education or schooling in routine-based ways dissimilar to the cultures in which it developed and is taught (Alangui, 2010; Muhtadi, 2017). This issue is connected to western colonialism's attempt to hegemonize the world's knowledge (D'Ambrosio, 2007; Joseph, 2011; Rosa et al., 2016). Thus, mathematics education becomes a process of knowledge transfer, and students receive it without engaging in reflective thought or being aware of the application of mathematics in daily life.

As a solution, ethnomathematics is proposed based on how mathematics has been taught in schools and how mathematics has developed (D'Ambrosio, 1985). It is a method for learning and combining ideas, procedures, and techniques developed and used by sociocultural or members of diverse cultures (D'Ambrosio, 2016; Rosa et al., 2016). This method seeks to reposition mathematics about various cultures, accommodating diverse ideas to develop students into critical thinkers, democratic citizens, and tolerant individuals (D'Ambrosio, 2016; Zevenbergen, 2001). Thus, as a pedagogical innovation in mathematics teaching and learning, ethnomathematics aims to instill a love of mathematics in students, motivate them, and enhance their creativity when solving mathematical problems.

With its rich and diverse cultural heritage, Indonesia has an opportunity to improve the country's mathematics education system through transformational efforts to connect mathematics to students' lives and cultures (Abdullah, 2017). Numerous cultures in Indonesia can be explored to provide context for mathematics education, including the culture of Ponorogo, also known as the city of reyog and popularly referred to as reyog Ponorogo.

Reyog Ponorogo as a performing art consists of at least 3 (three) distinct elements or types of art. Namely, the art of motion expressed through dances, fine art said through the properties used (e.g., barongan mask, ganongan mask, or klanasewardana mask), and music expressed through gendhing or gamelan reyog Ponorogo. The combination of these elements defines reyog Ponorogo. For example, there is an unbreakable connection between dance and gamelan. Similarly, the property and dance equipment characteristics known as reyog Ponorogo contribute to the folk art's uniqueness.

Previously, mathematical concepts in reyog Ponorogo were investigated (Damaningrum and Budiarto, 2021; Fatmahanik, 2019; Sugianto et al., 2019a). However, prior research has focused exclusively on the ethnomathematics elements found in reyog Ponorogo in general, especially in musical instruments, the rhythm of music, makeup, and dance movements (Kristiyasari and Sukoco, 2022; Sugianto et al., 2019a). On the other hand, no one has yet undertaken an in-depth examination of the mathematical concepts and philosophical values embedded in the gamelan device reyog Ponorogo. Indeed, if this is accomplished, mathematics educators will have an opportunity to investigate and use it as a context for mathematics learning. As such, this study aims to conduct an exhaustive examination of mathematical concepts found in gamelan reyog Ponorogo that can serve as a springboard for learning mathematics.

METHODS

This research employs a qualitative approach. The purpose of this research method is to decipher gamelan reyog Ponorogo ethnomathematics. The design of this research adheres to the framework of Alangui (2010) ethnomathematics study to conduct a qualitative method using Ethnomathematics in gamelan reyog Ponorogo. Table 1 summarizes the framework.

Table 1. Design of Ethnography Research (Alangui, 2010)

General Questions	Initial Answers	Starting Point	Specific Activity
Where to start looking?	In performing, reyog Ponorogo was carried out by the people of Ponorogo where gamelan was used in this performance, and there are mathematical practices in it.	Culture	Conducting interviews with people who know gamelan reyog Ponorogo
How to look?	We investigate the QRS (Quantitative, Relational, Spatial) aspects of gamelan reyog Ponorogo related to mathematics practice.	Alternative thinking and knowledge system	Determine what QRS ideas are contained in gamelan reyog Ponorogo related to mathematics practice
What is it?	Evidence (Results of alternative thinking in the previous process)	Philosophy of mathematics	We are identifying QRS characteristics in gamelan reyog Ponorogo related to mathematics practice. It shows that the gamelan reyog Ponorogo does have a mathematical character seen from the elements of knowledge and art systems used in everyday life.
What does it mean?	Valued important for culture and important value patterns for mathematics	Anthropologist	Describe the relationship between the two systems of mathematical knowledge and culture. Describe mathematical conceptions that exist in the gamelan reyog Ponorogo

The data for this study were gathered through field observation, a review of the literature, documentation, and an interview with Mr. Soemarto to investigate and clarify the cultural values prevalent in Reyog Ponorogo. Mr. Soemarto a.k.a Mbah Marto is an elder of Ponorogo, and a retired teacher. The works of Mbah Marto are often used as a reference in book writing, research, articles, and searches history of Ponorogo (Read: "Ponorogo dari Waktu ke Waktu (Soemarto, 2008), Melihat Ponorogo Lebih Dekat (Soemarto, 2011), dan Menelusuri Perjalanan Reyog Ponorogo (Soemarto, 2014)). He was active as a writer in the Javanese magazine "Pensebar Spirit" about social, cultural and literary matters (1988-2013). He was purposefully chosen to elicit additional information about his experiences. Semi-structured interviews were used to conduct the interviews. The data collection results were analyzed using the source triangulation technique to thoroughly investigate the relationship between the mathematical knowledge system and the reyog Ponorogo culture and observe the mathematical conceptions in the reyog Ponorogo performing. Finally, the findings are summarized in this study's results.

RESULTS AND DISCUSSIONS

Javanese people have deep-seated values that have stood the test of time, and they may be used as an option in character development education. Many parts of life can be covered by the principles, including the notion of God, self-esteem, life, neighborhood, leadership, responsibility, family, knowledge, clothing, thankfulness, and so on. Students should be exposed to Javanese philosophy through a variety of activities in order to internalize and apply the principles ingrained in the culture (Sawitri et al., 2020; Zaid, 2016). Reyog Ponorogo art is imbued with various values and messages: educational, philosophical, and religious. For instance, the educational message conveyed by the role of jathil is in the form of advice intended to instill in the people of Ponorogo a knightly spirit (honest, courageous, and responsible). This message is conveyed through his nimble dance movements (trengginas), which are brimming with vitality and devolve into the life attitude of a Janaka (knight figure in a puppet story). His philosophical message is conveyed throughout the art of reyog Ponorogo, both through material devices such as his companion gamelan and non-material devices such as jathil dance movements that embody the philosophy of approaching life optimistically. At the same time, the religious message is evident in konco reyog's total surrender, most notably during the ritual preceding the stage (Kurnianto, 2015; Wijayanto and Kurnianto, 2018).

Each instrument and device in reyog Ponorogo carries profound meaning. For instance, reyog's form is a satire, implying that the king (represented by the tiger's head) was influenced or motivated by his empress (represented by a peacock head above the tiger's head). Additionally, the 17 reyog devices serve as a reminder of the number of

obligatory prayers performed each day, namely 17 rakaat. Table 2 lists the instruments used in reyog Ponorogo.

Tabel 2. Instruments of Reyog Ponorogo (Wijayanto and Kurnianto, 2018)

No	Instruments	Amount (unit)
1	<i>Barongan</i>	One unit
2	<i>Klonosewandono's mask</i>	One unit
3	<i>Bujang Ganong's mask</i>	One unit
4	<i>Patra Jaya's mask dan Patra Tholo's mask</i>	Two units
5	<i>Eblek (Jaranan)</i>	Two units
6	<i>Kendang</i>	One unit
7	<i>Ketipung</i>	One unit
8	<i>Terompet</i>	One unit
9	<i>Kempul</i>	One unit
10	<i>Kethuk Kenong</i>	Two units
11	<i>Angklung</i>	Four units
Total		Seventeen units

1. Exploration of Ethnomatematics on Gamelan Reyog Ponorogo

The letters that make up the word gamelan contain a philosophy of meaning: G (gusti or God), A (Allah), M (maringi, give), E (emut, remember), L (lakononno, run), A (ajaran, teachings), N (Nabi, prophet). The word gamelan carries a connotation that gusti Allah uses to remind us to live according to the prophet's teachings. Additionally, the sounds produced by gong, kenong, and bonang have symbolic meanings: NENG (meNENG, silent), NING (weNING, contemplation), NUNG (ndhuNUNG, pray), NANG (meNANG, victory), and NONG (God) (Wijayanto and Kurnianto, 2018).

1. Values and Geometric Concepts of Gong

Gong means 'great' in the sense that God is great. Anything is possible with God's permission. These occurrences serve as a reminder of the magnificence of God's power (Wijayanto and Kurnianto, 2018). Figure 1 illustrates several geometrical concepts found on the gong).

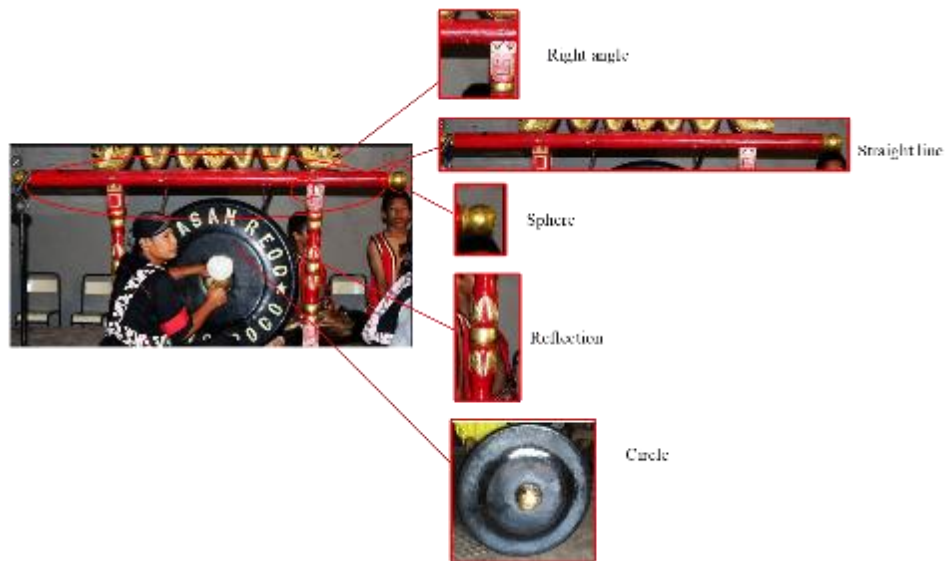


Figure 1. Geometrical Concepts on the Gong

2. Values and Geometric Concepts of Bonang

Bonang is derived from *babon* and *menang*, which means that 'true victory is achieved by conquering our lust, exercising self-control, refusing to be easily provoked, and being obedient to lusts'. It is because the winner is a person who can control his or her passions. *Bonang* is divided into two types for use in gamelan devices: *bonang panembung* and *bonang panerus*. *Panembung*, which means to inquire, indicates that we should direct our desires/inquiries solely to God. Only ask of Him. Make no other request than to Allah. Never make an association with God. Finally, *Panerus* means descendants, implying that our descendants must carry on the Islamic teachings and da'wah (Wijayanto and Kurnianto, 2018). Figure 2 illustrates several geometrical concepts found in *bonang*.

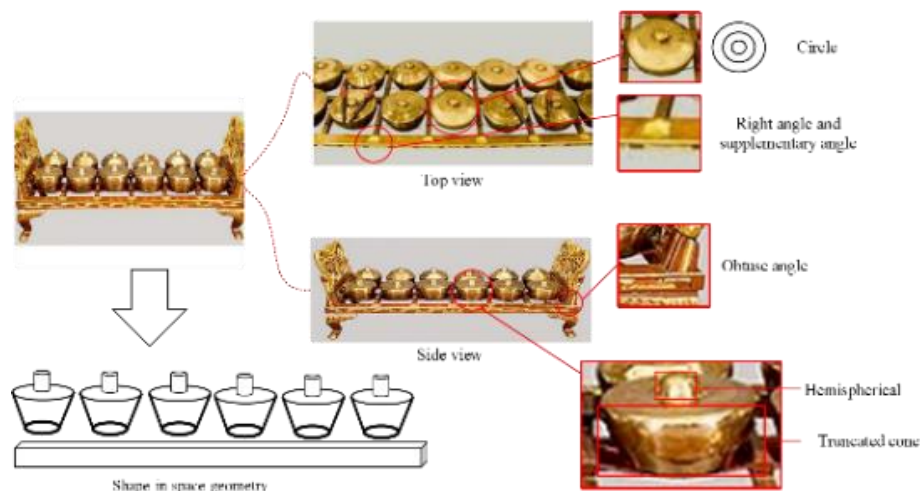


Figure 2. Geometrical Concepts on the *Bonang*

3. Values and Geometric Concepts of Saron

Saron translates as 'fun or loud'. Therefore, *Saron* implies that all efforts in Islamic education must be accompanied by diligence and abstinence (Wijayanto and Kurnianto, 2018). Figure 3 illustrates several geometrical concepts found in *saron*. Culture inheritance not only have a beautiful pattern such as geometrical pattern, yet containing philosophy, full of deep meaning and there are prayer and hope inside (Maryati and Prahmana, 2019; Prahmana and D'Ambrosio, 2020; Risdiyanti and Prahmana, 2018).



Figure 3. Geometrical Concepts on the *Saron*

4. Values and Geometric Concepts of Gambang

Gambang is an abbreviation for *gamblang*, which means 'clear'. *Gambang* implies that the da'wah delivered must be precise, with the intention and message conveyed very plainly and understandably. This meaning is intended to avert potential misunderstandings regarding its acceptance (Wijayanto and Kurnianto, 2018). Figure 4 illustrates several geometrical concepts found on the *gambang*.

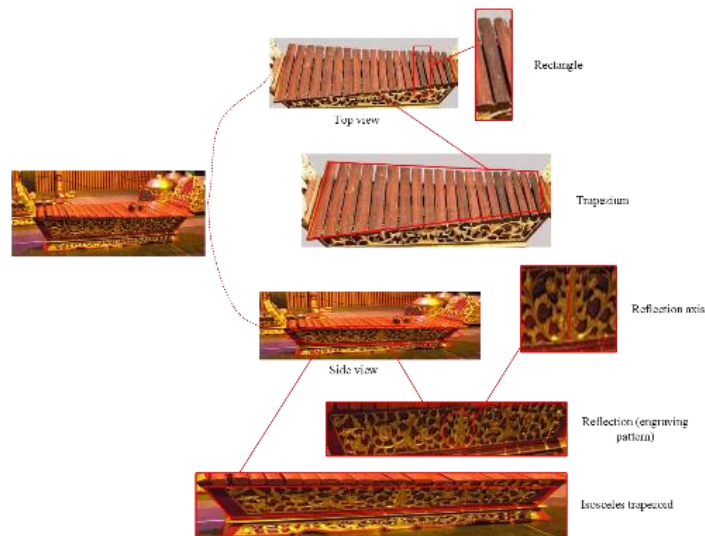


Figure 4. Geometrical Concepts on the *Gambang*

5. Values and Geometric Concepts of *Kethuk Kenong*

Kethuk is derived from the Arabic word '*khatha*', which means 'wrong' (Munawwir, 1973); humans must fully comprehend that they must sin regardless of how good a person is. Thus, the best human is not an innocent person because that is impossible; instead, a good human being makes errors/sins and immediately repents to God (Kurnianto, 2015).

Kenong is derived from the Arabic word '*qana'a*', which means 'satisfied with one's contribution'(Munawwir, 1973); this means that individuals must strive for the best possible quality of life. Simultaneously, the human must be fully aware that every effort will result in the certainty of God's will. As a result, humans must accept sincerity and patience whatever outcome God determines (Kurnianto, 2015). *Kethuk* on gamelan sounds '*NING*', which is derived from the Javanese language '*hening*' and means 'face the creator (God)' while *kenong* sounds '*NUNG*', which is derived from the Javanese language '*dunung*' and means 'understand the meaning and purpose of life' (Wijayanto and Kurnianto, 2018). Figure 5 illustrates several geometrical concepts found in *kethuk* and *kenong*.

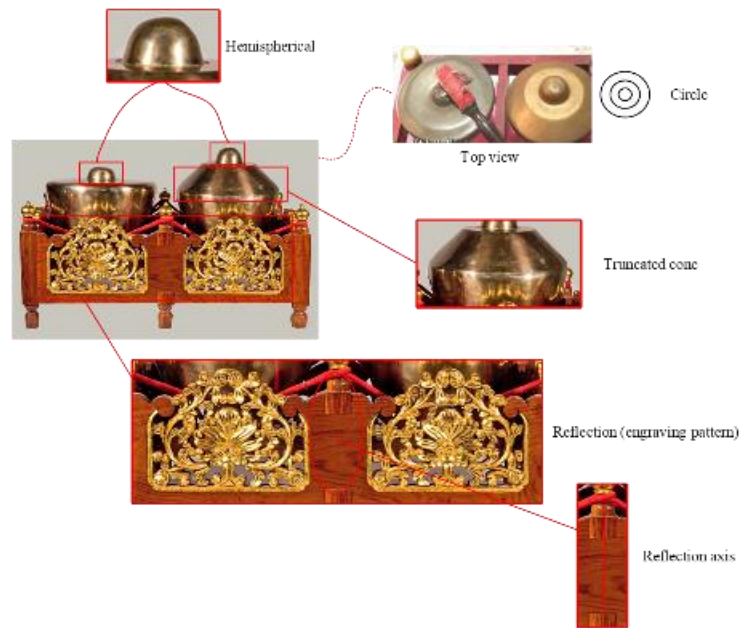


Figure 5. Geometrical Concepts on the Kethuk and *Kenong*

6. Values and Geometric Concepts of *Kendhang*

Kendang is derived from the Arabic word '*qada'a*', which means 'to control' (Munawwir, 1973); this means that a person must be adept at controlling his or her passions to avoid committing heinous acts, violating religious rules/norms, or harming others (Kurnianto, 2015). Additionally, *kendhang* derives from *kendhali* and *padhang*, which means that desire must be restrained with a pure mind and heart. Each of us desires to do so with a clear mind and a positive attitude. They are balanced with a pure heart to bring good people (Wijayanto and Kurnianto, 2018).

Kendang is used to regulate the dance and its accompaniment by indicating when to begin and when to stop. The implication is that in life, one must exercise control over one's actions. *Kendang* sounds '*ndang ndang ndang*' in Javanese and means 'fast'. The function and meaning of *kendang* serve as a reminder to all of us to always move quickly. The world is constantly changing; never miss an opportunity in the face of a continually changing life, and always remember to end with control. The point is that the advice *pepeling* reminds us to always be quick in our actions and work and do so with restraint (Wijayanto and Kurnianto, 2018). Figure 6 illustrates several geometrical concepts found on the *kendang*.

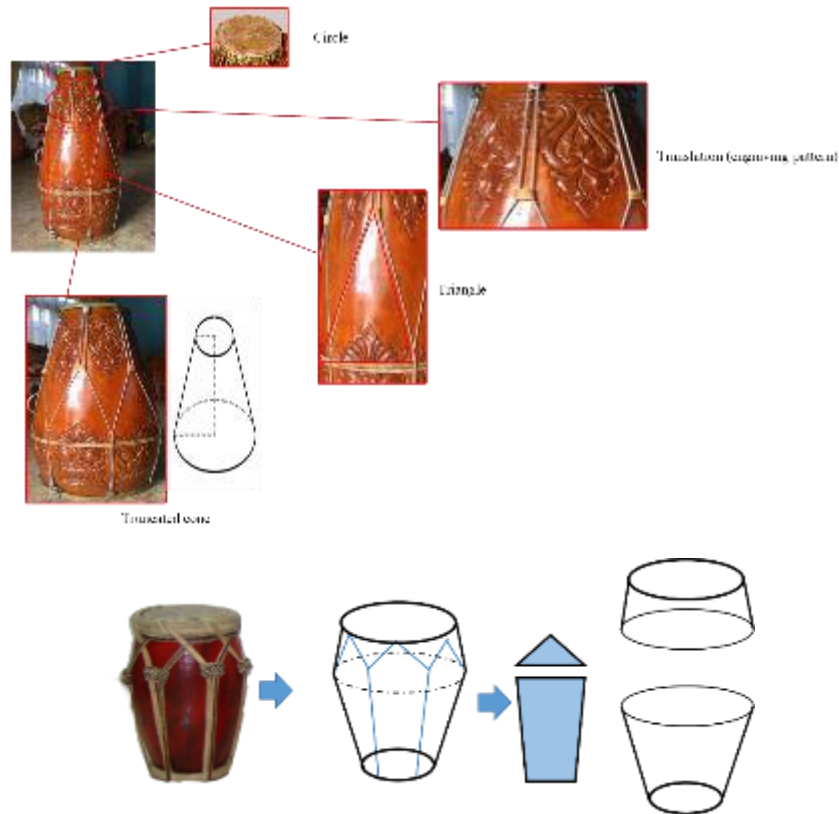


Figure 6. Geometrical Concepts on the *Kendang*

7. Values and Geometric Concepts of Angklung

Angklung is derived from the Arabic word '*intiqa*', which means 'to move' (Munawwir, 1973); this means that people must constantly emigrate or move away from ugliness/evil (violating rules, norms, and obedience) to pursue excellent or praiseworthy endeavors (Kurnianto, 2015).

Angklung has the pronunciation '*KLUNG*', which means *pasrah* (surrender). His philosophy is to submit to the master/teacher when studying (*pasrah* is understood to be obedient). Sincerity will facilitate learning from the teacher (Wijayanto and Kurnianto, 2018). Figure 7 illustrates several geometrical concepts found in *angklung*.

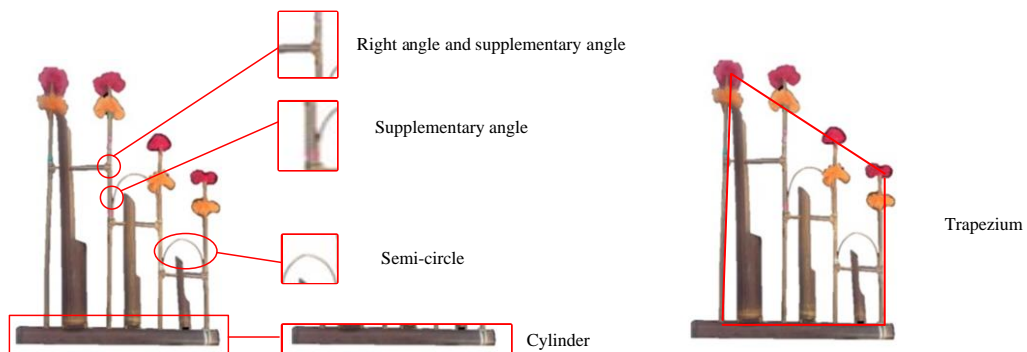


Figure 7. Geometrical Concepts on the *Angklung*

8. Values and Geometric Concepts of Ketipung

Ketipung is derived from the Arabic word '*katifun*', which means 'reply' (Munawwir, 1973); this means that humans must exercise caution in all their actions, as everything must be accounted for to His Lord and will be rewarded appropriately in the hereafter's trials. As a result, it must be pursued to ensure that all of his actions are good and consistent with religious guidance (Kurnianto, 2015).

The meaning of *ketipung* begins with the sound he makes, namely '*pung-pung-pung*', which Javanese means *aji mumpung*, or opportunity. It means that we have been given a chance to live; this opportunity must be fully utilized (Wijayanto and Kurnianto, 2018). Some geometrical concepts found in *ketipung* are shown as shown in Figure 8.



Figure 8. Geometrical Concepts on the *Ketipung*

9. Values and Geometric Concepts of Terompet

Terompet is derived from the Arabic word '*shuwarun*', which means 'depiction' (Munawwir, 1973); this means that a human being must always be aware that his life is a journey toward death. That journey will become increasingly closer to the end as his age diminishes. Thus, human beings must make sufficient provisions to ensure that when they are called to account for their deeds before God, they receive goodness and reward from their Lord in the form of the pleasures of His paradise (Kurnianto, 2015). In Javanese, the *terompet* sounds '*tret-tret-tret*' means 'last'; this means that, in essence, every human being has a destination, which is death. Therefore, individuals must remember to die and abstain from sin (Wijayanto and Kurnianto, 2018). Figure 9 illustrates some geometrical concepts found on *terompet*.

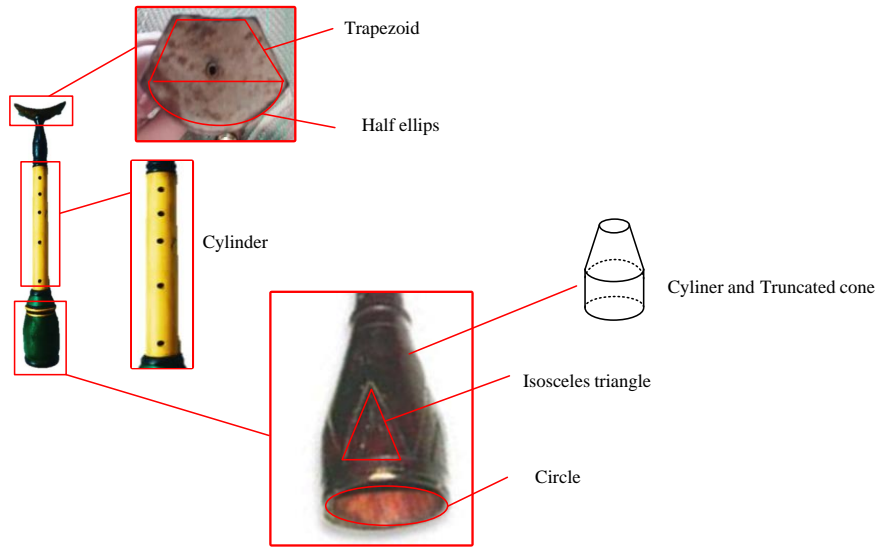


Figure 9. Geometrical Concepts on the *Terompet*

10. Values and Geometric Concepts of Kempul

Kempul is derived from the Arabic word '*kafulun*', which means 'reply' (Munawwir, 1973). Thus, each evil deed will be met with an equal measure of evil. Similarly, every good deed will be rewarded with happiness (Kurnianto, 2015). Figure 10 illustrates several geometrical concepts found in the *kempul*.

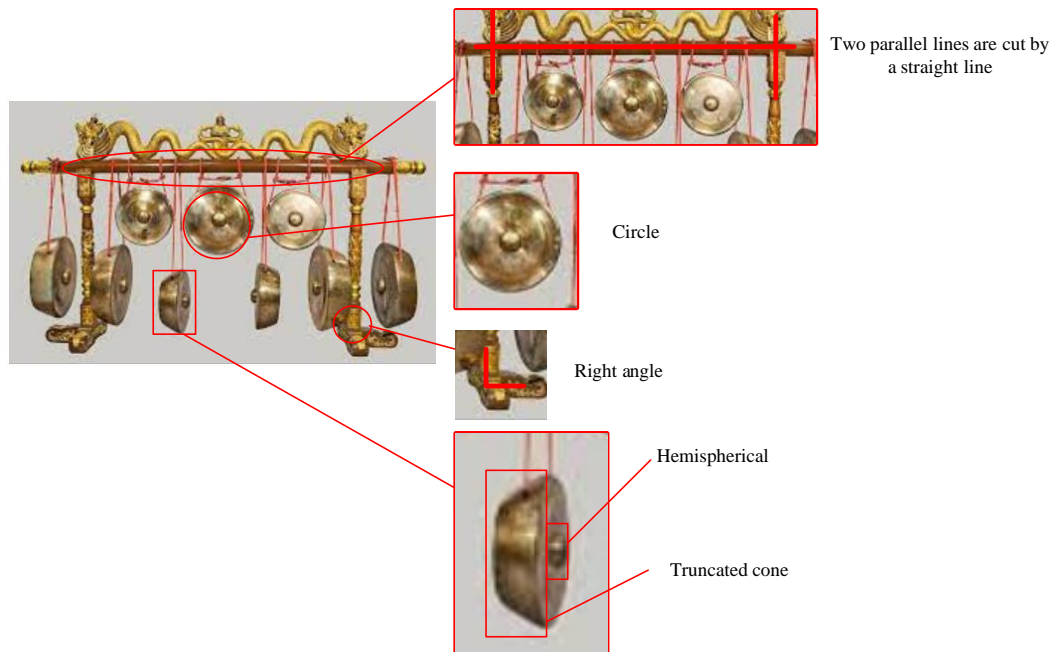


Figure 10. Geometrical Concepts on the *Kempul*

Based on the results of the gamelan reyog Ponorogo, it was found that the instrument of the gamelan reyog Ponorogo had ethnomathematics aspects. The

geometrical concepts associated with the gamelan reyog Ponorogo are field geometry, spatial geometry, transformation geometry, and angular concept. Table 3 lists the local value and geometrical aspect of instruments used in gamelan reyog Ponorogo.

Tabel 3. Exploration Results of Ethnomathematics Aspects

Instrument	Local Value	Geometrical Aspect			
		Field Geometry	Spatial Geometry	Transformati on Geometry	Angular
<i>Gong</i>	Recognition of God's greatness	✓	✓	✓	✓
<i>Bonang</i>	Self-controlling	✓	✓	NA	✓
<i>Saron</i>	Perseverance and unyielding	✓	NA	✓	NA
<i>Gambang</i>	The clarity in the delivery of information	✓	NA	✓	NA
<i>Kethuk</i>	Self-introspection	✓	✓	✓	NA
<i>Kenong</i>					
<i>Kendang</i>	Lust-controlling	✓	✓	✓	NA
<i>Angklung</i>	Self-improvement and submission to God	✓	✓	NA	✓
<i>Ketipung</i>	Accountability	✓	✓	NA	NA
<i>Terompet</i>	Self-awareness	✓	✓	NA	NA
<i>Kempul</i>	Consequences of action	✓	✓	NA	✓

Indonesia has a conundrum of Javanese cultural legacy in every part of life in the era of globalization, and in some circumstances, the values do not coincide with Western concepts of successful management (Irawanto et al., 2011). Furthermore, a more diverse application of ethnomathematics studies is required for instructors in the future to improve the teaching and learning process of mathematics (Maryati and Prahmana, 2018). In the future, instructors will need to use ethnomathematics studies in a more diversified way in order to improve the teaching and learning process of mathematics (Hidayati and Prahmana, 2022).

CONCLUSION

The musical instrument is called a gamelan used as a musical instrument of reyog Ponorogo dance accompaniment, but it also has a deep philosophical significance for human life. Additionally, ethnomathematics aspects were discovered on gamelan devices. The gamelan contains ethnomathematics such as field geometry, spatial geometry, transformation geometry, and angular concepts. Furthermore, certain geometrical concepts found in the gamelan instruments can substitute for mathematics education by teachers when developing culturally based teaching materials. Therefore, it can be

concluded that the gamelan reyog ponorogo is full of geometry concepts and the value of life

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Author Contribution : Author 1: Conceptualization, Writing - Original Draft, and Methodology; Author 2: Writing - Review & Editing and Formal analysis; Author 3: Writing - Review & Editing Validation and Supervision ; Author 4: Validation and Supervision; Author 5: Validation and Supervision; Author 6: Validation and Supervision; Author 7: Validation and Supervision (<https://www.elsevier.com/authors/policies-and-guidelines/credit-author-statement>)

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