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Revealing the traditional music of Gamelan: A mathematical content for elementary students

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Abstract

Gamelan, a traditional Indonesian musical ensemble, presents an intriguing avenue for integrating mathematical concepts into elementary school curricula. This study employs an ethnomathematics approach to unveil the inherent mathematical principles embedded within Gamelan compositions, aligning them with elementary mathematical content. Through participant observation, interviews with practitioners, and document analysis, the research elucidates Gamelan's potential to facilitate learning across various mathematical domains. Findings indicate that Gamelan can effectively convey geometric concepts such as squares, rectangles, circles, spheres, trapezoids, cylinders, and cones, as well as principles of measurement utilizing standard units and numerical operations through tangible, experiential methods.

Keywords: ethnomathematics, gamelan, geometry, measurement, numbers, traditional music

Introduction

Indonesia is rich in cultural wealth, encompassing ideas, norms, regulations, and intellectual traditions; the patterned behavioral activities of humans in society; and tangible human creations (Koentjaraningrat, 2015). Despite their varied forms, a clearer understanding of culture can be achieved through the examination of cultural artifacts (Fiske, 2010).

Mathematics education in elementary schools plays a crucial role in developing students' understanding of mathematical concepts and enhancing their logical thinking skills (English & Halford, 1995; Kinard & Kozulin, 2008). However, traditional learning approaches often fall short of achieving these objectives comprehensively (Grabinger & Dunlap, 2011). Integrating traditional arts, such as gamelan, into mathematics education offers a promising alternative to improve the quality of learning. *Gamelan*, which includes various traditional musical

instruments such as gender, kendhang, gong, and saron, has been present in Java since 404 AD, as evidenced by the reliefs of Prambanan and Borobudur Temples (Santosa et al., 2022). Javanese *Gamelan*, known for its gentle rhythms, is typically used to accompany puppet and dance performances (Nugroho, 2019; Anggraini et al., 2021).

Gamelan also serves an educational function, extending beyond its musical performance role to become an effective teaching tool in both cultural arts and extracurricular activities. In the context of education, traditional *Gamelan* music can be utilized as a medium for enhancing children's learning experiences. For instance, gamelan artifacts can be integrated into elementary and secondary mathematics curricula. Research has identified mathematical elements within *Gamelan*, such as planar and spatial geometries, including squares, rectangles, circles, trapezoids, spheres, cylinders, and truncated cones (Sumantri & Sari, 2022). Additionally, *Gamelan* artifacts can enrich the teaching of sets and numbers through their diverse types, shapes, and sizes (Oktaviyani et al., 2023). Further research is necessary to uncover the full extent of *Gamelan*'s mathematical value and its potential applications in elementary school mathematics education. This article will explore the mathematical value of *Gamelan*, particularly its role in enhancing elementary school mathematics learning.

Methods

This study employs a qualitative approach to explore ethnomathematics within *Gamelan*, aiming to provide meaningful learning materials for understanding related mathematical concepts. The research design is based on the framework of an ethnomathematics study as outlined by Alangui (Alangui, 2010; Prahmana & D'Ambrosio, 2020; Utami et al., 2019), as depicted in Figure 1. This framework facilitates a qualitative investigation into the ethnomathematical aspects of number and measurement within *Gamelan*.

The exploration was conducted through observation and interviews with local experts (Alangui, 2010; Chinn, 2014; Utami et al., 2021; Vinlove, 2016). We interviewed two individuals deeply knowledgeable about *Gamelan*. The first expert, Mr. Triyadi, is 68 years old and serves as a *Gamelan* player at the Sonobudoyo Museum in Yogyakarta and a *Gamelan* trainer at UKM Karawitan at Ahmad Dahlan University in Yogyakarta. He possesses a complete set of *Gamelan* instruments at his home in Tamanan, Banguntapan, Bantul, where he frequently plays *Gamelan* with his students. The second expert, Mr. Santoso, is 52 years old and works as an extracurricular *Gamelan* coach at Bakulan Elementary School and Patalan Baru Elementary School. Besides being a *Gamelan* trainer, Mr. Santoso also crafts and repairs *Gamelan* instruments. During the interviews, we recorded our findings using field notes and a tape recorder. We also conducted observations to study the form and structure of the *Gamelan* instruments.

Our observations were conducted at Bakulan Elementary School and Patalan Baru Elementary School, both of which offer *Karawitan* extracurricular activities using *Gamelan* instruments. At Bakulan Elementary School, music extracurriculars are held every Friday at 13:00, and additional *Karawitan* sessions for the residents of Bakulan Wetan village are

conducted every Saturday at 08:00. At Patalan Baru Elementary School, the Karawitan extracurricular activity takes place every Wednesday at 14:00. Besides these two schools, we also observed at the Sonobudoyo Museum in Yogyakarta and Mr. Triyadi's house. Both locations have complete sets of *Gamelan* instruments. Mr. Triyadi's *Gamelan* is frequently used for performances with Ahmad Dahlan University students at various venues.

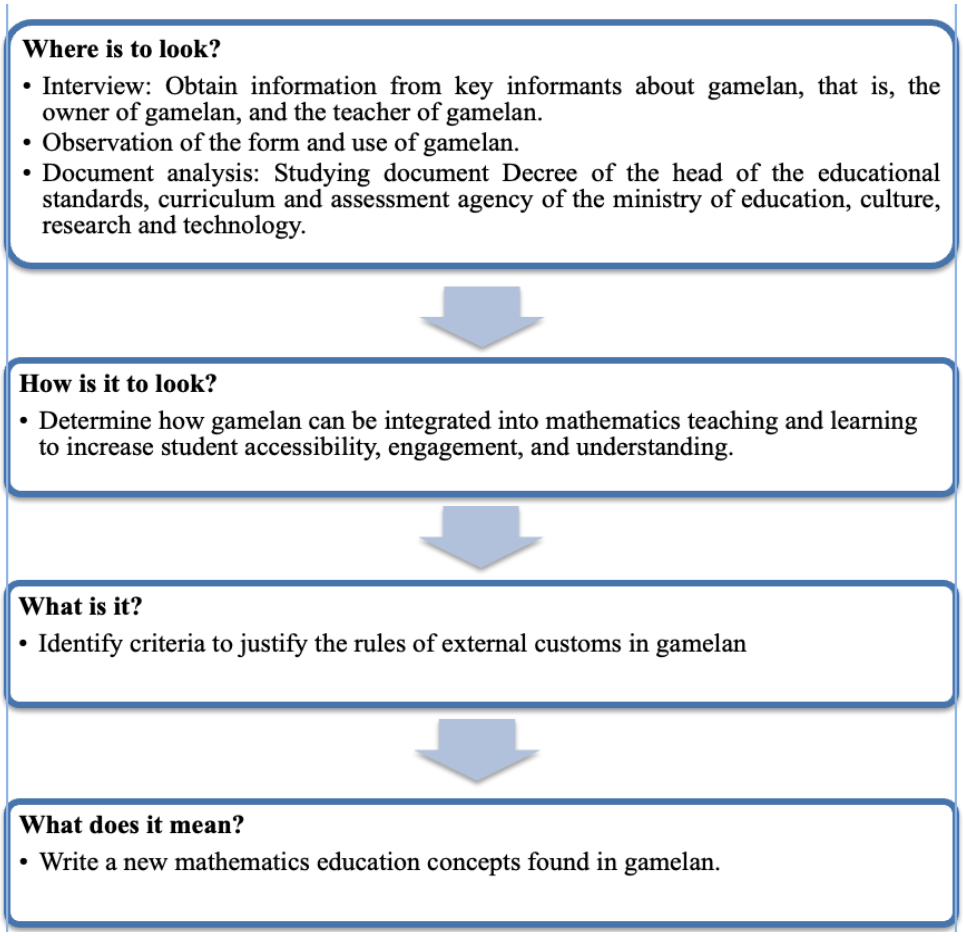

Figure 1. Research Procedure to Reveal Ethnomathematics on *Gamelan*

We also analyzed documents related to mathematics learning materials related to *Gamelan*. Document analysis involves activities such as skimming, reading, and interpretation (Bowen, 2009). The documents we reviewed include books on *Gamelan* and the Decree of the Head of the Educational Standards, Curriculum, and Assessment Agency of the Ministry of Education, Culture, Research, and Technology (number 008/H/KR/2022), which pertains to learning outcomes for early childhood, basic, and secondary education levels under the Merdeka curriculum. These documents were analyzed as supplementary data for this study. From these documents, we identified several elements of mathematics lessons: numbers, algebra, measurement, geometry, data analysis and probability, and calculus. In elementary school, the focus is typically on learning about numbers, algebra, measurement, geometry, data analysis, and probability.

Results and Discussion

Gamelan is an ensemble of traditional musical instruments from Indonesia that are played together. These instruments include gongs, kendhang, saron, bonang, and various others. The arrangement of *Gamelan* instruments can vary significantly. According to Mr. Santoso, "the arrangement of *Gamelan* instruments can differ based on regional customs, the specific composition of instruments being used, or the preferences of the *Gamelan* leader or puppeteer" (Mr. Santoso, November 2024). Typically, *Gamelan* instruments are organized by groups or types. A visual representation of *Gamelan* can be found in Figure 2.

Figure 2. *Gamelan* Artefact

The Parts of the *Gamelan* Instruments

Gamelan consists of various forms of musical instruments, as detailed in the interviews with *Gamelan* experts.

> *"In 1 set of Gamelan, there are Kendhang, Gendher, Slenthem, Saron, Demung, Gong, Kempul, Gambang, Bonang, Kenong. The ensemble doesn't need to be complete when playing Gamelan, but the music typically sounds more beautiful when all instruments are present"* (Mr. Triyadi, October 1, 2023).

Kendhang

Playing the *kendhang* involves striking the instrument either with a special stick or with the player's hands. The membrane that is struck is made of cowhide. *Kendhangs* are played by carefully considering the tempo, tone, and specific instrument. Based on their size, *kendhangs* are categorized into three types: large-sized *kendhang*, medium-sized *kendhang*, and small-sized *kendhang*. This information is based on interviews with *Gamelan* experts.

> *"Kendhang has 3 varieties of sizes, i.e., large, medium, and small. The way to play kendhang is to hit the membrane using the palm"* (Mr. Triyadi, October 1, 2023).

To play the *kendhang*, use the palm of your hand or a *kendhang* stick to strike the membrane of the instrument. A visual representation of the *kendhang* can be seen in Figure 3.

Figure 3. *Kendhang*

Saron

Saron are generally made of metal, with silver or copper often used for the main parts, while the base is usually made of wood. The *saron* has a rectangular shape and features metal blades arranged horizontally above the resonator. These blades determine the notes produced by the instrument, with each bar representing a particular note. Under each metal blade, there is a resonance box that amplifies the sound. To play the *saron*, players use a "*tabuh*" (mallet) to strike the metal blade with their right hand and hold the previously struck blade with their left hand to eliminate the residual buzzing sound. A visual representation of the *saron* can be seen in Figure 4.

Figure 4. *Saron*

Demung

In terms of shape, the *demung* is very similar to the *saron*. The primary difference is that the *demung* is larger than the *saron*. The playing technique is the same as that of the *saron*, but the *Tabuh* (mallet) used for the *Demung* is larger than the one used for the *saron*. Despite its large size, the *Demung* produces the lowest tones compared to other *balungan* musical instruments. A visual representation of the *Demung* can be seen in Figure 5

Figure 5. *Demung*

Bonang

The *Bonang* is made of metal and shaped like a series of small kettles arranged according to the order of the notes. It is played by striking the kettles with a mallet made of wood, with the end wrapped in cloth. The cloth wrapping helps control the sound, making it more pleasant. A visual representation of the *Bonang* can be seen in Figure 6.

Figure 6. *Bonang*

Bonang players usually sit in the middle of the *Bonangs*, holding a mallet in each hand. They can play the *Bonang* in several ways: by striking two notes simultaneously, hitting the notes one by one, or playing two different types of *Bonang* together.

Kenong

The *Kenong* is flat but wide, arranged in a hardwood box with a rope backing, known as a *Pangkon*. When played, the *Kenong* sways up and down due to its string base. To play the *Kenong*, you strike it with a wooden mallet covered in cloth. A visual representation of the *Kenong* can be seen in Figure 7.

Figure 7. *Kenong*

Gong

The *Gong* is tube-shaped with a hole on one side and is the largest of the *Gamelan* instruments. It is played by striking it with a wooden mallet covered in thick cloth. A visual representation of the *Gong* can be seen in Figure 8.

Figure 8. *Gong*

Kempul

The *Kempul* is similar in shape to a *Gong* but smaller in size. Like the *gong*, it is hung using a rope and is often placed close to the *Gong*. To play the *Kempul*, it is struck on the convex part with a mallet whose tip is covered with thick cloth. A visual representation of the *Kempul* can be seen in Figure 9.

Figure 9. *Kempul*

Gambang

The *Gambang* shares a similar shape with the *Saron* and *Demung*, but its blades are made of wood or bamboo. It produces a unique and distinctive sound. The *Gambang* typically has 18 wooden blades arranged sequentially from shortest to longest. To play the *Gambang*, the bamboo blades are struck with a special stick called a percussion mallet. After striking a blade, it must be immediately held to prevent any lingering disruptive sounds. A visual representation of the *Gambang* can be seen in Figure 10.

Figure 10. *Gambang*

Slenthem

The *Slenthem* is made of thin metal sheets strung with string. It is played by striking the blades. After being struck with the right hand, the left hand must immediately touch the blade to prevent any buzzing sound. The *Slenthem* typically has 7 blades. A visual representation of the *Slenthem* can be seen in Figure 11.

Figure 11. *Slenthem*

Gender

The *Gender* consists of 10 to 14 metal blades made from brass. A complete *Gamelan* set typically includes three genders. To play the *Gender*, the blades are struck with a wooden mallet covered with cloth at the end. A visual representation of the *Gender* can be seen in Figure 12.

Figure 12. *Gender*

Gamelan in Mathematics Learning in Elementary School

To preserve traditional musical instruments as cultural heritage, *Gamelan* can be introduced to students. This approach not only fosters familiarity with traditional music but also integrates

Gamelan into mathematics learning. Students can explore various mathematical concepts through *Gamelan*, such as calculating volumes and surface areas of architectural spaces, measuring with standard units, and practicing arithmetic with concrete objects. Table 1 details the mathematical elements associated with *Gamelan* instruments based on the independent curriculum.

Table 1. Mathematics Content on *Gamelan*

Gamelan	Mathematical elements of the independent curriculum
 *Bonang*	The mathematical elements found in this gamelan *bonang* are measurement of the area of a flat shape, and geometry of three-dimensional shapes.
 *Demung*	The mathematical elements found in this gamelan *demung* are measurement of the area of a flat shape, and geometry of three-dimensional shapes.
 *Gambang*	The mathematical elements found in this *gambang* are measurement of the area of a flat shape, and geometry of three-dimensional shapes.
 *Gender*	Mathematical elements found in *gender* are measurement of the area of a flat shape, and geometry of three-dimensional shapes.

Gong

The mathematical elements found in *gong* are measurement of the area of a flat shape, and geometry of three-dimensional shapes.

Kendhang

The mathematical elements found in *kendhang* are measurement of the area of a flat shape, and geometry of three-dimensional shapes.

Slenthem

The mathematical elements found in *slenthem* are measurement of the area of a flat shape, and geometry of three-dimensional shapes.

Kenong

The mathematical elements found in *kenong* are measurement of the area of a flat shape, and geometry of three-dimensional shapes.

Gong hitter

The mathematical elements found in gong hitter are measurement of the area of a flat shape, and geometry of three-dimensional shapes.

Gender hitter

The mathematical elements found in gender hitter are measurement of the area of a flat shape, and geometry of three-dimensional shapes.

Tabuh (*saron* hitter)

The mathematical elements found in *tabuh* are measurement of the area of a flat shape, and geometry of three-dimensional shapes.

The mathematical aspects of *Gamelan* within elementary school mathematics education, according to the independent curriculum, are broadly classified into two categories: measuring the area of plane shapes and understanding the geometry of three-dimensional shapes.

Mathematical Ideas on the Gamelan Context: Measurement of the Area of a Flat Shape

The *Kendhang* is a traditional musical instrument shaped like a long, cylindrical piece of wood with a hollow interior, often covered on one or both ends with animal skin. To play the *Kendhang*, one strikes the skin covering the hollow cavity with hands or specialized mallets. A crucial part of the *Kendhang* is the "*Janget*," a rope typically made from rattan or leather, which secures and stabilizes the instrument's two sides illustrated in Figure 13.

Figure 13. *Kendhangs*

Mr. Triyadi is a *gamelan* player. Mr. Triyadi wanted to repair the *janget* (string) of his three drums which were starting to break. The three drums have different sizes. The smallest drums have diameters of 21 and 28 cm. A medium-sized drum has a diameter 2 times the diameter of the smallest drum. The largest drum has a diameter 1.5 times the diameter of a medium-sized drum. Calculate how long the strings needed by Mr. Triyadi to repair his three drums!

To find the answer, the formula used is the circle circumference formula.

$$K = \pi \times d$$

With

K = circle circumference

$\pi = \frac{22}{7}$

d = circle diameter

Hence,

$$K \text{ small kendhang} = (\pi \times d_1) + (\pi \times d_2)$$
$$= (\tfrac{22}{7} \times 21) + (\tfrac{22}{7} \times 28)$$
$$= 66 + 88$$
$$= 154$$

So, the circumference of the small *kendhang* is 154 cm.

$$K \text{ medium kendhang} = (\pi \times d_1) + (\pi \times d_2)$$
$$= (\tfrac{22}{7} \times 42) + (\tfrac{22}{7} \times 56)$$
$$= 132 + 176$$
$$= 308$$

So, the circumference of the medium *kendhang* is 308 cm.

$$K \text{ big kendhang} = (\pi \times d_1) + (\pi \times d_2)$$

$$= (\tfrac{22}{7} \times 63) + (\tfrac{22}{7} \times 84)$$
$$= 198 + 264$$
$$= 462$$

So, the circumference of the big *kendhang* is 462 cm.

So the length of the rope that Mr. Triyadi needs is

= Circumference the small kendhang + Circumference the medium kendhang + Circumference the big kendhang

= 154 cm + 308 cm + 462 cm

= **924 cm**

Mathematical Ideas on the Gamelan Context: Geometry of Three-Dimensional Shapes

Gender musical instruments have resonator tubes located under the metal blades as shown in Figure 14. The function of this resonator tube is as a sound amplifier. Explain the characteristics of the resonator tube on the *Gender* musical instrument!

Figure 14. *Gender*

Answer :
The resonator tube in this gender is in the form of a tube. The characteristics of a tube structure are:

1. It has 3 sides, i.e., 1 curved side which is square/rectangular, and 2 circular sides as the base and lid.
2. The volume of the cylinder can be calculated using the formula
$$V = \pi r^2 h$$
where r is the radius of the base circle and h is the height of the cylinder.
3. Surface Area: The surface area of the tube can be calculated with the formula
$$L = 2\pi r(r + h)$$
where r is the radius of the base circle and h is the height of the tube.

Conclusion

Within the framework of elementary school mathematics education aligned with the independent curriculum, *Gamelan* musical instruments offer valuable opportunities to enhance students' learning in two core mathematical domains: measurement and geometry. In the realm of geometry, students can actively classify different types of plane figures and discern various spatial shapes. This hands-on approach allows them to engage deeply with geometric concepts such as identifying polygons, circles, and three-dimensional figures like cubes, spheres, and pyramids. By integrating gamelan into geometry lessons, educators can foster a deeper understanding of spatial relationships and geometric properties, thereby enriching students' mathematical reasoning and problem-solving skills.

Moreover, *Gamelan* instruments provide a practical context for teaching measurement concepts. Students can apply mathematical formulas to calculate surface areas, perimeters, and volumes, leveraging their understanding through concrete examples found in the shapes and dimensions of *Gamelan* components. This application-oriented learning not only reinforces mathematical principles but also encourages students to develop proficiency in measurement techniques using standard units. By exploring *Gamelan*'s mathematical dimensions, educators can create engaging learning experiences that connect theoretical mathematical concepts with real-world applications, thereby enhancing students' mathematical literacy and appreciation for cultural artifacts.

Furthermore, integrating *Gamelan* into the mathematics curriculum supports broader educational goals of promoting cultural heritage and fostering interdisciplinary learning. By incorporating traditional musical instruments like *Gamelan*, educators can bridge cultural understanding with mathematical proficiency, encouraging students to appreciate the cultural significance of these instruments while simultaneously reinforcing mathematical concepts. This approach not only enriches students' educational experiences but also cultivates a holistic appreciation for cultural diversity and heritage within the context of mathematics education.

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Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been covered completely by the authors.

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