Mathematical Concepts Exploration of Gamelan Musical Instruments and Dance Movements in *Kuda Lumping Wanareja*

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Abstract

This research explored mathematical concepts of Gamelan musical instruments and dance movements in Kuda Lumping Wanareja. This research used a qualitative approach with an ethnographic design. Located of research at Cihandiwung Lor, Adimulya, Wanareja, Cilacap, Central Java. Data was collected through observation, interviews, and documentation. Data were analyzed through reduction, presentation, and verification of conclusions. The research results showed that Wanareja's Kuda Lumping gamelan musical instruments consisted of *kendang, demung, saron, calapita, kenong, bonang, kethuk, drum, gong*, and *kempul*. Based on the shape of gamelan musical instruments, mathematical concepts include numbers, measurement, and geometry. The *saron, demung, bonang*, and *kempul* contain the concept of natural numbers, while *kempul* shows the concept of quantity. The *kendang, demung, saron, calapita, kenong, bonang, kethuk, drum, gong*, and *kempul* show the concept of a rectangle, circle, trapezoid, and tube. The layout of gamelan musical instruments (especially *bonang*) involves a matrix concept. The Kuda Lumping dance consists of *ngatur sembah, pecak pedhang*, losing to the enemy, fighting against the enemy from the right, fighting against the enemy from the left, ending the battle, *mejang beksa*, and *janturan/mendem.* The mathematical concept related to dance movement patterns is geometric transformation (reflection, translation, and rotation). Several dance movements for praying, breaking the sword, losing to the enemy, fighting against the enemy, and ending the battle show reflection and translation. The *janturan* and *mejang beksa* dance movements show rotation. Concerning Gamelan musical instruments, there are *kethuk* and *saron* which show two-dimensional geometric concepts such as circles and trapezoids. The results of this research are applied as context in mathematical problems.

Keywords: dance; gamelan musical instruments; kuda lumping wanareja; mathematical concepts

INTRODUCTION

Kuda Lumping is one of the traditional Javanese arts. Kuda Lumping has a broad meaning from several aspects such as dance arts performances, visualization of costumes and props, and educational values (Hardiarini & Firdhani, 2022). One of the meanings of Kuda Lumping is related to heroism which displays various decorations such as soldiers riding horses and accompanied by Gamelan music and dancing (Sumanto, 2022). The horses used in the dance are not real horses, but horses made from woven bamboo or buffalo skin that have been dried and decorated so that they resemble real horses (Anggraini & Cahyono, 2018). The Kuda Lumping dance is very popular among Javanese people, especially in Central Java and its surroundings (Sunarto et al., 2019).

The Kuda Lumping will not move if there is no musical accompaniment, therefore the gamelan plays an important role in accompanying the Lumping horse dance. Javanese Gamelan is a traditional musical instrument currently known internationally as the ancestral cultural heritage of the Javanese people. Many Javanese people often use gamelan at various events or celebrations that they hold (Hananto, 2020). In this case, it is in line with the opinion of Sunarto (2018) that Javanese Gamelan music has provided an extraordinary sensation for European musicians today. The exotic aesthetic found in Gamelan is very different from Western musical ideas, this makes European musicians very interested in listening to Gamelan, writing down its melodies, and studying the instrument and its

tunings. Like many other musicians, Debussy in 1889 was also very enamored with Gamelan music when he saw performances of the Annam theater and Javanese Gamelan at the Universal Exposition.

The Kuda Lumping Gamelan has significant cultural and artistic value. Gamelan games have good and excellent value in terms of immersion, presence, liking, challenge, and cultural preservation value (Syukur et al., 2023). Various efforts have been made to introduce Gamelan to society. For example, the development of a Gamelan orchestra learning application model to support ease in learning how to play Gamelan musical instruments (Fanani et al., 2020). In the context of mathematics learning, researchers believe that the Kuda Lumping Gamelan can be used as an interesting learning medium. In the context of mathematics learning, there are two benefits, namely introducing mathematical concepts as well as preserving culture. In line with Fitriatien (2016) mathematics is very closely related to culture because there is a group of people who use this method as a way of learning mathematics. Ethnomathematics is a means of exploring mathematical concepts that are implemented practically by certain groups in a social and cultural environment. Therefore, this research is important to introduce culture in mathematics learning.

Based on initial observations, researchers predict that many mathematical concepts can be explored. This is the reason the researchers are interested in researching the Kuda Lumping Gamelan musical instrument in Wanareja. To be able to develop novelty, exploration of the mathematics elements contained in Gamelan musical instruments and the Kuda Lumping dance in Wanareja needs to be carried out. In this research, the exploration of mathematical concepts is limited to the shape, layout, and movement patterns of the Lumping Horse Dance in Wanareja which can be found and applied to mathematical problems.

METHODS

This research used a qualitative approach with an ethnographic design. This qualitative approach was chosen because the study is related to historical developments. Susanto et al. (2022) stated that the life history of a person or society can be understood through qualitative methods. The data explored in this research were the Kuda Lumping Gamelan musical instrument and the movement patterns of the Kuda Lumping dance in Wanareja. The research location was in Cihandiwung Lor, Adimulya, Wanareja, Cilacap, Central Java.

Data collection techniques in this research included observation, interviews, and documentation. This data was obtained through direct observation at the Wahyu Sabdo Laras studio and lumping horse performances. The researchers carried out observations and interviews simultaneously at the research location on March 14, 2023. The researchers documented the activities by taking several photos and sound recordings, and then the researchers interviewed the general chairman of the Kuda Lumping community association regarding gamelan musical instruments. On March 16, researchers made observations by watching a Lumping horse dance performance, then researchers conducted interviews with lumping horse dancers on March 22, 2023.

The data analysis technique used in this research was the process of data reduction, data presentation, and conclusion verification. In this data reduction, researchers carried out an analysis of the data that had been collected to extract significant and relevant information. This step was carried out by filtering and grouping data, selecting and determining the most relevant data, and deleting irrelevant data. Data analysis focused on the connection of mathematical concepts to the content of numbers, measurement, algebra, and geometry related to the Kuda Lumping Gamelan musical instrument and movement patterns in the Kuda Lumping dance in Wanareja. In this context, analysis was carried out on mathematical activities which were activities that involved the process of abstracting from real experiences in everyday life into the mathematical domain or vice versa. Ethnomathematics refers to the various results of mathematical activities that exist or develop in a particular society. This includes activities such as grouping, calculating, measuring, and patterning that occur in everyday life. According to the National Council of Teachers of Mathematics (2000), there are five standards for mathematics content, namely: numbers and their operations; algebra; geometry; measurement; data analysis, and probability. These contents were interpreted in various forms of the Kuda Lumping gamelan musical instrument.

At the data presentation stage, researchers sometimes arrange the data in tabular form, and then explain the results of the data analysis. This explanation was accompanied by footnotes that had been prepared previously. In the final stage, the researchers checked the conclusions that had been made and validated the research results.

RESULTS AND DISCUSSION

The results of interviews and observations regarding Gamelan musical instruments and the Kuda Lumping dance movements in Wanareja showed that there were mathematical elements contained in them. Wanareja Kuda Lumping Gamelan musical instruments consisted of *kendang, demung, saron, calapita, kenong, bonang, kethuk, drum, gong,* and *kempul*. The Gamelan musical instruments are shown in Figure 1. In this section, the mathematical concepts of scales, shape, and layout of gamelan musical instruments are presented.

Figure 1. Gamelan musical instruments

On the other hand, the Kuda Lumping dance consists of *ngatur sembah, pecak pedhang*, losing to the enemy, fighting against the enemy from the right, fighting against the enemy from the left, finishing the battle, *mejang beksa*, and *janturan/mendem*. In this section, the findings of mathematical concepts in the Wanareja Kuda Lumping dance movement patterns are explained.

Numbers on the Kuda Lumping Wanareja gamelan scale

The Gamelan players at Wahyu Sabdo Laras Wanareja are usually called *niyaga*, consisting of 8-12 people. Gamelan musical instruments use *patet enem* or *nem* with the number 6 and each has 7 *Wilahan* (blades). Javanese Gamelan has a diatonic scale (Pamungkas & Utomo, 2022; Suranto & Santosa, 2019). In musical scales or *laras musik* (tunings), two types of tunings are commonly used, namely *laras slendro* and *laras pelog*. *Saron, demung, bonang, calapita*, and *kenong* have a *laras slendro* and a *laras pelog*. In both tunings, there are terms used that refer to the notes present. In *laras slendro*, these notes are represented by the numbers 1,2,3,5,6, known as *ji, ro, lu, mo, nem or siji, loro, telu, limo, enem*. Meanwhile, in *laras pelog*, the notes are represented by the numbers 1,2,3,4,5,6,7 or in Javanese terms *ji, ro, lu, pat, mo, nem, pi* or *siji, loro, telu, papat, limo, enem, pitu*.

Several things above show that the mathematical activities used on the Kuda Lumping gamelan musical instrument are in the form of natural numbers, Thus, the Gamelan musical instruments contain mathematical concepts. Further exploration can be carried out later in the future on the marching patterns built on the rhythmic beats of the Kuda Lumping Wanareja gamelan. The researchers recommend that future researchers explore it for future research as has been done by Dewi et al. (2020) and Falah et al. (2022).

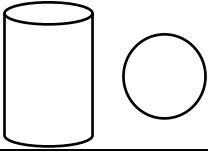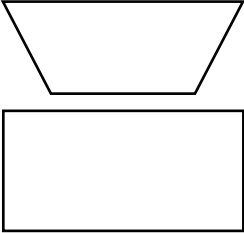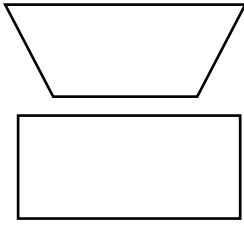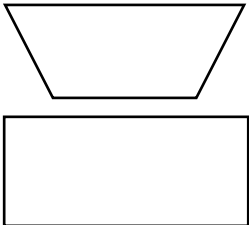### Measurements on the shape of the Kuda Lumping gamelan musical instrument

In Wahyu Sabdo Laras, there are four types of *kempul* used, namely large *kempul* with size 5 also known as a *limo*. Apart from that, there are also *kempul* with sizes 3, 2, and 1 which are usually referred to as *kempul telu, loro, siji*. *Bonang* consists of two types, namely *bonang barung and bonang*
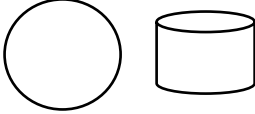
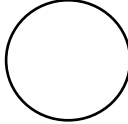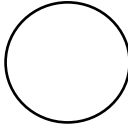*penerus*. *Bonang barung* usually has a larger shape containing 15-20. The size of the *bonang barung* itself is 45 cm long, 10 cm wide, and 10 cm high. Meanwhile, the *bonang penerus* is a *bonang* that is smaller than the *barung bonang* which contains 10-12 pieces of *bonang*. *Bonang barung* is 35 centimeters long, 8 centimeters wide, and 8 centimeters high. Apart from that, there are *demung* and *saron* gamelan musical instruments which have almost the same shape, but different sizes. The *demung* gamelan measures around 80-100 centimeters, while the *saron* gamelan is around 60-70 centimeters.

Geometry in the shape of the Kuda Lumping Gamelan musical instrument

The results of the exploration of mathematical concepts in Gamelan include geometric content such as points, planes, angles, plane shapes, and geometric shapes. Exploration is limited to geometry content for the elementary school level. Table 1 summarizes the connection between the two shapes. The Kuda Lumping Gamelan musical i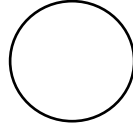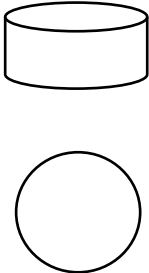nstrument in Wanareja which has been discovered by researchers contains various mathematical concepts that can be found in the Gamelan musical instrument and the Kuda Lumping dance movements. These mathematical concepts can be used for learning mathematics at the junior high school level. This is in line with the results of research Kholifa (2020), which stated that there was a connection between the Javanese Gamelan musical instrument *karawitan* and mathematics learning, especially in studying elements and properties that have the shape of a circle, trapezoid, rectangle, tube, beam, ball, and cone.

Table 1. Geometry on the Kuda Lumping Gamelan musical instrument

No	Gamelan Musical Instruments	Abstraction Image	Geometry
1	*Kendang*		1. Tube 2. Circle
2	*Deming*		1. Trapezoid 2. Rectangle
3	*Saron*		1. Trapezoid 2. Rectangle
4	*Calapita*		1. Trapezoid 2. Rectangle

No	Gamelan Musical Instruments	Abstraction Image	Geometry
5	*Kenong*		1. Tube 2. Circle
6	*Bonang*		Circle
7	*Kethuk*		Circle
8	*Gong* and *Kempul*		Circle
9	Drum		1. Tube 2. Circle

Matrix on the layout of the Kuda Lumping gamelan musical instrument

In Gamelan *bonang*, a matrix concept was found because the layout was very clear. There was a *laras slendro* in the first row and *a laras pelog* in the second row. For columns, the first column is *ji* (1), the 2nd column is *ro* (2), the 3rd column is *lu* (3), the 4th column is *mo* (5) for laras slendro I, and pat (4) for *laras pelog*, while the 5th column is *nem* (6) for *laras slendro*, and *mo* (5) *for laras pelog*, the 6th column has a high *ji* or 1 with a high note as notation for *laras slendro* and *nem* (6) for *laras*

pelog, finally the 7th column has a high *ro* or 2 with a high note as notation for the *laras slendro* and pi (7) for the *laras pelog.*

$$\begin{bmatrix} 1 & 2 & 3 & 5 & 6 & 1 & 2 \\ 1 & 2 & 3 & 4 & 5 & 6 & 7 \end{bmatrix} \begin{array}{l} \rightarrow \text{ line 2} \\ \rightarrow \text{ line 1} \end{array}$$

Laras slendro

Laras pelog
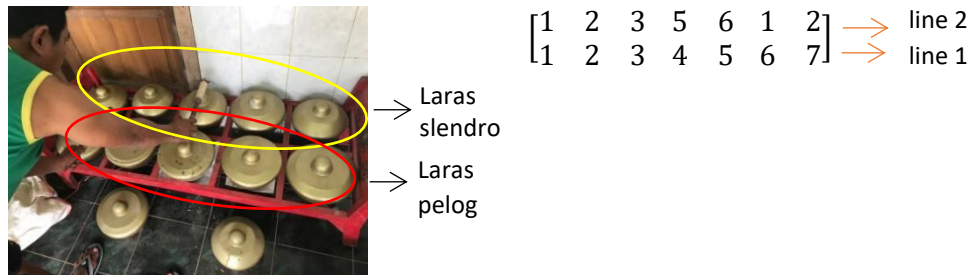
Lines and circles in the position of Kuda Lumping dancers

(a)

(b)

Figure 2. Dance movement patterns: (a) Mejang Beksa dance; (b) Janturan/Mendem dance

Figure 2(a) shows the line concept where the dancers' positions are parallel to form a straight line, while Figure 2(b) shows a circle shape where the dancers' positions gather together in the middle of the arena.

Geometry transformation in the Kuda Lumping dance movement pattern

Geometric transformation is a series of rules used to move a geometric figure from one position to another without changing its original shape (Hanipah et al., 2022). Geometric transformation is also a part of geometry that studies change in position, shape, and presentation of geometric figures by using images and matrices as a basis.

Reflection

(a)

(b)

(c)   **(d)**

Figure 3. Dance movement patterns: (a) Ngatur
Sembah, (b) Pacak Pedhang, (c) Kalah Dari Musuh,
(d) Gerak Perang Melawan Musuh dari Kanan

Based on Figure 3, the Kuda Lumping dance movement shows that there is a concept of geometric transformation, namely reflection (mirror) in mathematics, the distance from the origin to the line (mirror) is the same as the distance from the line (mirror) to the image. In dance movements, there is a reflection between one dancer and another where they face each other and imitate each other's movements. This position allows each dancer to follow the main movements performed by the lead dancer. The reflections in the image can each be represented as reflections on the x-axis, reflections on the y-axis, and reflections on the central coordinate point (0,0). This agrees with Yanti & Haji (2019) that in kain besurek Bengkulu (Bengkulu besurek cloth), reflection or mirroring occurs which produces an image by moving each point in a certain plane so that the distance between the image and the original object in the mirror is the same and the size and shape remain the same.

Translation

(a)   **(b)**

(c)   **(c)**

Figure 4. Dance movement patterns: (a) war against the enemy from the right,
(b) war against the enemy from the left, (c) finished fighting

Figure 4 shows a geometric transformation concept called translation. This transformation can be done by shifting an object or image from a starting point to another point with a certain distance and direction without changing the shape or size of the object. Strengthened by the opinion Yanti & Haji (2019) in making fabric motifs, the geometric transformation concept applied is translation, namely by shifting or moving the fabric motif sketch to a certain position with a certain direction and distance, be it a shift in a plane, line or point, This shows that translation has an important role in the process of making Bengkulu besurek cloth motifs. Apart from the Bengkulu besurek cloth motif, in the

Kuda Lumping dance movement the dancer can be seen shifting from the right position to the left position, the right position is called the object and the left position is called the shadow, even though the shift is done the dance movement is still maintained.
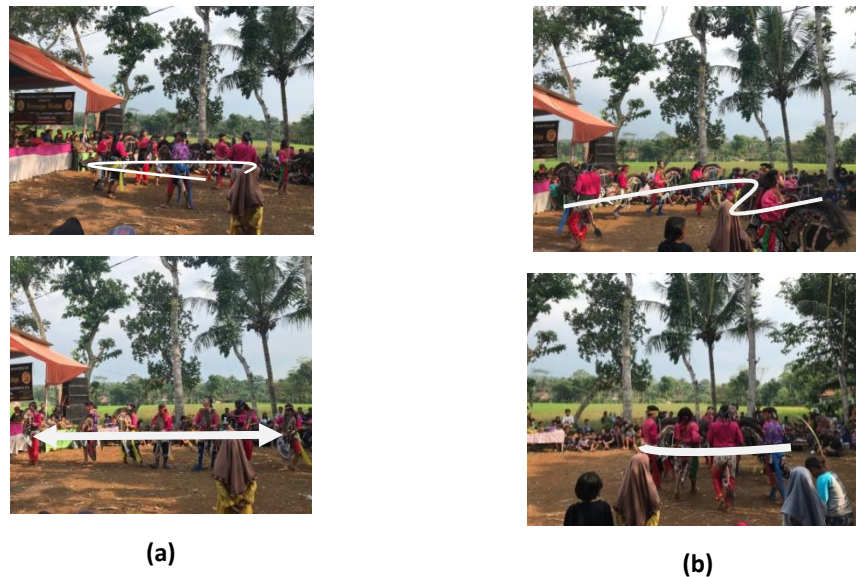
Rotation

Figure 5. Dance movement patterns: (a) Mejang Beksa; (b) Janturan/Mendem

Figures 5(a) and (b) are related to the geometric transformation namely rotation. The kangaga motif on the Bengkulu besurek cloth is the result of the concept of rotational geometric transformation. Rotation is a change in the position of each point on a geometric plane by rotating it at the center of a certain point (Yanti & Haji, 2019).

CONCLUSION

It can be concluded that the mathematical concept in the form of the gamelan musical instrument accompanying the Kuda Lumping in Wanareja consisted of the concepts of numbers, measurement, and geometry. For *Gamelan saron, demung*, *bonang* the concept of numbers was in the form of natural numbers, *Gamelan kempul* and *bonang* showed the concept of measurement in the form of quantities on gamelan musical instruments, while for *Gamelan kendang, demung, saron, calapita, kenong, bonang, kethuk, drum, gong* and *kempul* showed the concept of geometry in the form of geometric data shapes, namely rectangles, circles and trapezoids, and spatial shapes, namely tubes. The mathematical concept in the layout of the Gamelan musical instruments accompanying the Kuda Lumping in Wanareja consisted of the matrix concept, namely in the *Bonang gamelan*. This matrix concept included descriptions of the rows and columns in the matrix material. The mathematical concept in the movement patterns of the Kuda Lumping dance in Wanareja consisted of the concept of geometric transformation. These geometric transformations included reflection, translation, and rotation. The dance movements for praying, the *pecak pedhang* dance movements, the dance movements for losing to the enemy, the dance movements for fighting against the enemy, and the dance movements for ending the battle show reflection. The dance movements for fighting against the enemy and the dance movements after fighting show translation. Meanwhile, the *majeng beksa* dance movements and *janturan* dance movements show rotation. Examples of mathematical problems that can be built from the connection of gamelan musical instruments and the Kuda Lumping dance movements in Wanareja consisted of the Gamelan *kethuk* and Gamelan *saron* which showed the concept of two-dimensional geometry in the form of circles and trapezoids. For the layout of the Gamelan *bonang*, show an example of a matrix question. The *pecak pedhang* dance moves, the dance

moves against the enemy from right to left, and *the janturan* dance moves show examples of geometric transformation questions in the form of reflection, translation, and rotation.

Limitations and Future Direction

The limits of the exploration of mathematical concepts in the lumping horse are limited to the shape and layout of the gamelan as well as the movement patterns of the Lumping horse dance. Exploration of mathematical concepts in gamelan form is limited to elementary school mathematics content. Further research can explore the gamelan form of concepts related to calculus, especially integral. In the aspect of Gamelan tones, further exploration can be carried out about Gamelan beats which may be connected to number sequences, such as research that has been carried out by (Dewi et al., 2020; Falah et al., 2022). The results of this research can also provide ideas for developing teaching modules in local cultural contexts.

Acknowledgments

The author would like to thank all parties who have helped carry out this research, especially the Kuda Lumping community "Wahyu Sabdo Laras".

Declarations

The mathematical concepts contained in the results of this research are purely the author's interpretation. There is no conflict of interest in this matter.

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