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Eksplorasi Etnomatematika: Integrasi Matematika pada Kesenian Musik Ngesti Swara di Desa Jatisobo

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Abstrak

Tujuan dari penulisan artikel ini adalah untuk mengekplorasi bahwa matematika dapat diterapkan pada kesenian Ngesti Swara di Desa Jatisobo. Metode yang digunakan dalam penelitian ini adalah kualitatif dengan pendekatan etnografi. Domain dalam penelitian ini tidak dibatasi. Artinya setiap unsur yang mengandung matematika dalam kesenian ini akan dieksplorasi. Domain aljabar yang membahas tentang penerapan himpunan dalam matematika dan domain geometri yang diekspolarasi dari bentuk-bentuk dari alat yang digunakan dalam pertunjukan kesenian Ngesti Swara menjadi domain yang paling banyak dieksplorasi, tetapi domain ini tidak selalu menjadi hal utama dan semua unsur matematika dalam budaya akan dibahas dalam penelitian ini. Penelitian ini dilakukan di Desa Jatisobo sebagai tempat asal yang masih melestarikan budaya Ngesti Swara ini. Penelitian ini didukung dengan Teori Konstruktivismee Vygotsky yang membahas tentang pembelajaran berbasis sosial dan lingkungan sekitar. Hasil penelitian menunjukkan bahwa terdapat etnomatematika pada kelompok seni Ngesti Swara di Desa Jatisobo. Penelitian ini juga memberikan kontribusi dalam bidang pendidikan. Pengajaran dengan menggunakan etnomatematika sebagai pembelajaran yang kontekstual dapat dijadikan sebagai media pembelajaran matematika. Kesimpulan dari penelitian ini adalah matematika dapat dieksplorasi dari budaya musik Ngesti Swara di Desa Jatisobo. Hal ini menjadi salah satu cara untuk belajar matematika sekaligus melestarikan budaya.

Kata Kunci: Eksplorasi, Etnomatematika, Ngesti Swara

Exploration of Ethnomathematics: Mathematics Integration in Ngesti Swara Music in Jatisobo Village

Abstract

This article aims to explore how mathematics can be applied to Ngesti Swara art in Jatisobo Village. The method used in this research is qualitative with an ethnographic approach. The domain in this research is not limited. This means that every element of mathematics in this art will be explored. The algebraic domain, which discusses the application of sets in mathematics, and the geometry domain, which is studied from the shapes of the tools used in Ngesti Swara art performances, are the most explored domains. Still, these domains are not always the main thing and all elements of mathematics in culture will be discussed in this study. This research was conducted in Jatisobo Village the original place that still preserves this Ngesti Swara culture. This research is supported by Vygotsky's constructivist theory, which discusses social and neighborhood-based learning. The results showed that ethnomathematics is present in the Ngesti Swara art group in Jatisobo Village. This research also contributes to the field of education. Teaching using ethnomathematics as contextual learning can be a medium for learning mathematics. This research concludes that mathematics can be explored from the Ngesti Swara music culture in Jatisobo Village. This is one way to learn math while preserving culture.

***Keywords**: Exploration; Ethnomathematics; Ngesti Swara*

INTRODUCTION

Education is essential for human beings. A good education can make humans better (Alpian, Anggraeni, Wiharti, & Soleha, 2019). Despite being important for life, education can also be hampered due to obstacles. Education in Indonesia still faces many obstacles, such as applying wrong practices in the field (Fitri, 2021). This causes education in Indonesia to be said to be still low when compared to other countries (Wahyudi, et al., 2022). Unqualified education makes it difficult for humans to learn the things around them.

Mathematics is one of the sciences that can be learned and applied in everyday life. Mathematics is a science that can develop logical, organized, and rational thinking (Permatasari, 2021). Mathematics learning still experiences many obstacles. In line with this, research reveals many obstacles in learning mathematics, so many solutions are used to overcome these problems (Maryanto, Rachmawati, Muhammad, & Sugianto, 2023). One of the obstacles experienced in providing math teaching is the learning method. Conventional learning methods make math material difficult for students to absorb (Nisa, MZ, & Vebrianto, 2021). Conversely, interesting learning methods can increase student interest. This aligns with research that reveals that the lesson study learning method improves student learning achievement (Farahsanti, Pribadi, Ariyanti, & Gunawan, 2021). Therefore, interesting learning methods or learning media can be an intermediary for educators in delivering material, especially mathematics.

Learning media is one of the important things in carrying out learning. Learning media has uses in attention, knowledge, attitude, and compensatory functions (Samura, 2015). Generally, learning media is a tool that can help the learning process. The effectiveness of learning media like this is positive. This means that such learning media can be said to have an effect on learning. This aligns with research that reveals that snakes and ladders learning media can improve student learning achievement (Agustino, Susanto, & Wulandari, 2024). Based on these findings, it can be said that learning media in physical form can be an intermediary for distributing material from educators to students.

Ethnomathematics is a science that links mathematics with the culture around society. Ethnomathematics can be a new strategy for teaching students by exploring local culture (Muyassaroh & Sunaryati, 2021). Linking learning with culture means that learning does not always have to be done in the classroom. Learning outside the classroom can also cause students to be more active in the learning process. This is in line with research that reveals that outdoor learning can increase student understanding, so outdoor learning can be said to be effective (Rohim & Asmana, 2018).

Ethnomathematics can also be said to be a learning medium that can improve students' mathematical abilities (Andriono, 2021). Unlike learning media such as snakes and ladders, multiplication cards, etc. as learning media that are physical and can be touched. Ethnomathematics comes by linking math learning with the surrounding culture. Learning approaches with ethnomathematics can improve students' problem-solving skills rather than using a direct approach (Astuningtyas, Wulandari, & Farahsanti, 2017).

This research is based on a study that revealed that there are mathematical objects in the tambourine at the Raudlatul Ulum 2 Islamic Boarding School by analyzing geometry objects in the form of lines, angles, fields, length, width, and height (Septia, Wahyu, & Hasanah, 2023). Another study also revealed that tambourines have a role in implementing realistic learning (Andani, Arfinanti, & Azka, 2021). Similar to the previous studies, a study revealed that there are fundamental activities in measuring, calculating, placing, and explaining (Rijanto, Prasetyo, & Ningsi, 2024). Based on these descriptions, this research is novel regarding the object under study, namely the Javanese culture-based tambourine. In addition, the research location is also different from previous references. This research is important and is expected to contribute to mathematics learning in the community, especially among those with elementary school education levels and those in higher education.

Ethnomathematics learning does not always have to be done in the classroom. Its nature which links learning with culture causes teaching and learning activities to be carried out outdoors. One example is the culture in Jatisobo Village, namely the Ngesthi Swara tambourine group. Ngesthi Swara is a traditional tambourine group that sings religious Javanese songs. Ngesti Swara is interesting to discuss because it is a reasonably old culture in Jatisobo Village that is still preserved. The elements related to mathematics are interesting to discuss on the side of the culture still practiced by the

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community. One of the lessons that can be applied in tambourine is geometry. This is in line with the opinion that the tambourine can be a reference for geometry learning and this can be used as a learning medium at school (Mu'asaroh & Noor, 2021). In addition, learning using ethnomathematics on tambourines also affects students' numeracy skills (Zuhri, 2020). Based on these findings, this research elements of math that can be explored can be learned through musical instruments in the Ngesthi Swara tambourine group in Jatisobo Village. Through this culture, people can preserve the culture in their village and learn mathematics, especially those with elementary school to higher education levels.

METHOD

Qualitative methods were used in this study. The approach taken is ethnography. Research using an ethnographic approach can be used if the object under study is about culture, Moloeng (Wahyuni, Afghohani, & Wulandari, 2024). Researchers used this method to describe the geometry objects found in the Ngesthi Swara tambourine group in Jatisobo Village. There are three data collection techniques in this study. The three techniques are observation, interview, and documentation. This research was conducted on September 27, 2024, until completion. Observations and documentation of the data as the object being observed were made. Furthermore, interviews were conducted with informants on September 28, 2024. The informant in this study was Mr. Sarjono, the head of the Ngesthi Swara tambourine group. After the data is collected, the data is then analyzed based on the predetermined geometry and algebra domains.

RESULTS

Ngesthi Swara is an art form in Jatisobo Village. This group was established in 1964. This group became one of the traditional parts of Jatisobo Village because it often accompanies the bride and groom in the tradition of accompanying the bride and groom during the reception process. This art is almost dead due to the lack of people who want to preserve this culture. In addition, this culture became almost extinct due to entertainment when people held weddings already using such as single organs and the like.

Ngesti Swara art has a meaningful name. The word Ngesti means an effort made inwardly to get closer to God. Meanwhile, Swara means an invitation made using sound or voice. These meanings are contained in the name Ngesti Swara which means *mangesti mring gusti lumantar swaraning salawat*. The sentence means getting closer to God based on the inner self-using sound or voice through Salawat. This understanding was obtained from the interview process conducted with the head of this tambourine group, Mr. Sarjono.

The origin of Ngesti Swara cannot be separated from the history of Jatisobo Village. Initially, this performance was only allowed to be performed in the Surakarta Kasunanan Palace, but during the reign of Paku Buwono X, this art began to be taught to the wider community. This art emerged in Jatisobo Village spearheaded by a religious figure who founded Jatisobo Village, namely Kyai Khotib Imam. Kyai Khotib Imam was a messenger to spread Islam in the east-south direction.

When spreading Islam, Kyai Khotib Imam built a mosque in this village, the Great Mosque of Jatisobo Village. This mosque was used as a hermitage to spread Islam. This mosque became the forerunner of the Arakan Temanten tradition. This is intended so that people do not forget the mosque as a function of Muslim worship. This tradition runs by every community that performs a wedding, which must surround the Jatisobo Great Mosque and be accompanied by the art of Laras Madya Ngesti Swara.

Based on the research results, the researcher found the existence of ethnomathematics in the Ngesthi Swara tambourine group in Jatisobo Village. This is observed from the shape of the tambourine tools and the tone patterns used in chanting these tools. The shapes of the tambourine tools are grouped in the geometry domain, and the tone patterns are in the algebraic domain. This can be used in the learning process of geometry and algebra. This is related to the constraints of the abstract geometry learning process, which needs a contextual approach to teaching. The following will explain geometry objects in the Ngesti Swara tambourine group.

Figure 1. Picture of a drum

The picture above is one of the instruments used in Ngesti Swara's performances. Kendang is a traditional musical instrument that resembles a tube. The Kendang instrument in Central Java has a subdivision pattern in the beat. In learning kendang, the pattern is usually divided into several parts, among others:

1. Pattern 8 divided by 1: (1-2-3-4-5-6-7-8). The exploration is the representation of a directed connected graph.

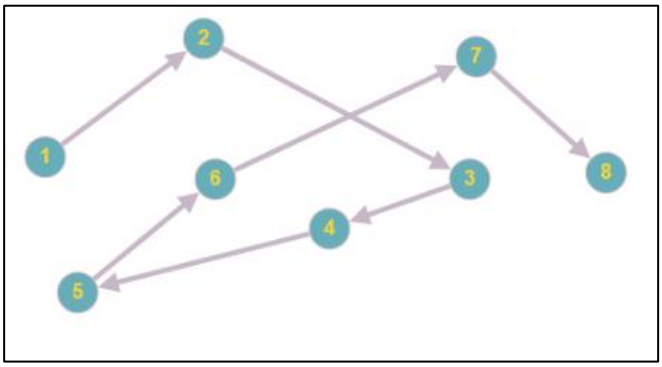

Figure 2. picture of the connected graph of the pattern 8 divided by 1

2. Pattern 8 divided by 2: (1-2-3-4, 5-6-7-8). The exploration is a representation of a directed graph with two connected components.

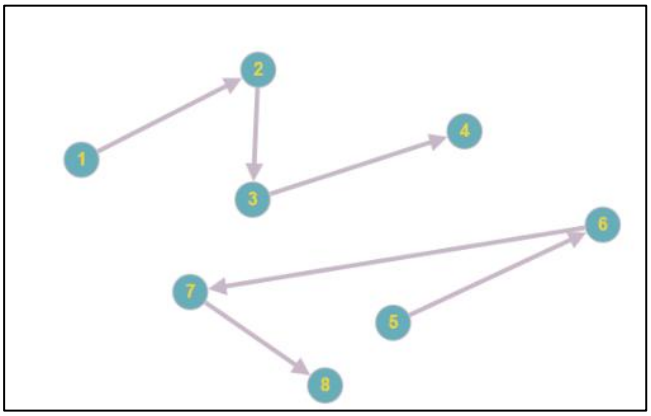

Figure 3. picture of two connected graph of the pattern 8 divided by 2

3. Pattern 8 divided by 4: (1-2, 3-4, 5-6, 7-8). The exploration is a representation of a directed graph with four connected components.

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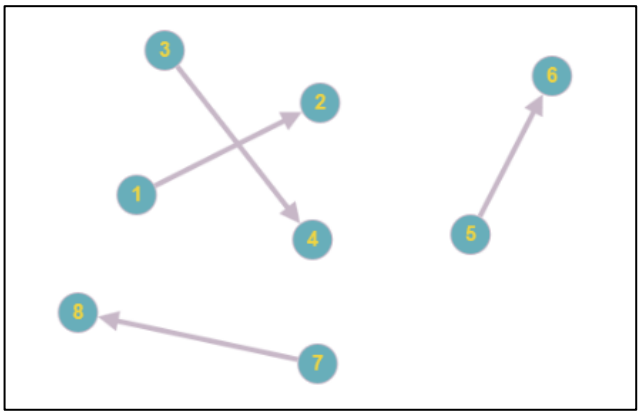

Figure 4. picture of four connected graph of the pattern 8 divided by 4

4. Pattern 16 divided by 4: (1-2-3-4, 5-6-7-8, 9-10-11-12, 13-14-15-16). The exploration is a representation of a directed graph with four connected components.

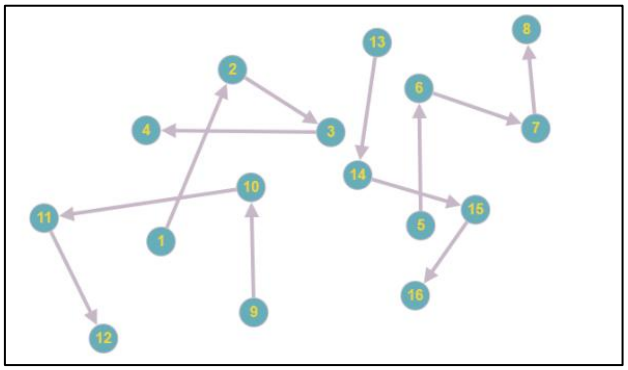

Figure 5. picture of four connected graphs of the pattern 16 divided by 4

The images above are examples of the graphs referred to in each subdivision, so the ethnomathematics that can be explored is that the drum beat pattern can represent the graphs studied in graph theory. This is based on the definition of ethnomathematics, which is the study of how mathematics is practiced and understood by various cultures and societies, including traditional and marginalized communities. In its implementation, six activities include counting, locating, measuring, playing, designing, and explaining (D'Ambrosio, 1993). In this study, the design activity was used to explore ethnomathematics.

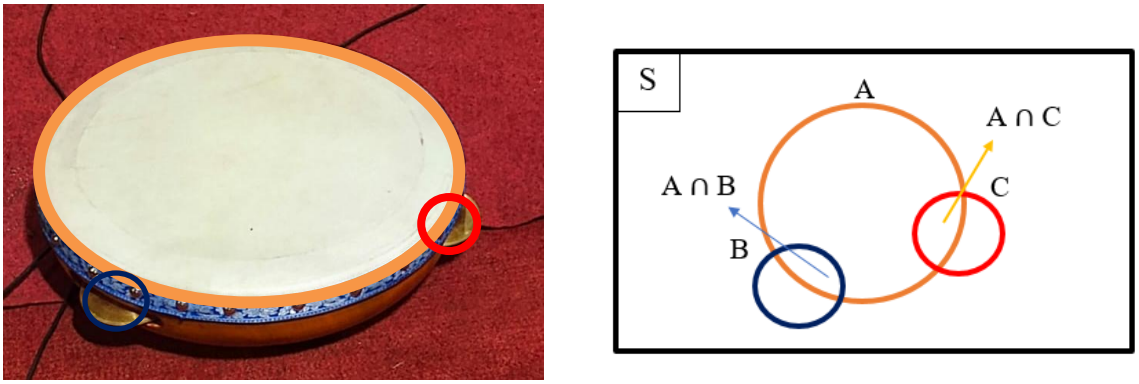

Figure 6. Images of Genjreng musical instruments and their application to mathematics

The picture above is a Genjreng musical instrument. Genjreng is a circular musical instrument covered with animal skin to create sound when struck. This tool is equipped with a thin iron, which helps give the impression of a "njreengg" sound when this tool is played. The shape of this tool resembles a Venn diagram. A Venn diagram is a diagram used for visualization of the set concept. The concepts of incidence, intersection, combination, difference, etc., will be recognized when studying the set. These concepts can be depicted on a Venn Diagram. Then, this Venn Diagram can be visualized in the real world as a Genjreng musical instrument. This can also be categorized as contextual learning. The concept of the shape or depiction of the Venn diagram can be adopted from the shape of the musical instrument in Figure 2. The Venn diagram concept on the set slice can resemble the genre of musical instruments. This becomes one of the set concepts that refer to culture, namely the genre of musical instruments, as in Figure 2. The geometry of the circle dominates this instrument. Based on the results of interviews conducted with Mr. Ahmad Dumadi, one of the players in this art, revealed that, in this case, the circular shape symbolizes the relationship between humans and God and the surrounding nature. This art is symbolic of human communication with God through sound and singing.

Figure 7. Images of bass instruments and their application to math

The picture above is of a Bas instrument. The bass here is a traditional instrument in the shape of a hemisphere with the top made of animal skin, usually cow. This instrument gives the impression of a booming sound in the performance. The math application that can be applied here is the geometric shape of a half sphere. This form of geometry makes students more contextual when learning about space. Students can directly calculate the area and volume. Mathematical concepts such as spheres are closely related to life—for example, the geometry object in the sphere. The shape of a whole sphere can be related to an absolute ball in the real world, so the shape of half of it can also be related to real life, as in this musical instrument. The musical instrument used in this cultural performance is why the concept of geometry in the hemisphere refers to Ngesti Swara's musical culture. The bass instrument in Ngesti Swara Music is composed of hemispherical geometry and, based on the results of interviews conducted with Mr. Ahmad Dumadi, one of the players in this art, revealed that this symbolizes a balance between heaven and earth in life. The sky is symbolized by the lid on the Bas, which is made of ox skin, and the shape of the lower half of the sphere symbolizes the earth. This also refers to the relationship between living creatures and their God.

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Figure 8. Picture of a Bedug and its application in math

The picture above is one of the traditional music, Bedug. Bedug is an upright circular cylinder-shaped musical instrument wrapped in cow or buffalo skin on both sides. The function of this tool is almost the same as that of the bass, but it is only different in size and shape. Bedug has a larger size. Since Ngesti Swara is part of the culture in Jatisobo Village, the Bedug is only used during the *Arakan Temanten*. Two people will carry the drum, with one holding a stick to hit it. Then, the mathematics that can be applied to this musical instrument is its geometric shape, which resembles a tube. This contextualization can be applied in learning mathematics, especially in calculating the area and volume of tubes. Because of its tube-like shape, the mathematical concept of this tool can be explored through it. Since the drum is a musical instrument included in Ngesti Swara's art, geometry refers to the culture represented by the drum, as shown in Figure 4 and based on the results of interviews conducted with Mr. Ahmad Dumadi, one of the players in this art, revealed that the tube shape of the drum is one of the things that symbolizes strength and wisdom. This is based on the structure of the side of the drum, which is made of hardwood as a symbol of strength, and the sound produced from the cylinder's base and lid, which symbolizes wisdom.

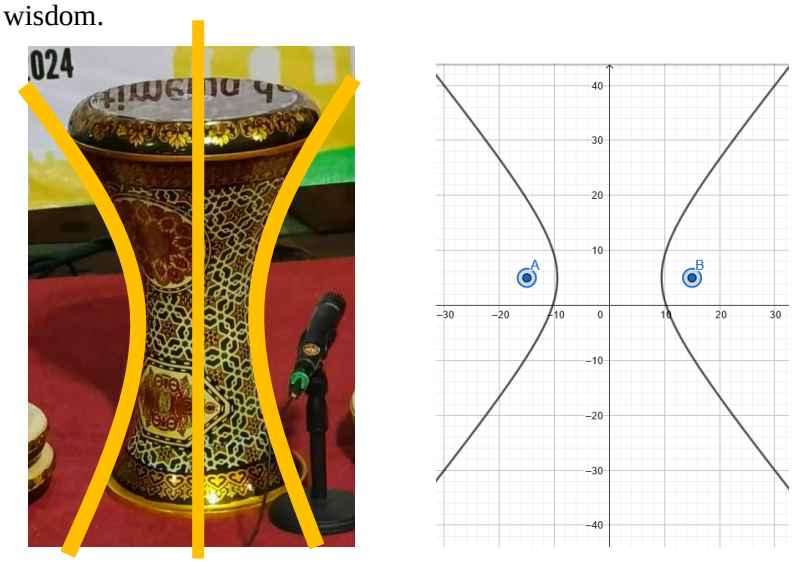

Figure 9. Picture of Jimbe musical instrument and its mathematical application

The picture above is a picture of the Jimbe musical instrument. Jimbe is a hyperbola-shaped musical instrument with a top covered with mica that is pulled until it stretches. This jimbe is one of the musical instruments in the Ngesti Swara performance. It is considered a variation because it is not often used in performances. The jimbe is also an instrument of Arabic origin. Therefore, this instrument is only used as a variation in Ngesti Swara, which contains elements of Javanese culture. The mathematical element in this instrument is the visualization of hyperbole. When the hyperbola is rotated, it becomes

a hyperboloid. The concepts of hyperbola and hyperboloid graphs are studied in analytic geometry. These graphical forms can be visualized in the real world. For example, in this Jimbe musical instrument. As the instrument is part of the performance, the hyperbola or hyperboloid graph refers to the cultural elements of the Ngesti Swara musical instrument culture and based on the results of interviews conducted with Mr. Ahmad Dumadi, one of the players in this art, revealed that the geometric objects in this jimbe musical instrument are a representation of the balance between feminine and masculine. The two sides resembling a hyperbola graph are balanced around a line, which is represented by the X or Y axis in a Cartesian diagram. There are many examples of this equation along the Cartesian diagram. An example is the hyperbola through the center P(0,0), which is $\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1$.

Figure 10. Kemanak musical instrument and its application in mathematics

The picture above is a traditional musical instrument called Kemanak. Kemanak is an ellipsoidal instrument made of brass. This instrument exists to give the impression of a "thing" sound that sounds alternately during the performance. The mathematical concept that can be applied to this instrument is ellipsoids. The shape of the ellipsoide itself can contextualize a similar shape. This can be an interesting reference for students who are learning the material. The ellipsoids studied in geometry are important in exploring mathematics in culture. Since Kemanak is one of the must-have tools in this music game, the concept of geometry refers to the culture being discussed. Based on the results of interviews conducted with Mr. Ahmad Dumadi, one of the players in this art, revealed that the elliptical shape of the Kemanak musical instrument is an expression of the journey of human life. The elliptical shape with four peak points symbolizes that there are four phases in human life: birth, growth, maturity, and old age. All the musical philosophies discussed above are based on interviews and supported by other sources stating that every musical instrument has a meaning in its creation (Department Pendidikan dan Kebudayaan, 1980).

In addition to the things described above, another ethnomathematics that can be analyzed in this culture is the beat on the instrument. The beat can also be seen as the tone pattern used. Generally, the pattern used is "TTDT TTDT TDTT TTDT". The symbols mean T as the sound "Tek" and D as "Dung." The shape of these patterns can be analyzed as part of a line. These patterned beats can stimulate students to analyze number patterns learned in mathematics and used in tests used to apply for jobs.

DISCUSSION

Based on the results obtained, pedagogical implications can be explored by applying the ethnomathematics of the Ngesti Swara tambourine group to mathematics learning. For example, students can be invited to play Ngesti Swara's art. In playing it, students can be asked to analyze both in geometry, the application of volume in calculating the shapes in the Ngesti Swara musical instrument, the shape of the graph represented by the musical instrument, and analyze the algebraic form of the

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musical instrument and the sound produced by the instrument. This kind of out-of-class learning that incorporates culture is an interesting thing for students to do. As a result, learning math will become fun. In addition, from the pedagogical side, it also impacts the ease with which teachers can convey material to students with things related to the objects analyzed in the Ngesti Swara art. One of the fundamental steps teachers can take in explaining mathematics to students is through realistic mathematics learning or with Realistic Mathematics Education (RME), especially in the Ngesti Swara music art in Jatisobo Village. This aligns with the expression that ethnomathematics is an important thing that must be understood in its implications in mathematics education (Risdiyanti & Prahmana, 2020). Geometric and numerical elements that exist in this group have been studied. This aligns with research that reveals that ethnomathematics has an important role in pedagogical implications (Astriandini & Kristanto, 2021). The existence of Ngesti Swara performances can be one of the media for people at certain levels of education to be able to learn mathematics, especially in geometric elements. In this case, it can be believed that ethnomathematics has an important role in implementing mathematics learning. Contextual learning can be the reason for applying ethnomathematics as a learning medium. Contextual learning significantly affects math problem-solving (Lestari, Andinny, & Seruni, 2023).

The concepts that have been discussed previously are a study that will have an impact on learning mathematics. People who participate in this activity can be invited to analyze these concepts with mathematics, such as calculating area volume, determining equations on graphs, and identifying geometric objects. Each of the tools discussed has shown the location of ethnomathematics. For example, the gendang musical instrument, which has geometric elements in the form of a circle, can trigger knowledge about the area of flat buildings. In addition to the circle element, the drum can also visualize the volume of rotating objects on a line and the equation of rotating objects in space analytic geometry. Learning the volume of rotating objects still experiences some obstacles in its implementation. These obstacles are a lack of understanding of concepts such as graphic images and areas and difficulties applying basic formulas (Ahmad, 2019). Furthermore, the Genjreng musical instrument connects with the concept of sets. A study shows many students struggle with writing set notation (Amanda, Maya, & Amelia, 2022). The existence of these difficulties can make a Venn Diagram as a visualization of these notations. Then, the contextualization of the Venn Diagram is contained in the Genjreng musical instrument, as in Figure 2.

The bass in this Ngesti Swara instrument is a visualization of a hemispherical shape, as shown in Figure 3. This means that the bass is included in the geometry domain. The geometry here is spatial geometry. In addition to the Bas, spatial geometry is found in the Bedug and Kemanak tools, as shown in Figures 4 and 6. Spatial analytic geometry needs to be visualized to increase students' thinking power and make them more active. This is because research reveals that the obstacles in learning space geometry are still related to students' understanding of the abstract (Unaenah, Meidianty, & Rihlah, 2023). Based on these findings, bringing students into more contextualized learning becomes important.

This research is based on Vygotsky's Constructivism learning theory. Vygotsky's constructivist theory is a learning process by students that links the social and environmental circumstances around them, Santrock in (Amahorseya & Mardliyah, 2023). This learning theory supports this research because it observes the environment and social circumstances around in the form of culture. This theory is influential in learning mathematics because it provides students with deep memories because of social connections (Arafah, Sukriadi, & Samsuddin, 2023).

Analysis of results can be done by seeing these concepts applied. This causes ethnomathematics to be used as a learning medium. Based on previous research described in the introduction, it is found that this research is in line. There are mathematical objects in renbana art, especially in the Ngesti Swara group in Jatisobo Village, which can be seen from the tools used. Then realistic learning can also be applied through this art. There are also general activities in mathematics that can be done through this Ngesti Swara art. These descriptions indicate and conclude that this research aligns with previous studies.

CONCLUSION

Based on the results and discussion that has been carried out, it is concluded that there are ethnomathematics in the Ngesti Swara art in Jatisobo Village. This can be observed in the geometry objects of the tools used and the concept of tone patterns in the art performance. There are also fundamental activities commonly carried out in mathematics learning that can be done through this art. Therefore, this art can be used as an alternative to learning mathematics. In addition, ethnomathematics can also be used as contextual learning for students to stimulate students' critical thinking to be more active.

Ethnomathematics is also an important concern in reviving culture and carrying out the learning process. This research provides learning alternatives for students who experience problems in doing math learning. It can also be one of the references for educators to provide engaging learning for students to learn mathematics by caring for their own culture.

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