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Number And Set Theory in *Gamelan*: An Ethnomathematics Study

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ABSTRACT

Numbers and Sets are mathematical subject matter that can be learned using context in life. One of the contexts that can be used is *gamelan* artifacts. *Gamelan* contains the values of local wisdom that have become part of the identity of the Indonesian nation. Ethnomathematics sets and numbers in *gamelan* must be explored as contexts in related mathematical learning. The study aims to explore ethnomathematics related to the sociocultural context of *gamelan*, offering an alternative approach to mathematical learning on sets and numbers. Employing an interpretive ethnographic approach based on Alangui's framework, the study unfolds across two art studios and three schools in Indonesia, engaging karawitan art culturalists and junior high school mathematics teachers as key informants. Through observation, documentation, field notes, and interviews, our findings reveal that *gamelan* artifacts can enrich the teaching of sets and numbers with their various types, shapes, and sizes. Hence, the results offer a transformative perspective for teachers, preservice teachers, and mathematics educators to integrate *gamelan* artifacts into mathematics lessons.

Keywords: Culture, Ethnomathematics, *Gamelan*, Number, Set Theory.

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INTRODUCTION

The theory of sets is known as classical set theory and fuzzy set theory. Classical set theory is material studied in school, commonly called set matter (Jamilah et al., 2020; Prahmana & Istiandaru, 2021; Wegner, 2021). Meanwhile, Fuzzy mathematics forms a branch of mathematics related to fuzzy set theory and fuzzy logic (Novák, 2012; Zadeh, 1968). Fuzzy sets (uncertain sets) are somewhat like sets whose elements have degrees of membership (Zadeh, 1968). Fuzzy set theory is studied more at an advanced level at university, for example, in mathematics, computer science, informatics, electrical engineering, or industrial engineering (Gunawan Gunawan & Richki Hardi, 2021; Habiburrahman & Uray, 2021; Nasution, 2020) with a level of depth of understanding that varies depending on the needs of each study program.

Classical and fuzzy set theories are very close to applied mathematics. There are so many applications of set theory in life. One application of classical set theory is grouping in data management, e.g., grouping trainees based on their preferences, interests, or expertise; grouping customers by

preferences, demographics, or purchasing behavior; Group tourist visits (Setio & Prasetyaningrum, 2021); grouping death insurance (Murniati, 2022a, 2022b). In addition, various set operations, such as set slices, can be used to find routes involving multiple cities or places simultaneously. Examples of fuzzy set theory that are applied are washing machines, car alarms, and others, as well as recent research on implementing artificial intelligence (Nasution, 2020; Ratanajaya & Wibawa, 2018).

Therefore, set theory is critical to be taught to students in schools and higher education. Several considerations have begun to be made regarding using fuzzy set logic to be included in the school mathematics curriculum (Mirza, 2012). However, in the secondary school curriculum, the set theory taught in middle and high school is classical set theory. Some research related to classical sets in schools has been done, and some have even been done by making fun mathematics learning media that can be accessed physically (Hidayatullah, 2018) or digitally (Ammy, 2021). In addition to utilizing the media, effective association development can be done by using a context close to student life or the culture around students (Prahmana & Istiandaru, 2021).

The object of study of numbers and sets can be taken from various examples of objects in life that have clearly defined membership elements of the collection of objects. One that can be used is *Gamelan*. *Gamelan* has multiple types and forms that can be used to prepare material related to numbers and sets. The *gamelan* is a musical ensemble from Indonesia and Java comprising metallophones (instrument of gleaming bronze), xylophons (*gambang*), chordophones (*rebab*, a two-stringed fiddle), membranophones (*kendang*, drums), and aerophone (*suling*, a notched vertical flute) (Capwell, 2004; Spiller & Clendinning, 2021). The *gamelan* accompanies traditional dances and shadow puppet plays (Capwell, 2004). The art of karawitan (Javanese *Gamelan*) and *gamelan* emerged from the Hindu-Buddhist culture that dominated Indonesia at the beginning of history (Ferdiansyah, 2010). This can be seen in some of the art of *gamelan* and dance. This culture entered the island of Java through the spread of the Hindu-Buddhist religion (Ferdiansyah, 2010).

The word *Gamelan* itself comes from the Javanese word "gamel," which means to hit or beat, followed by the suffix "an," which makes it a noun (Ferdiansyah, 2010). Furthermore, Iswantoro also explained that the term *gamelan* has a meaning as a whole unit of musical instruments that are sounded together and played rhythmically with different beats (Iswantoro, 2017). The meaning of the word *gamelan* is still under debate over its origin. Some convey the word *gamelan* occurs from the word "*gembel*". *Gembel* is a tool for hitting because it is beaten. This word *gamelan* shifted or developed into *gamelan*. It may also be because the way the *gamelan* is made is bronze, beaten, hammered, or embellished (Ferdiansyah, 2010).

In other words, *gamelan* is an object resulting from the object being embellished or beaten. For Javanese people, *gamelan* has been a part of their lives since Hindu-Buddhist culture, when it was still widely influential in Indonesia (Rudiansyah et al., 2015). Ferdiansyah (2010) also depicted the first

ensemble musical instrument in Borobudur Temple. On some parts of the walls of Borobudur temple, you can see the types of musical instruments that are currently known as *gamelan*, including roped drums around the neck, kendang shaped like pots, siter and harp, cymbals, flutes, saron, and xylophone (Ferdiansyah, 2010).

In addition, the use of *Gamelan*, which is certainly known to students as part of their nation's culture, makes students proud of the culture of their ancestors' heritage. Learners can appreciate mathematics while appreciating *gamelan* culture through the mathematical values embodied in *gamelan* culture (Gerofsky & Goble, 2007; Perlman, 1994; Prahmana & Istiandaru, 2021). Thus, the research objective of this study is to explore the mathematical values contained in *gamelan* cultural values through efforts to select, uncover, classify, and interpret the meaning of mathematics in *gamelan* culture related to mathematics in schools. Hence, students can learn numbers and set theory concepts based on the *Gamelan* context.

METHOD

This study employs a qualitative approach to uncover number and set theory in *Gamelan* so that it can be used as material learning to understand related mathematical concepts. The design of this research follows the framework of an ethnomathematics study from Alangui (Alangui, 2010; Prahmana & D'Ambrosio, 2020; Utami et al., 2019), which is shown in Figure 1, to conduct a qualitative method through ethnomathematics of number and set theory in *Gamelan*.

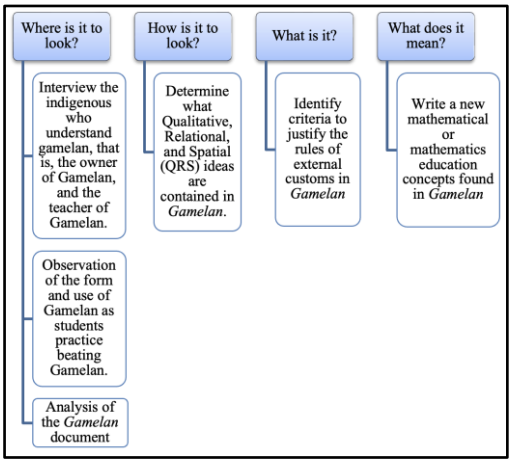


Figure 1. Framework of Ethnomathematics Study

Indigenous knowledge exploration was achieved by observing and interviewing the natives (Alangui, 2010; Chinn, 2014; Utami et al., 2021; Vinlove, 2016). We interviewed the indigenous who knew deeply about *Gamelan*, the owner, and the teacher of *Gamelan*. During the interview, we made notes in the form of field notes and tape recorders. We were also observing the *Gamelan*, i.e., the form and use of *Gamelan* in students' practice. We also analyzed the document. Analyzing the document

involves skimming (cursory examination), reading, and interpretation (Bowen, 2009). The *Gamelan* document was analyzed as supplementary data in this study.

Credibility in this study was obtained through data triangulation from various sources, i.e., *Gamelan* observations, documentation, interviews with indigenous people who knew deeply about *Gamelan*, the owner and the teacher of *Gamelan*, and the mathematics curriculum document.

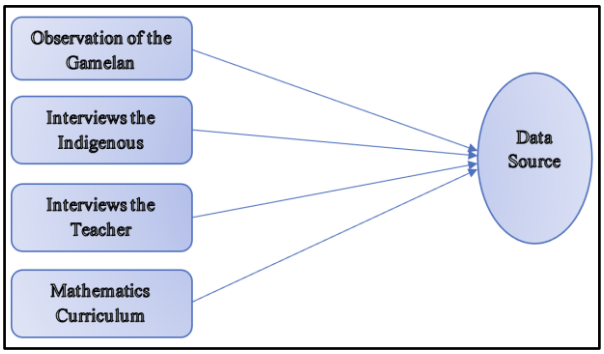


Figure 2. Triangulation Data

The research locations were Sanggar Larasita, Joglo Sutodiryan, Joglo SMP Muhammadiyah 1 Godean, SMP N 1 Turi, and SMP Muhammadiyah 1 Godean. The location of the research is determined in sanggar and schools that have *Gamelan* and carry out *Gamelan* practice activities continuously, both in subjects and in extracurricular activities.

RESULTS & DISCUSSION

Result

The traditional music artifact: Gamelan

Gamelan can be interpreted as a collection of traditional musical instruments played together with different beats (Judith Becker, 2019; Scott-Maxwell & Becker, 1984; Toth & Becker, 1983).

Figure 3. *Gamelan* Instruments

Figure 4. The parts of *Gamelan* Instruments

Based on observations and interviews, *gamelan* instruments have different shapes and names. Based on the results of observations in the field, several *gamelan* instruments and their characteristics include *Kendhang* consists of 3 sizes: *Kendhang Bem* (large), *Kendhang Bathangan* (medium), and *Kendhang Kethipung* (small). *Bonang* consists of 2 barrels (tones); it has a pelog barrel (14 pencon) called bonang barung and a slendro barrel (10 *pencon*) called bonang successor. *Saron*, the form of wilahan (blades), consists of two barrels: *saron ricik* (a pelog barrel with seven blades) and *saron peking* (a *slendro barrel* with six blades). Gender is a musical instrument with 10-14 pitched brass metal blades hung on beams above a bamboo or zinc resonator. The shape of the gender resembles a *slenthem*. The *xylophone* comprises 18-21 wooden slats on a boat-shaped resonator.

The *flute* is bamboo, and we can play it by blowing. *Siters* measure 30 cm with a string count of 11 or 13 that produce a distinctive sound and have adjustable strings for slendro and pelog tones. Rebab includes stringed instruments made of metal. *Kenong* and *kethuk* are both a kind of gong but smaller than gong and larger than bonang. *Kempul* is almost like gong instruments but smaller in size. The last

instrument is the gong, which has the most significant size compared to other *gamelan* instruments (Observation took place at Sanggar Larasita on March 3, 2021).

Exploring Gamelan Instruments in School

One of the activities using *gamelan* takes place at Joglo SMP Muhammadiyah 1 Godean. As an extracurricular, this activity occurs once a week, precisely every Saturday. Twenty students joined this extracurricular, whose purpose is to nurture students' talents and interests in the *gamelan* arts field. After arriving at Joglo, each student positions themselves near the *gamelan* instrument they typically play. Students play the *gamelan* instruments according to the ones available in Joglo. The playing position involves sitting cross-legged with an upright posture.

The layout of the *gamelan* forms a right angle, with slendro-tuned instruments typically facing the audience and pelog-tuned instruments on the left side of the *gamelan* player. Transitioning from playing *gamelan* in slendro to pelog is done by facing left. Instruments arranged in this layout include *slenthem, saron barung, saron penerus, demung, gender barung, gender penerus, gambang, bonang barung,* and *bonang penerus*. The kenong instruments form a rectangle or square.

The practice session begins with a prayer, followed by the teacher checking attendance. Warm-up involves playing previously learned *gendhing* (a traditional song played with *gamelan*) to refresh students' memory and build their repertoire. The teacher writes the notes of the *gendhing* on the board for the students to note in their notebooks. Before playing the *gamelan*, the teacher explains the notes of the *gendhing* to the students. The teacher then demonstrates playing one of the *gamelan* instruments, the kendhang, which functions as the rhythm leader or tempo regulator. Once the *kendhang* plays the *gendhing* correctly, other instruments can follow suit. This practice process is repeated until students become skilled in playing the *gamelan*.

Interview Insights from Gamelan Culture Enthusiasts

The *gamelan* instructor shared the condition of *gamelan* activities in the community before the pandemic. Regular practices occurred at the cultural center every Saturday and Sunday afternoon, involving elementary to high school students and adults. An additional session catered to parents aged 50 to 70 on Sunday evenings. These practices bore fruit, often showcased during birthdays, puppet celebrations, and local and district cultural festivals. The younger generation even took it a step further, participating in performances at the provincial and national levels, including national television of Indonesia broadcasts. The trainer highlighted the organic growth of interest among the youth, who voluntarily joined *gamelan* practices, showcasing the community's inherent passion for this art form. The instructor also explains the origins of *gamelan*, linking it to the term *gangsa*, which is the intricate process of crafting *gamelan* instruments from copper and iron, representing the very essence of the *gamelan*.

Another cultural expert shared the challenges of preserving *gamelan* in the digital age. While acknowledging the positive impact of online visuals in spreading awareness, the expert emphasized the need for hands-on, genuine engagement in learning *gamelan*. In the current digital era, where people might only encounter *gamelan* through images and videos, active participation becomes crucial for preserving this cultural heritage. The expert stressed that, despite global recognition of Indonesia's *gamelan* culture, it is imperative for Indonesians themselves to learn and keep it actively. The existence of *gamelan* outside Indonesia, with many foreigners learning it either in Indonesia or their home countries, underscores the urgency for Indonesians to take the lead in learning and preserving their cultural treasures. The expert also highlighted the role of extracurricular *gamelan* activities in schools and cultural centers as vital contributors to *gamelan* preservation. Beyond direct instrument play, the expert proposed exploring interdisciplinary approaches to package *gamelan* culture, making it more accessible and appealing to diverse audiences.

Mathematical Ideas on the Gamelan Context: Set Theory

Gamelan instruments form a collection of instruments played with their characteristics. The mathematical concept associated with such a collection is a set. The set is a collection of objects whose membership requirements are precise (Liu, 1986). Therefore, a collection of *gamelan* instruments consisting of *bonang, barung, bonang successor, demung, saron, peking, kenong, slenthem, gender, gong, kempul, gambang, kendhang, rebab, siter,* and *flute* can be viewed as sets.

On the concept of sets:

K = {a, b, c} to write the set S with members a, b, and c.

a is one of the members of the set S, it can be written as a $\in$ K. While m is not a member of K, it can be written as m $\notin$ K

(Liu, 1986).

Therefore, the set of *gamelan* instruments (S) can be written as:

S = {*bonang barung, bonang penerus, demung, saron, peking, kenong, slenthem, gender, gong, kempul, gambang, kendhang, rebab, siter, suling*}.

It can be written that *pekinm* $\in$ S, and bananas $\notin$ S because bananas are not members of the *gamelan* instrument association.

The set can also be presented with a notation supplemented by the characteristics of the set members (Liu, 1986). Thus, the set of *gamelan* instruments can be written into the form of notation:

S = {x | x is a *gamelan* instrument}.

Because *gamelan* instruments have different shapes, the way to play them is also different. There are several ways to play the *gamelan* instrument including being beaten, blown, and swiped. *Gamelan* instruments that are played by being beaten are s*aron, peking, demung, slenthem, bonang barung, bonang successor, kenong, kempyang, kethuk, kempul, kendhang*, and *gong*. While the instruments are

played by blowing, one of them is a flute; swiped, there is a rebab; and plucked, there is a *siter*. A new set can be formed based on several ways of playing *gamelan* instruments. Suppose set A is the set of ways to play a *gamelan* instrument by being struck, such that:

A = {*saron, peking, demung, slenthem, bonang barung, bonang penerus, kenong, kempyang, kethuk, kempul, kendhang, gong*}.

Whereas if set B is the set of how to play *gamelan* instruments by blowing,

B={suling}.

Furthermore, if the set C is the set of ways to play the *gamelan* instrument by swiping, then

C={rebab}

and if set D is the set of ways of playing a *gamelan* instrument with plucks, then

D={siter}.

Next,

Given two sets P and Q, P called a subset of Q if any member P is also a member Q. It can be written by to state that P ⊆ Q P is a subset of Q. For example, the {group m, n} is a subset of {m, n, p, z}, while but not a subset of {m, K, L, O} (Liu, 1986)

Since each member of the set A, B, C, and D is a *gamelan* instrument that is also a member of the set S, it can be stated that and in addition, we can write the sets A, B, C, D A⊆S, B⊆S, C⊆S, D⊆S. with the notation forming the set. Since each member is a *gamelan* instrument, it can be written:

A = {x | x ∈ S, x played by being hit},

B = {x | x ∈ S, x played by blowing},

C = {x | x ∈ S, x played by swiping} and

D = {x | x ∈ S, x played in a quoted way}.

Can a *Gamelan* instrument be played by stepping on it with the feet? The answer to that question is no. Suppose defined set:

Z = {x | x ∈ S, x played by being stepped on}.

Since no *gamelan* instruments are played by stepping on them, the set of Z has no members. In set theory, a set can have no members. The set is called an empty set denoted by or {}. One example of an empty set is the set Z ∅ (Liu, 1986).

In addition to how to play it, *gamelan* instruments can be grouped based on the category of instrument sound sources which are divided into several categories, namely the ideophone category (instruments whose sound source comes from the body of the musical instrument itself), membranes (instruments that have a sound source on the skin membrane or the like), aerophones (instruments whose sound source comes from blown air) and chordophones (instruments whose sound source comes from vibrating strings). *Gamelan* instruments that belong to ideophone sound sources consist of *saron, peking, demung, slenthem, bonang barung, bonang successor, kenong, kempyang, kethuk, kempul, gong, saron,*

demung, slenthem, peking, and *xylophone*. Meanwhile, kendhang is a *gamelan* instrument included in the membranes category, and *flute* is included in the aerophone category. Instruments that fall into the chordophone category are *siter* and *rebab*. Suppose I, M, E, H are respectively defined as the set of *gamelan* instruments that fall into the categories of ideophones, membranophones, aerophones, and chordophones, then we get:

I = {saron, peking, demung, slenthem, bonang barung, bonang penerus, kenong, kempyang, kethuk, kempul, gong, saron, demung, slenthem, peking, dan gambang},

M = {kendhang},

E = {distilled}, and

H = {siter, rebab}.

By The concept of subsets can be obtained I ⊆ A and M ⊆ A, in other words, *gamelan* instruments that fall into the ideophone category are played by striking, then E ⊆ B and B ⊆ E. Given two sets P and Q, if P ⊆ Q and Q ⊆ P, P and Q are equal. In other words, two sets are equal if they have the same members (Liu, 1986). Therefore, it can be said that the *gamelan* instruments played by blowing equal the set of *gamelan* instruments in the aerophone category. Then, other cap C subset or equals cap H and cap D subset or equals cap H, meaning that *gamelan* instruments played by plucking and swiping fall into the category of chordophones.

In addition to how to play it, *gamelan* instruments can also be grouped based on their shape. Some *gamelan* instruments have blades or are commonly referred to as wilahan, including *slenthem, saron barung, saron successor, demung, gender barung, gender successor*, and *xylophone*. In addition, *gamelan* instruments have elements resembling half a ball called pencon (pencu), including *bonang barung, bonang successor kenong, kempyang, kethuk, kempul*, and *gong.* There are also *gamelan* instruments in the form of wires (strings) including *rebab* and *siter*, and there are those in the form of bore, namely *kendhang*.

Like musical instruments, the wiyaga (players) playing *gamelan* instruments also use the barrel (*titi laras*) tone. There are two titi scales used, namely slendro titi using tones: 1, 2, 3, 5, 6 (*ji, ro, lu, mo, nem*) and pelog titi using tones: 1, 2, 3, 4, 5, 6, 7 (*ji, ro, lu, pat, mo, nem, pi*). Suppose that a set of L and P is formed that successively contains numbers that are the titi of the barrel on the s*lendro* barrel and the *pelog* barrel, retrieved:

L={1,2,3,5,6} and

P={1,2,3,4,5,6,7}.

There are several notes that are shared by *slendro* and *pelog*-tuned titi, namely 1, 2, 3, 5, 6. Given two sets P and Q, the intersection of the sets P and Q is notated with a set whose members are both in P and Q (Liu, 1986), so that obtained:

L ∩ P={1,2,3,5,6},

which L ∩ P = L

This is because each member of L is also a member of P or L ⊆ P.

Mathematical Ideas on the Gamelan Context: Number Theory

Gambang is one of the *gamelan* instruments in the form of wilahan (consisting of blades), played by beating. One of the interesting things about xylophone is that this instrument has 21 blades of different lengths. The slats on the xylophone are made of wood cut into rectangles of the same width. The length of the tip blade is 29 cm, while the length of the next blade is 30 cm, 31 cm, 32 cm, etc.

Figure 5. The Xylophone Instrument and the Mathematical Model Representation

Based on the length of the blades in the xylophone, the following pattern can be seen: 29, 30, 31, 32, 33, ... Can you predict how long the 21st bar is? The length of the blades on the xylophone forms a number pattern commonly known as the arithmetic sequence pattern. An arithmetic sequence is a row that has the same "difference". To determine the n^{th} order in the arithmetic sequence, it can be obtained by the formula:

$U_n = a + (n-1)b$ "a" being the first order and

$b = U_2 - U_1 = U_{n+1} - U_n$.

At the length of the xylophone blade, it is obtained a = 29 cm and b=1 cm

Thus, the 21st blade length can be obtained:

$U_{21} = a + (21-1)b$

$\Leftrightarrow U_{21} = 29 + (21-1)1$

$\Leftrightarrow U_{21} = 49$

Furthermore, if one xylophone instrument is to be made, what is the length of all the blades needed? To answer this question, the concept of the sum of each sequence in the arithmetic series, which is commonly called the arithmetic series, can be utilized. The sum of n first order in the arithmetic sequence (Sn) can be found by

$$S_n = U_1 + U_2 + U_3 + \cdots + U_n = \frac{1}{2}n(a + U_n).$$

Therefore, the length of all blades needed to make one xylophone instrument can be found as:

$$S_{21} = \frac{1}{2}.21.(29 + U_{21})$$

$$\Leftrightarrow S_{21} = \frac{1}{2}.21.(29 + 49)$$

$$\Leftrightarrow S_{21} = 819$$

It was obtained that the length of the blade needed to form one xylophone instrument was 819 cm or 8.19 m.

In addition to the length of the xylophone blade, the number pattern can also be found in the tapping pattern in the alit gendhing. The structure (pattern) of gendhing alit is divided into smooth beats (Fig. 6 (a)), ketawang beats (Fig. 6 (b)), and *ladrang* beats (Fig. 6 (c)) (Supardi, 2013).

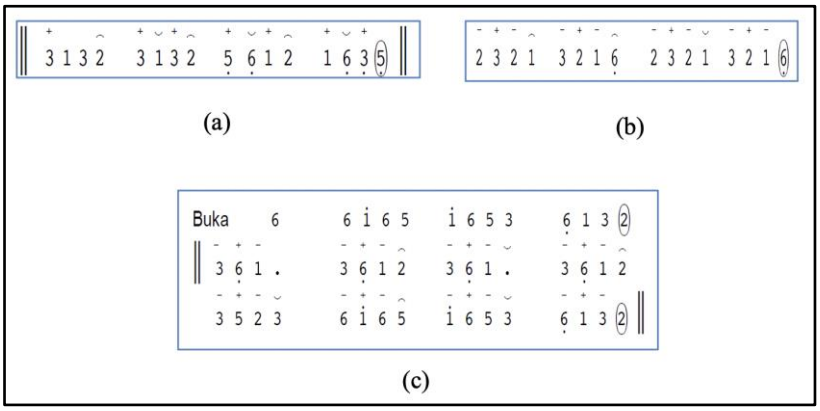


Figure 6. The Beat Pattern of Gendhing Alit

The notes in the rhythm in this smooth beat are 8 beats, while the ketawang beats are 16 beats, and the *ladrang* beats are 32 beats. This beat pattern forms a pattern of numbers 8,16,32. The beat patterns that make up this number can be presented in geometric sequences of 3 terms, i.e., $U_1 = 8$, $U_2 = 16$, and $U_3 = 32$ with $r = 2$.

The geometric sequence

$$U_1, U_2, U_3 \ldots U_n$$

Ratio $\quad r = \frac{U_2}{U1} = \frac{U_n}{Un-1}$

Formula $\quad Un = ar^{(n-1)}$

In addition to the number series, the beat pattern can be contextualized in the geometry series material with $U_1 = 8$, $U_2 = 16$, and $U_3 = 32$. The geometric series formed is 8 + 16 + 32.

The geometric series

$$U_1 + U_2 + U_3 + \cdots + U_n$$

Ratio $\quad r = \frac{U_2}{U1} = \frac{U_n}{Un-1}$

$$S_n = U_1 + U_2 + U_3 + \cdots + U_n S_n = \frac{a(r^n - 1)}{r - 1} \; if \; r > 1$$

$$S_n = \frac{a(1-r^n)}{1-r} \; if \; r < 1$$

Discussion

The process of learning mathematics can utilize various learning resources in the culture and environment around students. The existence of a socio-cultural environment shows the relationship of individuals with the environment, both to social interactions and other objects around them, including thoughts and behaviors that have become habits or customs (Moalosi et al., 2010). Everything in the surrounding environment can be used as an alternative to learning mathematics. *Gamelan*, one of the Javanese cultures close to student life, especially in Yogyakarta, is expected to be one of the learning resources that can be utilized in learning mathematics.

Learning occurs when there is interaction between students and educators, between students and students, and between students and the environment during learning. Cooperation between educators, students, and the learning environment can support the learning process. Bruner's learning theory holds that learning emphasizes the influence of culture on a person's behavior. The learning process will run well and creatively if the teacher provides opportunities for students to find a concept, theory, rule, or understanding through examples encountered in their lives (free discovery learning). By presenting and incorporating cultural wisdom values into the mathematics learning process, students are expected to better understand mathematical concepts contextually through cultural results in the surrounding environment.

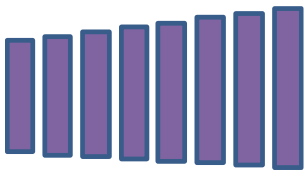
According to Bruner, the stage of representation of a person in learning can be divided into three stages, i.e., the enactive, iconic, and symbolic (Kincheloe & Horn, 2007). In the enactive stage, students learn by doing activities to understand the surrounding environment. At the iconic stage, learners learn through pictures and verbal visualizations. The symbolic stage is characterized by learners having been able to have abstract ideas or ideas strongly influenced by their ability in language and logic. In understanding the surrounding world, the child learns through the symbols of language, logic, mathematics, and so on using many symbols. The more mature a person is in his thinking, the more dominant his symbol system will be. The use of media in learning activities is proof that there is still a need for an active and iconic system in the learning fields (Budiningsih, 2005). Using *gamelan* as one of the contexts for learning mathematics is in line with the stage of representation presented by Bruner. With these stages, it is expected that students will find it easier to interpret mathematics because it is directly related to the activities around them. Learning activities on the Set topic presented in Table 1 provide examples of learning that can be done at each stage of representation.

Table 1. Learning Sets Activities through *Gamelan* Context

Representation Stage	Learning Activities	Basic Concepts of Mathematics
Enactive Stage	Learners watch a *gamelan* performance. Students can get to know the *gamelan* instrument directly and its characteristics.	Universal set
Iconic Level	Learners begin to group the types of *gamelan* instruments according to their characteristics. They can create drawings, sketches, or charts to facilitate grouping.	Elements or Set Membership, Subsets
Symbolic Level	Students write down sets that can be formed from *gamelan* instruments along with the tones used. They can write in several ways, one of which is with set-forming notation.	Subsets, intersection of sets, union of sets.

Furthermore, Table 2 presents learning activities on the topic of Number Patterns which provide examples of learning that can be done at each stage of representation.

Table 2. Learning Activities on the Topic of Number Patterns

Representation Stage	Learning Activities	Basic Concepts of Mathematics
Enactive Stage	Learners watch a *gamelan* performance. Students can get to know *gamelan* instruments, especially xylophone, along with the characteristics of the blade length (there are 21 blades). 	Measurements, patterns on concrete objects
Iconic Level	After taking measurements, students begin to make drawings, sketches, or charts to create mathematical models on the length of the xylophone blade. 	Arithmatic Sequence
Symbolic Level	Students write down numbers formed from the pattern of blade length on the xylophone. $U_1 = 29$ $U_2 = 30$ $U_3 = 31$ $U_4 = 32$ Further, the participants were educated to solve the given problems such as: "What is the length of the 15th blade?"	Arithmetic Sequence

In addition to preserving culture, the use of *gamelan* as a context in learning can also insert good characters during learning. Based on observations and interviews, each *gamelan* instrument name contains a good meaning that can be exemplified. For example, the kendhang instrument comes from the word "*ndang*" which means to hurry up in the worship of the Supreme Creator. In addition, another meaning is that humans must immediately carry out activities in the morning so that sustenance comes

to them. Bonang instruments have a *"nang"* sound when played. The sound is interpreted as after humans are born. Humans must be able to think with a clear heart, so the decisions taken are full of awareness. The *saron* instrument comes from the word "*sero*" which means hard. Saron taught people to always be vocal in speaking the truth. The value of good character can be inserted at each stage of learning, so it is expected to inspire students to always have good character in their lives.

Although this research provides insight into integrating *gamelan* for mathematics learning, several limitations must be noted. First, the focus on the ethnomathematics of *gamelan*, while culturally rich and pedagogically promising, is specific to the Indonesian context. Generalizing these findings to other cultural settings may require careful consideration of unique cultural nuances.

Research should be conducted that involves more diverse groups of people and observes different types of schools. It would be helpful to see whether *gamelan* can benefit people of different ages. Conducting more extended research can help us see whether the use of *gamelan* for mathematics remains effective over time. Talking to teachers and students about their thoughts on using *Gamelan* in math classes is also a good idea. To extend the impact of this research, educators and policymakers are encouraged to consider strategies for the widespread incorporation of cultural elements, such as *gamelan*, into the mathematics curriculum. This might involve teacher training programs, curriculum adjustments, and the creation of interdisciplinary learning materials that seamlessly integrate cultural content with mathematical concepts.

CONCLUSION

Gamelan cultural values can be used as an alternative to mathematics learning, especially on number patterns and set through mathematical values in *gamelan* culture. Presenting the concept of mathematics by integrating cultural values in *gamelan*, has a positive contribution to the preservation of the nation's culture and the mathematical ability of students in learning mathematics at school. Ethnomathematics is considered relevant for mathematics learning today, especially for Indonesians who have cultural diversity. Indirectly, students can appreciate mathematics while appreciating *gamelan* culture through mathematical values contained in *gamelan* culture.

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