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Article

Utilization of Local Wisdom in Ponorogo Wayang Gamelan as a Source of Science Learning: Socio-Cultural Analysis and the Concept of Sound Vibration Physics

Firly Urbatussa'adah ^{1 *}, Nungky Rahmawati ², Refina Dzurotul Mahmudah ³

¹²³ Kiai Ageng Muhammad Besari State Islamic University, Ponorogo, Indonesia

* Correspondence address: firlyurbatus@gmail.com

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ABSTRACT

Gamelan is an example of local wisdom that needs to be preserved, one way is by integrating it as an educational tool. Gamelan musical instruments are very relevant to junior high school science material on Vibration and Sound. This can be demonstrated because of the differences in sound when the gamelan is played. This study aims to identify ethnosociophysics practices in gamelan puppetry, especially those in Ponorogo, and the reconstruction of traditional knowledge into modern science. This study uses a qualitative research type through an ethnographic approach, and uses research methods in the form of direct observation and interviews at the residence of Mr. Muh. Hadi as the owner and player of the gamelan. Literature studies are also used to strengthen the research data. The practice of making, techniques, and how to play gamelan musical instruments is still very simple but also follows the development of the times and can be reconstructed into modern science. Gamelan can be used as a topic or educational tool, especially in the material of Vibration and Sound, this is included in contextual learning, so that students can understand science material by relating it to real-life practices.

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INTRODUCTION

The current era of globalization threatens local cultural values in Indonesia. Cultural values and local wisdom have changed, and the younger generation has abandoned them. Preserving Indonesian culture is very difficult, despite the many conveniences offered by modern progress. Those living in Indonesia today tend to prefer and enjoy learning about other cultures rather than their own. They seem to forget that Indonesian culture is very diverse, and this diversity is a significant asset for Indonesia, making it known to others. It is crucial for students to instill a love of Indonesian culture in themselves so that Indonesia's local wisdom remains strong and remembered. By using an ethnosociophysics approach, it is hoped that students can learn contextually and utilize their environment as a learning resource. This approach is intended to address current issues. The intellectual generation grows, develops, and is shaped in educational institutions. An ethnographic approach is used to teach students to maximize contextual blended learning and enhance the environment as a learning resource (Fahrozy et al., 2022).

Physics education in schools largely focuses on material found in textbooks. Not many physics courses truly explain and apply the cultural and social realities surrounding students. The content studied is not fully integrated with culture and society. Given this phenomenon, new learning methods must be created, and these methods must be usable (Nahda, 2024). Like the material on vibration and sound, this material is difficult to visualize and is relatively limited by textbook formulas. Therefore, an ethnosociophysics approach is an appropriate step for implementing innovative learning.

One of the local cultures or traditions still preserved in Ponorogo Regency is the wayang performance. Wayang has existed and been known to the Javanese people for more than 1,500 years. The arrival of Hindu culture in Java caused wayang performances to evolve into what is now known as wayang (Anjani & Fahrudin, 2024). However, over time, especially when Islam entered Java, wayang was used as a medium for spreading Islam. Wayang performances became unique because they were accompanied by ancient music called "gamelan." Javanese gamelan is a traditional musical instrument that has been internationally recognized as a cultural heritage of the Javanese people. Most Javanese people often play gamelan at every celebration or event (Hananto, 2020). Gamelan is an indigenous Indonesian art form that has existed since the Majapahit kingdom and continues to survive to this day. It is a treasure owned by the Indonesian people. In 2014, the United Nations Educational, Scientific and Cultural Organization (UNESCO) designated gamelan as an Indonesian cultural heritage (Iswantoro, 2017). When played, the gamelan vibrates, producing sounds or rhythms. This aligns with the "Vibration and Sound" learning material.

Based on the background that has been described, the problem formulation can be drawn, namely regarding the use of gamelan so that it can be reconstructed into a scientific concept in science education, especially in the material of vibration and sound in grade 8 of junior high school. This study aims to identify gamelan practices in Ponorogo puppet performances that have social and cultural values, and reconstruct these values into teaching materials for the physics concept of vibration and sound in science education. Thus, this study not only helps preserve local culture, but also offers innovation in the creation of teaching materials based on local wisdom and integrated with social and cultural values.

The novelty of this research lies in the combination of an ethnosociophysics perspective in understanding gamelan, not only as a traditional musical instrument, but also as an educational tool that connects modern physics with local culture. This method offers a new perspective on how science learning can be contextualized with local cultural practices rich in values and meaning. Furthermore, this method helps promote cultural preservation in the school environment. Generally, students only learn from textbooks and memorize formulas about vibration and sound. Combining the culture of gamelan musical instruments with physics material on the concepts of vibration and sound in learning is very appropriate for teaching in schools.

METHOD

This research used a qualitative method with an ethnographic approach. An ethnographic approach is an in-depth study of the behavior of a culture or social group in its natural state. This means that the qualitative research approach, known as ethnography, aims to explore the culture of a community (Windiani & Farida Nurul R, 2016). The researchers used ethnography because they wanted data and information about wayang kulit gamelan.

To obtain research data and information, researchers use the following data collection techniques:

1. Observation

Observation is a data collection method by observing ongoing activities (Nova Ariyanti et al., 2022). The observation method is used to observe the structure of the shadow puppet

gamelan, the arrangement of the shadow puppet gamelan, and the sounds produced by the shadow puppet gamelan.

2. Interview

An interview is a meeting between two parties to share ideas and information through questions and answers to create meaning about a particular topic (Nova Ariyanti et al., 2022). The interview was conducted to obtain in-depth information about social science and physics concepts in wayang kulit gamelan. The interview was conducted with a resource person named Mr. Muh. Hadi, the owner and player of the gamelan.



Figure 1 Interview with Mr Hadi

3. Literature review

A literature review is a data collection method conducted by reading literature, books, notes, and various reports related to the problem to be solved (Aqil, 2020). The literature review method is used to explore knowledge or information from other sources, with the aim of gaining a deeper understanding and comparing the culture of gamelan shadow puppetry with other regions to identify the characteristics of each region.

Researchers conducted research using traditional gamelan instruments as the object of study. The gamelan instruments studied are generally used for children's practice and wayang performances in several areas in Ponorogo. The research was conducted twice, namely on Sunday, April 20, 2025, and Tuesday, April 22, 2025, at the residence of Mr. Muh. Hadi, the owner and player of the gamelan, in Gontor Village, Mlarak District, Ponorogo Regency. Below is a map and geographic coordinates.

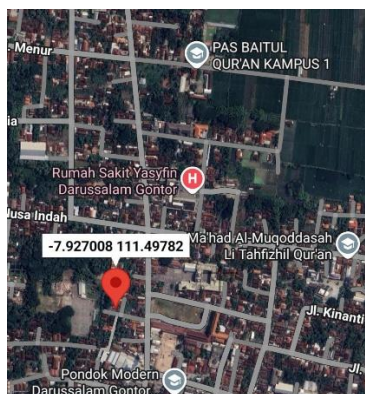


Figure 2 Map and geographic location

RESULTS AND DISCUSSION

Gamelan is a term that refers to a type of musical instrument that is formed and played as a single unit. Gamelan comes from the Javanese word *gamel*, which means to strike or beat, followed by the suffix "an" which makes it a noun (Iswantoro, 2017). Gamelan is a musical instrument present in Javanese culture. Therefore, it is not surprising that gamelan and Javanese society have a close relationship. Gamelan has several functions, including entertaining listeners, facilitating communication between players and audiences, facilitating communication between the community and ancestral spirits, representing cultural identity, accompanying dances, and others. According to the Javanese people, gamelan has its own social and spiritual values, such as educating a sense of beauty, cultivating polite character, and accompanying traditional or religious ceremonies. Gamelan wayang has social and cultural elements in community life. Over time, people began to view gamelan in wayang as only an additional element in wayang, namely as an addition to artistic beauty (Handayani & Swazey, 2019). However, if interpreted more deeply, gamelan in wayang can be used as an educational medium, forming social bonds in society, and conveying cultural values.

The relationship between gamelan musical instruments and education

The relationship between gamelan and education is deeply intertwined and multidimensional, making it a flexible and beneficial medium, not only musically but also for character development and cultural preservation. Fundamentally, gamelan serves as a means of cultural education that introduces the younger generation to Indonesia's traditional heritage, instilling an understanding of the philosophical, social, and spiritual values inherent in the art of *karawitan*. In educational institutions, from elementary school to university, gamelan lessons directly train musical skills such as instrument playing, understanding music theory, and sharpening one's listening (Widayat, 2021). Furthermore, the process of playing gamelan also fosters systematic, creative, and critical thinking skills in students, as they must follow a regular rhythmic pattern while also being able to improvise within existing constraints.

Beyond cognitive aspects, gamelan is a highly effective medium for developing character education and social skills. Playing gamelan is a collaborative activity that requires each player to listen to each other, respect the roles of others, and work together as a whole ensemble. This fosters a sense of togetherness, unity, and respect for diversity. Mental attitudes such as respecting the instructor (teacher/coach), listening to directions, and not dominating the game are also inherently taught in the learning process. Furthermore, gamelan also plays a role in developing a healthy personality; its distinctive gamelan rhythms can have a relaxing effect that helps reduce stress and anxiety, and provide a positive outlet for emotions. Thus, gamelan not only preserves traditional arts but also contributes significantly to shaping individuals with musical skills, strong character, and a deep appreciation for their nation's culture.

Gamelan wayang plays a significant dual role in the educational context, not only as a traditional musical instrument but also as a learning resource rich in ethnosociological values (Nurzaytun & Susilowati, 2025). Socially and culturally, gamelan serves as a medium for education and cultural inheritance, instilling polite character, and fostering a sense of beauty. Through wayang performances accompanied by gamelan, life values and morality can be conveyed effectively and indirectly to the younger generation. Specifically, in science education (IPA) at the junior high school level, gamelan is highly relevant to the topic of Vibration and Sound. Each gamelan instrument, such as the *saron* or *gong*, operates based on the principles of physics, where a blow triggers mechanical vibrations that produce longitudinal sound waves. Scientific concepts that can be learned contextually include frequency, which

determines pitch (for example, a shorter bar produces a higher pitch), and amplitude, which affects the loudness of the sound (a strong blow produces a loud sound). Furthermore, the resonance phenomenon in instruments such as gongs and kenongs can explain how resonators dramatically amplify sound, while wave interference is intuitively utilized by players to create harmony. The integration of gamelan into science materials is an example of Contextual Teaching and Learning (CTL) (Purnomo et al., 2018). This approach has proven effective because it connects physics materials with students' local culture, thereby increasing their motivation and understanding of scientific concepts. Thus, utilizing local gamelan wisdom not only preserves cultural heritage but also offers innovation in integrated and contextual science learning.

The creation and use of gamelan instruments and the vibrations and sounds they produce

The main focus in the gamelan-making process lies in the metal forming stage. In general, this process consists of five stages: melting, casting, forging, grinding, and tuning. Over time, gamelan-making techniques have undergone significant changes compared to the past. As stated by Muh. Hadi, "In the past, the manufacturing process was still done manually, while today it is mostly done with the help of machines. In the past, melting, casting, and other stages required greater labor, although the resulting sound quality was not much different." From this statement, it can be concluded that the gamelan-making process in the past was more complex due to technological limitations. At that time, the main material used was generally bronze, which had to undergo a process of melting, forging, and shaping manually. In contrast to the current situation, gamelan production today mostly uses materials such as brass or iron, which can be shaped more easily through machine casting and welding techniques.

There's an interesting aspect about the Javanese people: Javanese society is deeply rooted in tradition and culture, leading to rituals before making gamelan instruments. Performing these rituals is believed to ensure the success of the process. The rituals used in each region also vary, depending on the beliefs of the craftsmen. There are three rituals commonly performed by gamelan craftsmen: 1) Slametan (a traditional Javanese holiday), 2) fasting for a full day, and 3) abstaining from sexual intercourse the night before the gamelan is made (Handayani & Swazey, 2019).

Wayang gamelan is similar to gamelan in general, namely having an ensemble featuring metallophones, xylophones, drums, and gongs. There are various types of materials used in making gamelan, such as bronze, brass, and iron. The materials used in gamelan affect the frequency and quality of the sound produced. The denser the material, the lower the frequency of the sound produced, while thinner materials can produce a louder sound. Bronze is considered the best material because it can produce a rich and loud sound. Therefore, bronze gamelan materials are more expensive because they produce the most beautiful frequencies. In addition to gamelan made of metal, there are gamelan parts made of wood, such as drums and gamelan mallets, but not all types of wood can be used. This was also explained by Mr. Hadi, "Usually, the wood used is jackfruit and rain tree wood, which produce a louder and more beautiful sound," said the gamelan owner. The criteria for selecting wood for gamelan production are weight, durability, and strength, straight grain, yellowish-brown color, and hardness (Jepri et al., 2016). The size of a gamelan instrument also affects the frequency of the sound it produces. This applies to the saron, whose blades taper toward the right. Conversely, its octaves become higher and more strident toward the right. This occurs because the wider blade has a concave shape underneath, so the sound produced when struck appears to buzz and vibrate. Below is an image of the concavity beneath the saron blade.



Figure 3Curves on the saron

The meaning of the gamelan's sounds depends on the piece being played. If the gamelan is struck more forcefully, the rhythm reflects passion. If the wayang is played softly and calmly, the gamelan beats become softer. The players' seating arrangement is also crucial, as it can affect the balance of the sound, the clarity of the musical structure, and the smoothness of communication between team members. The wiyaga (gamelan players) also have their own seating arrangements. The most common seating technique is sitting cross-legged. If the wiyaga sits in the wrong position, the sound produced by the gamelan will certainly be less than optimal.

Types of Gamelan Wayang Musical Instruments

Wayang gamelan consists of a variety of musical instruments, each played in a different way by each individual. The wayang gamelan at Mr. Muh. Hadi's residence in Gontor Mlarak, Ponorogo, features six types of instruments. The following are the traditional gamelan instruments used in wayang performances.

Table 1. Types of Gamelan

Musical Instrument Pictures	Name of Musical Instrument	Material	How to Play	Sound Produced
	drum	Wood and Leather	Beaten or beaten	Low and shaky
	Saron	Bronze, metal, iron	The right hand attacks, the left hand holds the sword blade	Loud, sharp, shrill, and short resonance
	Gender	Bronze, brass, and iron	The right hand attacks, the left hand holds the sword blade	Soft, vibrating, and long resonating

	Bonang	Bronze, brass, and iron	Beaten	Loud, bright, shrill, and clear
	Kempul	Bronze, brass, and iron	Beaten	A resonant, round, and long resonance
	Gong	Bronze, brass, and iron	Beaten	Deep, resonant, and very long resonance

The musical scale used in gamelan is called titi laras. The musical scale or titi laras used in gamelan is a pentatonic scale. A pentatonic scale is a scale that has 5 notes in its arrangement. In gamelan, there are two types of pentatonic scales, namely titi laras pelog and titi laras slendro (Rudiansyah: 2015). Titi laras slendro has 5 notes, namely 1, 2, 3, 5, and 6. Meanwhile, titi laras pelog has 7 notes, namely 1, 2, 3, 4, 5, 6, and 7.

Cultural Ensembles and Social Aspects of Gamelan Wayang in Social Interaction

The wayang gamelan cultural ensemble is not simply a collection of musical instruments, but rather a complex cultural system rich in artistic, philosophical, and social values. Its interaction in society is very significant, functioning as a social glue, a medium for education and cultural inheritance, an expression of identity, entertainment, a means of moral communication, and contributing to the economy (Damarsha et al., 2024). Understanding and preserving wayang gamelan means preserving cultural richness and strengthening positive social interactions in society. Wayang gamelan is not simply accompanying music for shadow puppet performances, but rather a cultural ensemble rich in artistic values, traditions, and social interactions. The wayang gamelan ensemble is a traditional Javanese orchestra rich in diverse instruments, creating complex and dynamic harmonies and melodies. This ensemble includes metal percussion instruments such as the saron, demung, peking, bonang, and gender, as well as large gongs such as the kempul, kenong, gong ageng, and suwuk. The kendang serves as a rhythmic regulator, while the rebab, suling, and sindhen vocals complete the melody and sound texture. Each of these instruments has its own distinctive role and playing technique, reflecting the extraordinary richness of Javanese cultural expression.

Wayang gamelan music is highly structured, always following the storyline and scenes of a wayang performance. Each "pathet" (musical mode) and "gendhing" (musical composition) has unique emotional characteristics, designed to reinforce the mood and message conveyed in the story. The function of music here is not only as accompaniment, but also to provide dramatic emphasis, create smooth transitions between scenes, and even become a "language" in itself that can be understood by the audience. To be able to play wayang gamelan well, high technical skills and a deep understanding of the traditions and context of the performance are required. The nayaga (gamelan players) must not only master their respective instruments, but also be able to interact and respond to each other musically, creating

intuitive harmony (Damarsha, 2023:1). Knowledge of the pathet, gendhing, and their relationship to the wayang story is also crucial. Beyond their musical beauty, some of the instruments and melodies in wayang gamelan are also loaded with symbolic and philosophical meaning. This is often related to Javanese cosmology, life values, and the characters of wayang characters. For example, the sound of the gong ageng is often believed to represent the power of the universe, indicating the depth of meaning contained within each element of the gamelan.

More than just a performing art, gamelan wayang plays a significant social role in Javanese social interactions. It serves as a social and communal glue; gamelan wayang rehearsals and performances often involve many people of various ages and backgrounds (Nurzaytun & Susilowati, 2025), strengthening bonds of brotherhood and a sense of togetherness. Gamelan is also an important medium for education and cultural transmission, where younger generations learn about traditional music, wayang stories, ethics, and morals, thereby preserving cultural heritage. As an icon of Javanese cultural identity, the presence of gamelan wayang at various events reinforces local identity and even becomes a tourist attraction. Furthermore, wayang kulit performances accompanied by gamelan are a popular form of entertainment and recreation that creates a festive and solemn atmosphere at various celebrations. Through wayang stories accompanied by gamelan, it also serves as an effective medium of communication and moral education, indirectly conveying life values. Finally, the existence of gamelan wayang also supports the local economy by involving instrument craftsmen and various parties supporting the performance, ultimately creating jobs and driving the creative economy in the region.

Physics of Vibration and Sound in Wayang Gamelan

Although gamelan is a traditional art form, the principles of physics play a crucial role in producing its distinctive and harmonious sounds (Nurzaytun & Susilowati, 2025). Every time a player strikes a gamelan instrument such as the saron, demung, peking, bonang, gender, kempul, kenong, or gong, the blades or tongues vibrate. This vibration is the primary source of sound. From this mechanical vibration, energy is transferred to the surrounding air molecules, creating longitudinal sound waves that travel until they reach our ears. The frequency of this vibration determines the pitch of the resulting sound. Imagine, the faster the blades vibrate, the higher the frequency of the sound waves, and the louder the pitch we hear. This is why shorter and thinner blades tend to produce higher pitches. Meanwhile, the amplitude of the vibration affects the loudness or volume of the sound. A stronger strike will produce a greater amplitude, making the gamelan sound louder and more thunderous.

The phenomenon of resonance plays a crucial role in amplifying gamelan sounds. Examples include gongs and kenongs, which have resonators at the base of their bells. These resonators are hollow chambers specifically designed to amplify sound. The size and shape of these resonators are crucial because they affect the length of the air column within them. This air column has a natural frequency at which it vibrates. When the frequency of the sound produced by the hammer aligns with the natural frequency of the air column in the resonator, resonance occurs. As a result, the amplitude of the sound waves within the resonator increases dramatically, creating a sound that is not only louder but also has longer sustain, lending a magical feel to each strike. The differences in the resonator sizes of gongs and kenongs also cause them to produce different fundamental tones.

English: When a bar or pencon vibrates, it produces not only a single fundamental frequency, but also emits other, higher frequencies, known as harmonics or overtones. This

unique combination of fundamental and harmonic frequencies is what gives each gamelan instrument its distinctive timbre, making each one unique. When multiple gamelan instruments are played together, the sound waves they produce interfere with each other. Constructive interference occurs when wave crests from different sources meet, amplifying each other and producing a louder sound. Conversely, destructive interference occurs when wave crests from one source meet wave troughs from another source, causing the sounds to weaken each other, even disappearing at certain points. Nayaga, or gamelan players, intuitively exploit this principle of interference to create beautiful harmonies from the combination of multiple simultaneously played notes and captivating melodies, forming rich musical patterns that correspond to the storyline of wayang (wayang puppetry) .

The choice of material and shape of the instrument also significantly impacts the sound quality of the gamelan. Most instruments are made of bronze or other metal alloys, chosen for their excellent resonance, producing a rich, long-lasting sound. The quality and composition of the metal directly affect the timbre and sustain of the sound. Furthermore, the shape and thickness of the blade or tongue also affect the frequency and quality of the sound. Different shapes can create different vibration patterns, resulting in an infinite variety of timbres. The larger the overall size of the instrument, the lower the range of notes it can produce. The acoustics of the room where the puppet show takes place play a crucial role in the listening experience. Sound waves from the gamelan are reflected off the walls, floor, and ceiling of the room. These reflections can produce echoes or reverberation, which are repeated and rapid reflections of sound. Well-designed room acoustics will produce balanced reflections, enriching the gamelan sound without making it too harsh or unclear, so that every note sounds clear and harmonious.

These physical concepts do not stand alone but interact in complex ways within the wayang gamelan ensemble. The instrument makers' skill in selecting materials and designing shapes, as well as the nayaga's sensitivity in striking the instruments with precise techniques, produce harmonies that support the atmosphere and narrative of a wayang performance (Cahyanti et al., 2024). An intuitive understanding of resonance, wave interference, and the sound characteristics of various instruments allows for dynamic and expressive music. Thus, while wayang gamelan is a profound cultural art form, its foundations in physics—vibrations, sound waves, resonance, and interference—are crucial elements that enable the creation of the beautiful sounds we hear and enjoy. This demonstrates how science and art can blend harmoniously within a rich tradition.

Science Concepts and Their Relation to Junior High School Student Learning Outcomes

This reading on the concepts of vibration and sound in wayang gamelan has strong relevance to the Learning Outcome (CP) in Natural Sciences (IPA) for junior high school/Islamic junior high school level, particularly in the Physics element. This text comprehensively explains how each strike on a gamelan instrument triggers vibrations that then produce longitudinal sound waves, which travel to our ears. Concepts such as frequency, which determines pitch, and amplitude, which affects the strength of the sound, are explained concretely, such as how a shorter bar produces a higher pitch or a strong strike produces a thunderous sound. This directly supports the LO, which expects students to be able to analyze the characteristics of vibrations and waves and explain the processes of sound production and propagation.

Furthermore, this reading highlights the important phenomenon of resonance in instruments such as gongs and kenongs, where resonators are specifically designed to amplify sound. The explanation of how the sound frequency of the pencon aligns with the natural frequency of the air column within the resonator to increase the amplitude of sound waves provides a concrete example of the application of resonance, vibration, and waves that students must understand according to the Science Competency Standards. Students can understand vibrations and waves that are frequently used in everyday life. This embodies Core Competency 3.11, analyzing the concepts of vibration, waves, and sound in everyday life, including the human auditory system and sonar systems, as well as Core Competency 4.11, presenting experimental results on vibration, waves, and sound. Furthermore, the complexity of gamelan sound is explained through the concept of harmonics (overtones) that form the unique timbre or sound color of each instrument, as well as how wave interference, both constructive (which amplifies the sound) and destructive (which weakens the sound), is intuitively utilized by musicians to create harmony. Understanding pitch, timbre, resonance, and sound wave interference is an integral part of the science learning outcomes in junior high school. The text also discusses the important role of instrument material and form in determining the sound quality of gamelan instruments. The choice of bronze for its good resonance, as well as the influence of the shape and thickness of the bar on the frequency and quality of the sound, provides an applicable illustration of the relationship between material properties and the characteristics of the resulting object, in accordance with CP. Finally, the discussion of the acoustics of the room where puppet shows take place, which involves sound reflections such as echoes or reverberation, is highly relevant to CP, encouraging students to apply the concepts of sound reflection and absorption in room design. Thus, this reading not only enriches students' understanding of basic physics concepts but also demonstrates how science and art can blend harmoniously within a profound cultural heritage.

The Effectiveness of Wayang Gamelan in Integrating the Concept of Vibration and Sound in Science

Traditional gamelan instruments, commonly played in wayang performances, can be integrated into science concepts, particularly in physics lessons on vibration and sound. Combining the local wisdom of gamelan instruments with physics is crucial because, in addition to fostering a sense of nationalism, it also allows students to better understand vibration and sound, such as frequency, amplitude, and wave types, as these instruments are abundant in the concepts of vibration and sound. Local wisdom is rarely integrated into the learning process, especially in physics education, or even combined with it. The values of local communities, rich in local wisdom, are neglected in various types of learning. Yet, this integration is very possible to implement in the learning process. One way or solution is to integrate local wisdom into physics learning (Erlangga et al., 2022).

When gamelan is played, the concepts of vibration and sound occur within the gamelan. Gamelan produces sounds, such as gongs, kenongs, sarons, and bonangs, due to mechanical vibrations on metal surfaces. Sound waves then propagate through the air and produce sounds or rhythms. The aspect of cultural contextualization also shows how effective wayang gamelan is in integrating scientific concepts. Students tend to feel closer and more motivated to understand the material being taught because the physics material is related to their local culture. This integration is also an example of CTL (Contextual Teaching and Learning). Contextual learning (CTL) is an idea that helps teachers connect subject matter to real-world situations and motivates students to connect what they know with what they can do in their lives as family members, citizens, and members of the workforce (Anggraini, 2017). In practice, gamelan has an inseparable relationship with scientific concepts. Cultural acculturation plays a very

important role in the concept of scientific reconstruction of gamelan, which is increasingly evident along with the rapid development of science. The following is an overview of local practices that have been reconstructed into scientific concepts.

Table 2. Scientific Reconstruction

NO.	Community Activities	Indigenous Practices (Indigenous Knowledge)	Scientific Knowledge (Modern Science)
1	Making gamelan instruments from certain materials	Making gamelan instruments from certain materials to produce good sounds	Material selection in gamelan construction is crucial because the density, mass, and elasticity of the material can affect the sound frequency. There are differences in resonance and sound intensity based on the material: silicon bronze has a resonance duration of 15.4 seconds, while steel only has a resonance duration of 6.6 seconds, and the intensity also varies (Santoso et al., 2019). Science Concepts: Frequency and Amplitude
2	Making gamelan instruments with certain sizes	Gamelan instruments are made in various sizes because they can produce a wide variety of sounds.	The choice of size, shape, and striking technique significantly affects the resulting sound. The relationship between the instrument's length and its area, as well as the wavelength and frequency of the sound, also plays a role. Furthermore, the striking technique, whether hard or soft, is directly proportional to the resulting sound. As with the angklung, the shorter the tube, the higher the frequency, and the tube diameter also affects frequency (Nurhidayati et al., 2022). Science Concepts: Wavelength and frequency
3	Ritual before making gamelan	In the past, before making gamelan, local people would perform special rituals, such as fasting and so on. This was believed to ensure a smooth construction process and produce a beautiful sound.	Preparation procedures ensure focus, concentration, and quality results, while scientific production principles minimize errors. Gamelan makers use the time during rituals to reflect and analyze materials, dimensions, and construction techniques (Handayani & Swazey, 2019). Science concepts: Work Preparation Procedures
4	Store the gamelan in a special place	Gamelan instruments are stored in special places to prevent damage and changes in the sound they produce.	Protecting musical instruments from humidity, high temperatures, and metal oxidation is a key principle. Humidity and high temperatures can cause metal or iron to rust. This rust will affect the sound quality produced when the gamelan is played. Furthermore, rust also reduces the gamelan's aesthetic value. Atmospheric corrosion (humidity, pollution, oxidation) affects copper and bronze, the primary materials used in metal instruments such as gamelan and bells (Sugeng Slamet et al., 2021). Science concepts: Humidity and Temperature

The results of scientific reconstruction indicate that students can gain a better understanding of cultural activities related to science and how these activities relate to their education. Furthermore, these findings demonstrate a connection between scientific traditions and modern education (Kristanto et al., 2024).

CONCLUSION

The conclusion of this study is that gamelan musical instruments can be used as a learning resource because they are a form of local wisdom directly related to modern scientific concepts of vibration and sound. The size, shape, and materials used in their construction greatly influence the sound they produce. In the social realm, gamelan functions as a social glue and community builder, as well as entertainment for the local community. In the cultural (ethno) realm, gamelan plays an important role in the inheritance of culture and identity, as well as in moral education in everyday life. This shows that local gamelan wisdom not only provides

cultural and social values, but also provides an example of the integration of contextual learning with modern scientific concepts.

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