

Integrating Ethnoscience of Gejog Lesung into Science Education: A Mixed-Methods Study on Cultural Contextualization of Sound Wave Concepts

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ABSTRACT

Integrating local cultural knowledge into science education can provide meaningful contexts for understanding abstract scientific concepts. Gejog Lesung, a traditional Javanese musical practice, contains observable sound-wave phenomena and therefore has potential as an ethnoscience-based learning resource. This study aimed to examine the relationship between Gejog Lesung ethnoscience integration and students' learning achievement and to explore its potential for contextualizing sound-wave concepts. This study employed an explanatory sequential mixed-methods design involving 102 prospective elementary school teachers selected through purposive sampling. The learning intervention was conducted in four meetings integrating Gejog Lesung with sound-wave concepts. Quantitative data were collected using a learning achievement test and an ethnoscience perception questionnaire, while qualitative data were obtained through classroom observations, open-ended responses, and documentation. Quantitative data were analyzed descriptively and inferentially, while qualitative data were analyzed through coding, categorization, and theme development. The findings identified period, amplitude, frequency, resonance, and sound propagation as scientific concepts embedded in Gejog Lesung. Quantitative analysis showed a positive relationship between ethnoscience integration and learning achievement ($R = 0.330$). Qualitative findings indicated that students perceived the learning activities as contextual, engaging, and helpful for understanding sound-wave concepts while increasing their appreciation of local culture. These findings suggest that Gejog Lesung can serve as a culturally relevant science learning resource that bridges local knowledge and formal scientific concepts. Further studies with more diverse samples and stronger experimental designs are recommended.

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1. INTRODUCTION

Indonesia is some archipelagic country rich in culture. The cultural diversity in Indonesia poses challenges in the field of education, especially in the 21st century (Coutinho et al., 2020). The challenges of the 21st century urge teachers to be more creative in enhancing their students' learning skills. Increasing awareness of the importance of ethnosciences at all levels of education, supported by a learning approach focused on the development of ethnoscientific skills (Rahayu et al., 2021; Suprpto et al., 2021). The ethnoscientific skills of students will be key to ensuring that every student in Indonesia is ready to face the rapidly evolving demands of the 21st century (Ardianti et al., 2023). It is hoped that with good ethnoscientific skills, students will become knowledgeable, creative, and empathetic individuals. However, the situation in the field is still far from the goal (Siew & Chin, 2009). The lack of ethnoscientific skills among students, especially during teaching and learning activities, has been noted (Abdjul & Katili, 2021). Previous research indicates that many students still do not fully understand the ethnosciences of local wisdom in their environment (Duda et al., 2019; Rahayu et al., 2021). Ethnosciences, with an ethnos approach or known as ethnoscientific literacy, is a form of learning that emphasizes self-ability in analyzing, reading, and writing based on local wisdom (Abdjul & Katili, 2021; Ramdani et al., 2021). Local wisdom can involve cultures that apply habits or cultural symbols to evoke scientific concepts. Scientific concepts need to be applied given the multitude of branches of knowledge applied in basic education (Hartini et al., 2018). Ethnoscientific literacy can serve as a bridge to improve the quality of Indonesian education, especially for students in elementary teacher education (Handayani et al., 2023; Kordigel Aberšek et al., 2015).

The integration of Gejog Lesung ethnoscience into science education opens up opportunities to bridge the gap between traditional knowledge and modern education. Traditional knowledge, such as the Gejog Lesung practice of using the rhythmic sound of a wooden mortar, reflects the community's empirical understanding of sound wave phenomena. However, this knowledge is often not accommodated in formal curricula that emphasize Western scientific theory. As a result, students lack exposure to local riches that are actually relevant to the science concepts they are learning (Widiyanti et al., 2021).

This gap is also caused by modern learning approaches that tend to be disconnected from the cultural context and everyday lives of students. Modern science education focuses on abstraction and generalization of concepts, while traditional knowledge is contextual and applicable. This creates an epistemological distance between "school science" and "community science," making it difficult for students to connect learning to their own cultural experiences (Suryawati & Osman, 2022). Without contextual integration, science in schools can feel foreign and less meaningful to students. Therefore, the integration of ethnoscience, such as Gejog Lesung, is a crucial strategy for creating meaningful, relevant, and culturally inclusive science learning. By examining the sounds produced by Gejog Lesung, students can understand the concepts of frequency, amplitude, and resonance in a real-life local context. In addition to improving scientific literacy, this approach also fosters an appreciation for local wisdom as a legitimate and scientifically valuable learning resource (Rahayu et al., 2023). This integration is expected to narrow the gap between traditional knowledge and modern education, while strengthening the nation's cultural identity.

The integration of ethnoscience in education is a strategic effort to contextualize science learning with local culture. Ethnoscience believes that the practices and knowledge of traditional communities contain scientific values that can serve as authentic learning resources. In the context of science education, the application of ethnoscience encourages students to understand scientific concepts through phenomena close to their lives, such as the use of traditional musical instruments, agricultural systems, and herbal remedies. Research shows that an ethnoscience approach can improve students' conceptual understanding and scientific literacy by connecting school science with their cultural experiences (Suryawati & Osman, 2022; Kurniawan & Fauziah, 2024). This approach not only strengthens cultural identity but also fosters an appreciation for science as a universal product rooted in various cultures (Rahayu et al., 2023).

Meanwhile, local wisdom in the context of STEM (Science, Technology, Engineering, and Mathematics) plays a crucial role in building integrative and contextual learning. Linking local wisdom with STEM helps students develop critical, creative, and collaborative thinking skills through the exploration of technology and traditional practices rich in scientific value (Rahmawati & Ridwan, 2021). Furthermore, this integration contributes to the development of soft skills, such as communication, cultural empathy, and teamwork. Ethnoscience-based learning in STEM not only emphasizes cognitive achievement but also shapes 21st-century character and competencies needed in the global era (Widiyanti et al., 2021; Lestari & Susilo, 2020). Thus, the integration of ethnoscience, local wisdom, and soft skills development creates a holistic, relevant, and sustainable science education.

This study examines ethnoscientific literacy in natural science learning, especially in elementary schools. Science learning focuses on the students' learning process, adapting to their own abilities. Understanding the subject matter will be easier to grasp as it is tailored to each student's abilities (Ardianti et al., 2023). Science learning allows students to learn according to their abilities and needs, making them more comfortable in their learning activities. Through science learning, students can cultivate their identity and socialize norms and values of society adapted to their own regional conditions. Science learning emphasizes the qualification of achieving varied learning objectives (Material, 2022).

Effective learning processes will produce quality graduates ready to enter the workforce. Learning science can be applied by utilizing infrastructure and culture in a region (Nunaki et al., 2019). Learning science from musical instruments is a challenging field that requires individuals resilient to work pressure. Educational partners such as traditional musical instrument practitioners are intriguing subjects for study. Based on observations, complaints are still prevalent in the workforce such as the low quality of accepted workers, lack of resilience, and easily discouraged due to encountering different cultures. This condition is disadvantageous for both parties (Rezkiti & Fitrotun, 2016; Suprpto et al., 2021). If not addressed promptly, it can hinder the achievement of learning goals for students leading to obstacles and challenges in the field of education. Consequently, the decline in students' soft skills such as communication, teamwork, and critical thinking skills can hinder the improvement of educational quality (Budaya & Abad, 2018).

Higher education institutions are educational institutions that need to prepare young generations early on to have quality in global competition. Through soft skills, students can enhance creativity in the workforce, compete effectively, and have high levels of discipline. Based on the emerging issues in the field of education, this research offers a solution in the form of Strengthening Ethnoscientific Literacy Through Science Learning to Improve Students' Soft Skills Towards Quality Education with Global Competitiveness (Coutinho et al., 2020; Rupnik & Avsec, 2020). This study aimed to analyze the influence of ethnoscience in the Gejog Lesung musical instrument on students' learning achievement, as well as to explore Gejog Lesung as a source of science learning. Based on the description above, the research question is how ethnoscience influences the Gejog Lesung musical instrument on student learning achievement, as well as being a source of science learning.

2. METHODS

2.1 Research Design

This study employed a mixed-methods approach using an explanatory sequential design to investigate the integration of Gejog Lesung ethnoscience in science learning, particularly in the context of sound wave concepts. In this design, quantitative data were collected and analyzed in the first phase, followed by qualitative data collection and analysis to explain and enrich the quantitative findings.

The quantitative phase focused on examining students' learning achievement and their perceptions of ethnoscience-integrated learning. The qualitative phase explored students' learning experiences and identified scientific concepts embedded in Gejog Lesung as a culturally contextualized learning resource. Integration of the quantitative and qualitative findings was conducted during the

interpretation stage to provide a comprehensive understanding of how Gejog Lesung ethnoscience supports the learning of sound wave concepts.

2.2 Participants

The participants consisted of 102 prospective elementary school teachers who were selected using purposive sampling. The participants were enrolled in a science education course and had participated in learning activities integrating Gejog Lesung with sound wave concepts. Purposive sampling was employed because the participants were expected to have direct experience with the ethnoscience-based learning activities and were therefore able to provide relevant quantitative and qualitative data.

2.3 Learning Intervention

The learning intervention was conducted in four meetings, with each meeting lasting 2×100 minutes. The learning process consisted of four stages: orientation, exploration, concept construction, and reflection.

During the orientation stage, the lecturer introduced basic concepts of sound waves and provided an overview of Gejog Lesung as a traditional cultural practice. During the exploration stage, students observed and played Gejog Lesung and examined the characteristics of the sounds produced by different striking patterns and intensities.

In the concept construction stage, students discussed the relationship between the observed sound phenomena and scientific concepts, including frequency, amplitude, period, intensity, resonance, and sound propagation. Students were also encouraged to connect their empirical observations with scientific explanations. During the reflection stage, students presented their findings, reflected on the learning experience, and completed the learning achievement assessment and perception questionnaire.

The integration of Gejog Lesung into science learning was intended to provide students with an authentic learning experience in which abstract sound wave concepts could be understood through a familiar cultural context.

2.4 Research Instruments and Data Collection

Data were collected using a student learning achievement test, a students' perception questionnaire, classroom observation, open-ended questionnaire responses, and documentation of learning activities.

The student learning achievement test was used to assess students' understanding of sound wave concepts. The test covered four indicators: concept understanding, application of knowledge, problem-solving skills, and critical thinking.

The students' perception questionnaire was used to examine students' responses to the integration of ethnoscience in science learning. The questionnaire included indicators related to scientific attitude, learning interest, learning motivation, cultural awareness, learning effectiveness, classroom engagement, and relevance to daily life.

Classroom observations were conducted during the implementation of Gejog Lesung-based learning to document students' participation, engagement, conceptual responses, and interactions during contextual sound-wave demonstrations. Open-ended questionnaire responses were used to obtain deeper information regarding students' experiences, their understanding of the relationship between Gejog Lesung and scientific concepts, and their perceptions of culturally contextualized learning.

In addition, documentation of Gejog Lesung performances and learning activities was used to identify relevant sound-wave concepts, including period, amplitude, frequency, resonance, intensity, and sound propagation.

2.5 Instrument Validity and Reliability

The research instruments were evaluated for content validity by two educational experts. The degree of agreement among the experts was analyzed using Aiken's V coefficient. The results indicated that the student learning achievement instrument obtained an Aiken's V value of 0.84, while the students' perception of ethnoscience integration instrument obtained an Aiken's V value of 0.82. These values indicated that both instruments met the required content validity criteria.

Instrument reliability was examined using Cronbach's alpha coefficient. The reliability coefficient for the student learning achievement instrument was 0.84, while the students' perception questionnaire obtained a Cronbach's alpha coefficient of 0.87. These values indicated a high level of internal consistency for both instruments.

2.6 Data Analysis

Quantitative data were analyzed using descriptive and inferential statistics with IBM SPSS. Descriptive statistics were used to summarize students' learning achievement and perceptions of ethnoscience integration. Inferential analysis was conducted to examine the relationship between the implementation of Gejog Lesung ethnoscience and students' learning achievement.

The correlation coefficient (R) was used to determine the strength and direction of the relationship between ethnoscience-based learning and students' learning achievement. The coefficient of determination (R^2) was used to estimate the proportion of variation in learning achievement associated with the ethnoscience-based learning variable.

Qualitative data obtained from classroom observations, open-ended questionnaire responses, and documentation were analyzed using descriptive qualitative procedures. The analysis involved data reduction, coding, categorization, data display, and theme development. The qualitative analysis focused particularly on identifying sound-wave concepts embedded in Gejog Lesung and explaining students' experiences in connecting cultural practices with scientific concepts.

2.7 Integration of Quantitative and Qualitative Data

Integration of the quantitative and qualitative findings was conducted during the interpretation stage. The qualitative findings were used to explain and contextualize the quantitative results, particularly regarding how students experienced the integration of Gejog Lesung and how cultural characteristics of the traditional instrument supported their understanding of sound wave concepts.

The integrated interpretation was intended to provide a more comprehensive explanation than either quantitative or qualitative data could provide independently. Quantitative findings described the measurable relationship between ethnoscience integration and learning achievement, whereas qualitative findings provided contextual explanations of students' conceptual understanding, engagement, and cultural experiences during the learning process.

3. FINDINGS AND DISCUSSION

3.1 Students' Responses to Gejog Lesung-Based Science Learning

The findings showed that students responded positively to the use of Gejog Lesung as a contextual science learning resource. Based on the questionnaire results presented in Figure 1, most students expressed positive levels of interest in using Gejog Lesung as a medium for learning science.

The positive responses were also reflected in students' participation during the learning activities. Students actively observed, played, and discussed the sounds produced by different striking patterns and intensities. These activities provided opportunities for students to relate direct observations of Gejog Lesung to scientific concepts associated with sound waves.

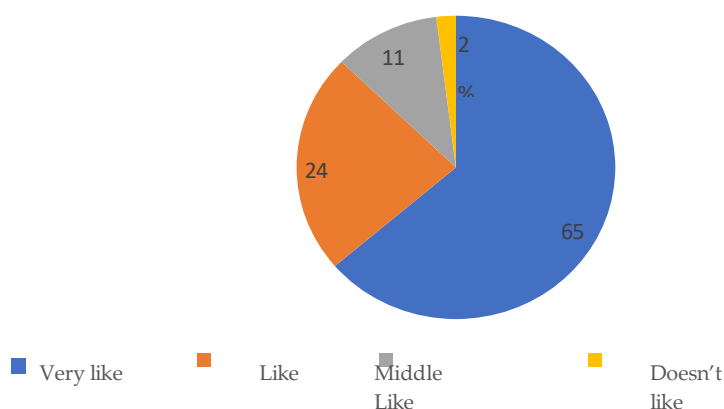


Figure 1. Students' responses to the use of Gejog Lesung as a science learning medium.

Science learning based on ethnosciences makes learning more meaningful and contextual. This ethnoscientific-based learning is in line with the current independent curriculum implemented in Indonesia. Teachers can develop themselves by determining media based on local wisdom, such as introducing regional music in science learning. The local culture, such as Gejog Lesung, can produce rhythmic and dynamic sounds. Playing Gejog Lesung is done collectively. The loudness of the sound produced emerges due to vibrations. The two main instruments in this traditional music are *gejog* and *lesung*. When a *lesung* is struck by a *gejog*, it produces a simple rhythmic sound. When repeated strikes are made with different intensities, it turns out to produce different sounds as well. The image of Gejog Lesung is shown in Figure 2.



Figure 2. The image of Gejog Lesung is shown

In science learning, sound occurs due to the vibration of an object. The sound produced belongs to the category of waves. The type of wave that includes sound is longitudinal. We require a medium to connect the ear and the Gejog Lesung. The intensity and number of strikes, as well as the manner of striking, result in various types of sound produced. There are single strikes, double strikes, combinations of two and one strike, and other variations of strikes.

3.2 Identification of Sound-Wave Concepts in Gejog Lesung

Qualitative analysis of the learning activities and observations identified several sound-wave concepts embedded in the Gejog Lesung performance. The identified concepts included period, amplitude, frequency, resonance, and sound propagation.

The period (T) was represented by the repetitive rhythmic strikes produced by the players. Variations in playing tempo resulted in differences in the duration of each rhythmic cycle. Amplitude

(A) was observed through differences in striking force, in which stronger and weaker strikes produced differences in sound intensity.

Frequency (f) was identified through differences in the sounds produced by variations in striking patterns, playing speed, and striking positions. Resonance was observed in the amplification of sound produced by the hollow structure of the lesung. In addition, the transmission of sound from the instrument to the listener illustrated the propagation of sound waves through air.

The identified science concepts are summarized in Table 3.

Table 3. Sound-wave concepts identified in Gejog Lesung

No.	Scientific Concept	Observation in Gejog Lesung
1	Period (T)	Repetitive rhythmic strikes form observable sound cycles whose duration varies according to playing tempo.
2	Amplitude (A)	Differences in striking force produce variations in sound intensity.
3	Frequency (f)	Variations in striking patterns, playing speed, and striking positions produce differences in sound frequency.
4	Resonance	The hollow structure of the lesung amplifies vibrations and the resulting sound.
5	Sound propagation	Sound generated by the instrument propagates through air from the sound source to the listener.

These findings indicate that Gejog Lesung contains observable physical phenomena that can be related directly to fundamental sound-wave concepts.

3.3 Student Learning Achievement

The learning achievement results were obtained from assessments conducted during the implementation of Gejog Lesung-based science learning. The quantitative analysis also examined the relationship between ethnoscience integration and students' learning achievement. The analysis produced a correlation coefficient of ($R = 0.330$). This value indicates a positive relationship between ethnoscience integration and students' learning achievement.

The current manuscript also reports a coefficient of determination ((R^2)) of 0.098. However, this value should be verified using the original statistical output before final submission because it is not mathematically consistent with the reported correlation coefficient of ($R = 0.330$).

Therefore, the quantitative result presented in this study is interpreted as indicating a positive relationship between ethnoscience integration and students' learning achievement rather than as evidence of a direct causal effect.

3.4 Students' Learning Experiences

The qualitative findings showed that students perceived Gejog Lesung-based learning as contextual and meaningful. Students reported that learning sound-wave concepts became easier to understand when scientific explanations were connected to a familiar cultural artifact.

Students also indicated that direct exploration of Gejog Lesung helped them understand concepts related to vibration, resonance, frequency, intensity, and rhythm. The hands-on learning activities enabled students to observe physical phenomena directly and relate these observations to scientific concepts discussed during the learning process.

In addition, students reported increased appreciation of traditional Indonesian culture. The learning activities encouraged them to recognize traditional musical practices not only as cultural heritage but also as potential sources of scientific learning.

3.5 Integration of Quantitative and Qualitative Results

The integration of quantitative and qualitative findings showed complementary patterns. Quantitatively, a positive relationship was found between ethnoscience integration and students' learning achievement, with a reported correlation coefficient of ($R = 0.330$).

Qualitatively, students described the learning activities as contextual, engaging, and helpful for understanding sound-wave concepts. They were able to relate observations of Gejog Lesung to concepts including period, amplitude, frequency, resonance, and sound propagation.

Taken together, the results indicate that Gejog Lesung can function as both a cultural and scientific learning resource in the teaching of sound-wave concepts.

Discussion

The findings of this study demonstrate that Gejog Lesung can serve as a meaningful ethnoscience-based learning resource for contextualizing sound-wave concepts. The traditional performance provided observable examples of period, amplitude, frequency, resonance, and sound propagation, allowing students to connect abstract scientific concepts with concrete cultural practices. This finding supports the argument that ethnoscience can bridge formal school science and community-based knowledge by presenting scientific concepts through phenomena that are familiar to learners (Suryawati & Osman, 2022). Similar findings have also been reported by Hartini et al. (2018), who emphasized the potential of local wisdom-based learning materials to support science learning, and by Sudarmin et al. (2019), who showed that ethnoscience integration can strengthen students' thinking skills through culturally contextualized learning activities.

The contextualization of sound-wave concepts through Gejog Lesung appears to be particularly relevant because students were able to observe the scientific phenomena directly. Differences in striking force, rhythmic patterns, and the physical structure of the instrument provided concrete representations of amplitude, frequency, and resonance. This form of learning may reduce the distance between abstract scientific explanations and students' everyday experiences. Suryawati and Osman (2022) argue that culturally contextualized science learning can function as a bridge between students' cultural knowledge and formal scientific understanding. In a similar way, Rahayu et al. (2023) highlight that the integration of local wisdom in science learning can strengthen both scientific literacy and cultural identity. The present findings therefore suggest that Gejog Lesung is not merely an instructional medium, but also a cultural context through which scientific meaning can be constructed.

The quantitative findings showed a positive relationship between ethnoscience integration and students' learning achievement, with a reported correlation coefficient of ($R = 0.330$). Although the relationship was not strong, the result indicates that students who responded more positively to ethnoscience-integrated learning also tended to demonstrate better learning achievement. This result should be interpreted cautiously because correlation does not establish a direct causal effect. Nevertheless, the finding is consistent with previous studies showing that ethnoscience-based and local wisdom-oriented learning can support students' scientific understanding and thinking skills (Ramdani et al., 2021; Ardianti et al., 2023). Ethnoscience-based learning may contribute to achievement by helping students associate scientific concepts with phenomena that are culturally and experientially meaningful.

The qualitative findings provide further explanation for the quantitative relationship. Students reported that sound-wave concepts became easier to understand when they were connected with Gejog Lesung and explored through direct observation and hands-on activities. Such experiences may support conceptual understanding because students are encouraged to move from empirical observation toward scientific interpretation. Aikenhead and Ogawa (2007) emphasize the importance of recognizing relationships between indigenous or local knowledge and scientific knowledge, particularly when students are required to negotiate different ways of understanding natural

phenomena. In this study, Gejog Lesung functioned as an epistemological bridge through which students could interpret a traditional cultural practice using scientific concepts.

Another important finding concerns students' cultural engagement. The learning activities encouraged students to view Gejog Lesung not only as a traditional musical performance but also as a potential source of scientific knowledge. This finding is in line with studies emphasizing that ethnoscience-based learning can strengthen students' appreciation of local culture while simultaneously supporting scientific literacy (Rahayu et al., 2023; Widiyanti et al., 2021). Such integration is particularly relevant in the Indonesian context, where cultural diversity provides rich opportunities for science learning based on local practices. Suprpto et al. (2021) also emphasize the importance of accommodating local wisdom within educational practices and curriculum development.

The findings further suggest that ethnoscience integration can support active and engaging learning. Students were involved in observing, playing, discussing, and interpreting the sounds produced by Gejog Lesung. These activities encouraged participation and provided opportunities for collaborative meaning-making. Previous research has shown that learning approaches connected to local wisdom can promote critical thinking, metacognitive skills, and student engagement (Nunaki et al., 2019; Ramdani et al., 2021). In this study, the cultural context appears to have enhanced the relevance of the learning experience by connecting scientific content with practices that students could observe directly.

Overall, the integrated findings indicate that Gejog Lesung has pedagogical value beyond its function as a cultural artifact. It can provide a contextual platform for explaining sound-wave concepts, supporting learning achievement, increasing engagement, and strengthening cultural awareness. However, because the reported quantitative relationship was modest and the participants were limited to prospective elementary school teachers, the findings should not be generalized beyond the study context without caution. Future research should involve more diverse participants, stronger experimental or quasi-experimental designs, and comparisons with other cultural practices such as *angklung*, *gamelan*, or *talempong*. Such studies would help determine the extent to which ethnoscience-based learning can consistently support science learning across different cultural and educational contexts.

4. CONCLUSION

This study found that the integration of Gejog Lesung ethnoscience into science learning can provide a meaningful cultural context for understanding sound-wave concepts, particularly period, amplitude, frequency, resonance, and sound propagation, while also showing a positive relationship with students' learning achievement and supporting their engagement and cultural awareness. The findings indicate that Gejog Lesung can function as both a cultural artifact and a contextual science learning resource for prospective elementary school teachers. However, this study was limited by the use of purposive sampling, the involvement of participants from a specific educational context, the focus on a single cultural practice and science topic, and the modest quantitative relationship identified in the analysis, which restricts the generalizability of the findings. Future research is therefore recommended to involve larger and more diverse samples, apply stronger experimental or quasi-experimental designs, and compare Gejog Lesung with other local cultural practices such as *angklung*, *gamelan*, or *talempong* to examine the consistency and broader effectiveness of ethnoscience-based learning across different science topics and educational contexts.

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