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Development of PjBL-Based Science Teaching Materials Integrated with Gendang Beleq Ethnoscience on Sound Concepts to Improve Students' Science Process Skills

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Abstract

This study aimed to develop Project-based Learning (PjBL)-based science teaching materials integrated with Gendang Beleq ethnoscience on sound concepts to improve students' Science Process Skills (SPS). The study employed a Research and Development (R&D) approach, followed by a quasi-experimental effectiveness test using a nonequivalent control group design. The research subjects were eighth-grade students at SMP Negeri 2 Sakra, consisting of 61 students in the experimental group and 62 students in the control group. The developed products included the learning objective flow (ATP), teaching modules, student teaching materials, project worksheets, SPS test instruments, assessment rubrics, validation sheets, observation sheets, and teacher and student response questionnaires. Data were collected through expert validation, observation, questionnaires, pretest, and posttest. The data were analyzed using descriptive statistics, N-gain, the Shapiro-Wilk normality test, Levene's homogeneity test, and Welch Robust ANOVA. The results showed that the teaching materials obtained an average validity score of 3.77, which was categorized as valid. Product practicality reached 88.78%, classified as highly practical; learning implementation reached 89.69%, classified as very well implemented; and student activity reached 87.15%, classified as highly active. The improvement in SPS in the experimental group yielded an N-gain score of 0.711, categorized as high, which was higher than that of the control group, which obtained an N-gain score of 0.616, categorized as moderate. The Welch Robust ANOVA results showed a significant difference between the experimental and control groups in both posttest and N-gain scores. Therefore, the PjBL-based science teaching materials integrated with Gendang Beleq ethnoscience were valid, highly practical, and effective in improving students' SPS. The integration of Gendang Beleq provides a concrete local cultural context that enables students to connect the concepts of vibration, frequency, amplitude, resonance, and sound reflection through direct scientific experience.

Keywords: Project-based learning; Science teaching materials; Ethnoscience; Gendang beleq; Science process skills

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INTRODUCTION

Science learning at the lower secondary school level should not be directed solely toward the mastery of concepts, definitions, and formulas. It should also develop students' ability to think and act scientifically. One important competency that represents this ability is Science Process Skills (SPS). SPS includes the ability to observe, ask questions, formulate hypotheses, design and conduct experiments, collect and analyze data, draw conclusions, and communicate the results of scientific investigations. These skills serve as an essential foundation for scientific literacy because they help students understand how scientific knowledge is constructed through investigative processes, rather than merely received as final information from teachers or textbooks. In various studies, SPS is positioned as a fundamental competency that determines the quality of students' engagement in science learning, particularly when learning is directed toward problem solving, evidence-based reasoning, and scientific decision-making (Almeida et al., 2024; Dávila, 2023; Ruiz et al., 2016; Zurita et al., 2024).

The urgency of developing SPS becomes stronger because science learning in many contexts still faces fundamental problems. Students often experience learning that emphasizes memorization, problem drills, and basic conceptual understanding rather than scientific inquiry that requires observation, testing, modeling, data analysis, and evidence-based argumentation. This condition may lead students to perceive science as a collection of concepts to be memorized, rather than as a way of thinking to explain natural phenomena. Several studies have shown that weaknesses in SPS development affect students' limited ability to connect concepts with real phenomena, construct scientific explanations, and transfer knowledge to new situations (Comley, 2009; Holmes et al., 2021; Nwune et al., 2024; Salvetti et al., 2023). Therefore, science learning needs to be designed as a learning experience that enables students to engage directly and meaningfully in scientific activities.

One science topic that requires concrete learning experiences is sound. On the one hand, sound is a phenomenon that is very close to students' daily lives. They hear human voices, music, transportation sounds, falling objects, and various environmental sounds almost every day. On the other hand, sound concepts are often still understood abstractly because students need to connect sensory experiences with physics concepts such as vibration, longitudinal waves, frequency, amplitude, resonance, sound reflection, reverberation, and echo. This difficulty arises when sound is taught only through definitions and formulas without sufficient observation and inquiry experiences. Batlolona and Jamaludin (2024) showed that students often experience misconceptions about sound concepts, particularly in relation to vibration, frequency, pitch, resonance, and wave propagation. Thus, sound learning requires an instructional approach that can bridge everyday experience and scientific reasoning.

One effort to bridge scientific concepts and students' experiences is the use of contextual teaching materials. Contextual teaching materials can help students see that science concepts are not separate from real life. However, the use of context in learning does not automatically improve students' understanding and SPS. The selected context must be authentic, relevant to learning objectives, and able to guide students toward clear scientific activities. Without careful design, context may become an interesting supporting narrative, but it may not necessarily strengthen conceptual understanding or scientific skills. Holmes et al. (2021) and Tytler and Darby (2009) emphasized that contextual learning needs to maintain a balance between real-life relevance and scientific conceptual accuracy. In other words, contextual teaching materials should contain a sequence of activities that integrates phenomena, concepts, inquiry processes, and assessment.

In the Indonesian context, ethnoscience is one relevant approach for developing contextual teaching materials. Ethnoscience positions local knowledge, cultural practices, and community wisdom as learning resources that can be connected to formal science concepts. This approach is important because students do not learn science in an empty social space. They bring cultural experiences, language, environment, and everyday practices into the classroom. The integration of ethnoscience in science learning can increase students' engagement, strengthen scientific literacy, and help them understand that science is related to culture and community life (Aisyah & Khotimah, 2023; Dewi et al., 2019; Hikmawati et al., 2021; Sarwi et al., 2023). Nevertheless, ethnoscience integration still requires appropriate reconstruction so that local knowledge is not merely displayed as a cultural identity, but is also translated into a coherent scientific learning experience.

One local cultural object with strong potential for sound learning is Gendang Beleq, a traditional art form of the Sasak community in Lombok that has strong, rhythmic, and resonant sound characteristics. Gendang Beleq not only carries cultural, social, and community identity values, but also contains acoustic potential that can be used to explain sound concepts. Studies on Gendang Beleq show that this art form plays an important role in the sociocultural life of the Sasak community, particularly as a symbol of identity, togetherness, and local cultural preservation (Apriawan & Hilmi, 2022; Munawir & Pradoko, 2021). From the perspective of instrument form and structure, Gendang Beleq has physical characteristics that allow it to be reconstructed as a context for sound learning, especially through organological studies of its form, size, membrane, and ensemble components (Saputra, 2020; Sukandar et al., 2017). In addition, Gendang Beleq contains ethnopedagogical and ethnoscientific potential that can be connected to sound concepts in science learning (Alditia & Nurmawanti, 2023).

The potential of Gendang Beleq as a learning resource lies not only in its cultural closeness to students, but also in its ability to provide scientific phenomena that can be investigated. For example, differences in the size and characteristics of Gendang Mama and Gendang Nina can be used to discuss the relationship between membrane area, cavity volume, and sound frequency. Membrane tension can be used to explain changes in pitch, while the strength of the strike can be associated with amplitude. The drum cavity can provide a context for discussing resonance, while Gendang Beleq performances in open or closed spaces can be connected to sound reflection, reverberation, and echo. Thus, Gendang Beleq can be positioned as an ethnoscience object that enables students to understand sound through observation, testing, and reasoning based on cultural experiences close to their lives.

To ensure that this ethnoscience potential does not remain merely as a cultural illustration, a learning model is needed that can guide students toward systematic scientific activities. Project-Based Learning (PjBL) is one suitable model because it involves students in formulating problems, designing projects, preparing schedules, conducting investigations, producing products, presenting results, and reflecting on their learning. PjBL provides opportunities for students to learn through real activities that require collaboration, creativity, problem solving, and scientific communication. In science learning, PjBL can strengthen SPS because students do not merely receive conceptual explanations, but also engage in inquiry processes to generate evidence and learning products. Previous studies have shown that ethnoscience-integrated PjBL has the potential to improve critical thinking skills, creativity, scientific literacy, and science process skills when designed with authentic contexts and appropriate assessment (Ariyatun, 2021; Rahman et al., 2023; Rahayu et al., 2023; Rusmansyah et al., 2023).

Although studies on PjBL and ethnoscience have continued to develop, there remains an important area for further development. Some ethnoscience-based teaching materials still position local culture merely as an example or an introduction to the topic, rather than as a structured object of scientific investigation. In addition, local culture-based sound learning still requires teaching materials that explicitly connect physics concepts, PjBL syntax, project activities, and SPS indicators. In the context of Gendang Beleq, the integration of local acoustic phenomena with scientific project activities has not been widely developed as systematic teaching materials for lower secondary school students. In fact, this context has strong potential to help students understand sound through direct experiences that are culturally familiar to them.

Based on the above discussion, this study aims to develop PjBL-based science teaching materials integrated with Gendang Beleq ethnoscience on sound concepts to improve students' Science Process Skills. The developed teaching materials position Gendang Beleq not only as a cultural narrative, but also as a context for scientific inquiry through a project to create a miniature membranophone instrument. Through this activity, students are guided to observe sound phenomena, design and conduct tests, record and analyze data, draw conclusions, and communicate project results.

Specifically, this study seeks to answer the following research questions.

1. What are the characteristics of the PjBL-based science teaching materials integrated with Gendang Beleq ethnoscience on sound concepts developed to improve students' Science Process Skills?
2. What is the validity level of the PjBL-based science teaching materials integrated with Gendang Beleq ethnoscience based on validators' assessments?
3. What is the practicality level of the developed teaching materials based on learning implementation, teacher responses, and student responses?
4. How are students' activities during science learning using PjBL-based teaching materials integrated with Gendang Beleq ethnoscience?
5. How do students' Science Process Skills improve after learning with the developed teaching materials?
6. How effective are the PjBL-based science teaching materials integrated with Gendang Beleq ethnoscience in improving students' Science Process Skills compared with learning in the control group?

LITERATURE REVIEW

Science Process Skills in Science Learning

Science Process Skills (SPS) refer to a set of scientific abilities that enable students to understand science as a process of inquiry. SPS is not only related to the ability to know scientific concepts, but also to the ability to acquire, test, interpret, and communicate scientific knowledge. In science learning, SPS includes the ability to observe, classify, measure, ask questions, formulate hypotheses, design experiments, use tools and materials, collect data, interpret results, draw conclusions, and communicate findings. These skills are important because science learning aims to develop students who are able to think scientifically, use evidence, and explain natural phenomena rationally.

SPS serves as an important foundation for the development of scientific literacy. Students who possess SPS are not only able to remember concepts, but also understand how those concepts are obtained through inquiry processes. Investigative skills such as observing, analyzing data, and constructing evidence-based explanations are essential components of meaningful science learning (Almeida et al., 2024; Dávila, 2023; Zurita et al., 2024). Science learning should provide sufficient opportunities for students to develop investigative thinking skills from the primary and secondary levels (Ruiz et al., 2016).

A common problem in science learning is the dominance of memorization-based instruction, problem drills, and verbal explanation. Such conditions cause students to receive more information than to construct understanding through scientific activities. Limited inquiry experiences can restrict the development of SPS, particularly in formulating problems, designing investigations, analyzing data, and evaluating evidence (Comley, 2009; Holmes et al., 2021; Nwune et al., 2024; Salvetti et al., 2023). Therefore, science learning needs to be designed so that students gain direct experience in observing phenomena, testing variables, recording data, and communicating the results of investigations scientifically.

Contextual Teaching Materials and Ethnoscience

Teaching materials play a strategic role in guiding students' learning processes. Good teaching materials do not merely present content, but also organize learning experiences, student activities, assessment, and reflection. In science learning, contextual teaching materials are needed so that students can connect scientific concepts with phenomena they encounter in everyday life. A contextual approach helps students understand that science is not separate from social, cultural, and environmental realities, but is present in various practices of community life.

Contextual teaching materials need to be designed carefully. The context used in learning must be relevant to conceptual objectives and must not obscure scientific conceptual accuracy (Holmes et al., 2021; Tytler & Darby, 2009). If the context is not connected to scientific processes, learning may become superficially interesting but fail to produce strong conceptual understanding and SPS. Therefore, contextual teaching materials should contain clear connections among phenomena, concepts, inquiry activities, and assessment.

Ethnoscience is one contextual approach that is relevant to science learning in Indonesia. Ethnoscience connects local knowledge, community culture, and everyday practices with formal science concepts. The integration of ethnoscience in learning can increase students' engagement, strengthen scientific literacy, and help students understand science through cultural experiences close to their lives (Aisyah & Khotimah, 2023; Dewi et al., 2019; Herayanti et al., 2025; Hikmawati et al., 2021; Sarwi et al., 2023). In this context, local culture is not positioned merely as a learning background, but as a source of knowledge that can be reconstructed into scientific concepts.

The integration of ethnoscience also has pedagogical value because it can help students see the relationship between community knowledge and scientific knowledge. However, the integration process requires careful reconstruction. Ethnoscience-based learning needs to be developed by considering curriculum alignment, teacher readiness, conceptual accuracy, and the availability of assessments that can measure learning outcomes scientifically (Jannah et al., 2022; Jufrida et al., 2024; Pieter & Risamasu, 2024). Thus, ethnoscience-based teaching materials need to be designed as instructional tools that integrate cultural context, science concepts, investigative activities, and skill indicators in a coherent manner.

Gendang Beleq as an Ethnoscience Context for Sound Concepts

Gendang Beleq is one of the traditional art forms of the Sasak community in Lombok and has strong potential as an ethnoscience context in learning sound concepts. Culturally, Gendang Beleq holds an important position in the life of the Sasak community because it appears in various traditional events, performances, and expressions of collective identity. Gendang Beleq has social and cultural meanings in contemporary Sasak society and contains educational values that can be associated with character formation, togetherness, and appreciation of local culture (Apriawan & Hilmi, 2022; Munawir & Pradoko, 2021).

In terms of form and structure, Gendang Beleq has physical characteristics that are relevant to sound concepts. Organological studies show that Gendang Beleq can be understood through its instrument structure, ensemble components, and the way the musical instrument produces sound (Saputra, 2020). Gendang Beleq can also be examined from the aspects of form, size, components, and visual elements, which makes it potentially relevant to culture-based learning (Sukandar et al., 2017). This information can be used in science learning to connect the physical structure of the drum with the concepts of vibration, membrane, frequency, amplitude, resonance, and sound reflection.

The potential of Gendang Beleq as a context for learning sound becomes stronger because this art form enables students to observe concrete acoustic phenomena. Sound in Gendang Beleq is produced by striking the membrane and is then amplified by the drum cavity as a resonance chamber. Differences in size, membrane tension, and striking force can be associated with differences in pitch and sound intensity. In science learning, these phenomena can be reconstructed into scientific activities such as observing sound sources, testing membrane tension, comparing sound characteristics, recording observation results, and drawing conclusions about relationships among variables. The traditional art of Gendang Beleq contains ethnopedagogical elements that can serve as a basis for developing local culture-based learning (Alditia & Nurmawanti, 2023).

Sound itself is a topic that is close to students' daily lives, but it is often understood abstractly. Students still experience misconceptions about sound concepts, particularly in relation to vibration, frequency, resonance, and wave propagation (Batlolona & Jamaludin, 2024). Therefore, sound learning requires concrete experiences that can connect everyday auditory experiences with physics concepts. Gendang Beleq can serve as an appropriate context because students in Lombok are generally familiar with this art form, although they do not necessarily understand the scientific principles underlying the sounds it produces. By using Gendang Beleq as an ethnoscience context, sound learning can move from cultural experience toward more systematic scientific explanation.

Project-Based Learning in Science Learning

Project-Based Learning (PjBL) is a learning model that places projects at the center of learning activities. In PjBL, students are involved in determining problems, designing solutions, preparing work plans, conducting investigations, producing products, presenting results, and reflecting on their learning. This model is relevant to science learning because it provides opportunities for students to learn through direct experience rather than only through teacher explanation. PjBL also promotes twenty-first-century skills such as collaboration, communication, creativity, and critical thinking.

In the context of SPS, PjBL has a strong alignment because the process of completing a project requires students to engage in scientific activities. Students need to observe phenomena, formulate questions, design work procedures, use tools and materials, collect data, interpret results, and communicate findings. PjBL integrated with ethnoscience can improve critical thinking, creativity, scientific literacy, and learning outcomes because students learn through authentic problems that are close to their lives (Ariyatun, 2021; Rahman et al., 2023; Rahayu et al., 2023; Rusmansyah et al., 2023).

The development of PjBL-based teaching materials needs to consider learning syntax so that project activities do not merely produce physical products, but also strengthen scientific processes. Teaching materials need to include driving questions, project planning guides, inquiry steps, data recording sheets, assessment rubrics, and reflection activities. Local wisdom-based teaching materials need to be designed by considering the integration of context, activities, assessment, and learning outcomes (Muskania et al., 2024; Nabila et al., 2023). Without such integration, projects risk becoming product-making activities without sufficient conceptual depth and scientific skill development.

The integration of PjBL and ethnoscience becomes increasingly relevant because both have mutually supportive orientations. Ethnoscience provides a cultural context that is close to students, while PjBL provides a structure of scientific activities to explore that context. In this study, Gendang Beleq is not only used as an introduction to sound concepts, but also serves as the basis for developing a miniature membranophone instrument project. Through this project, students are guided to understand sound concepts through the processes of designing, making, testing, recording, analyzing, and presenting results.

Conceptual Framework for the Development of PjBL-Based Science Teaching Materials Integrated with Gendang Beleq Ethnoscience

The development of PjBL-based science teaching materials integrated with Gendang Beleq ethnoscience is based on the relationship among science learning needs, the characteristics of sound concepts, the potential of local culture, and the development of SPS. Sound concepts require concrete learning experiences because they are related to the phenomena of vibration, frequency, amplitude, resonance, and sound reflection. Gendang Beleq provides cultural and acoustic contexts that can be directly observed and investigated. PjBL provides a learning sequence that enables students to transform this context into systematic scientific activities.

Conceptually, the developed teaching materials need to fulfill three main functions. First, the teaching materials function as an information source that explains sound concepts and their relationship with Gendang Beleq. Second, the teaching materials function as a guide for project activities that direct students to create a miniature membranophone instrument, test sound variables, and record observation data. Third, the teaching materials function as a tool for developing SPS because each activity is designed to encourage students to observe, ask questions, design experiments, use tools and materials, interpret data, draw conclusions, and communicate results.

This conceptual framework positions teaching materials as a bridge between formal science concepts and students' cultural experiences. The integration of Gendang Beleq enables sound learning to become more contextual, while PjBL ensures that the context is processed through scientific activities. Therefore, the development of PjBL-based science teaching materials integrated with Gendang Beleq ethnoscience is expected to produce learning experiences that are conceptually valid, practical to implement, and effective in improving students' Science Process Skills.

METHOD

Research Type and Design

This study employed a research and development approach, or Research and Development (R&D), followed by an effectiveness test using a quasi-experimental design. The R&D approach was used because this study aimed to produce a product in the form of PjBL-based science teaching materials integrated with Gendang Beleq ethnoscience on sound concepts. The developed product consisted of an integrated set of instructional tools, including the Learning Objective Flow (ATP), teaching modules, student teaching materials, project worksheets, test blueprints, Science Process Skills (SPS) test instruments, project assessment rubrics, presentation rubrics, validation sheets, learning implementation observation sheets, teacher response questionnaires, and student response questionnaires.

The effectiveness test was conducted using a quasi-experimental design with a nonequivalent control group design. In this design, both the experimental and control groups were given a pretest and a posttest. The pretest was used to identify students' initial SPS, while the posttest was used to determine students' final SPS achievement after learning. The experimental group received instruction using PjBL-based science teaching materials integrated with Gendang Beleq ethnoscience, whereas the control group received instruction without using the developed teaching materials. The research procedure is presented in Figure 1.

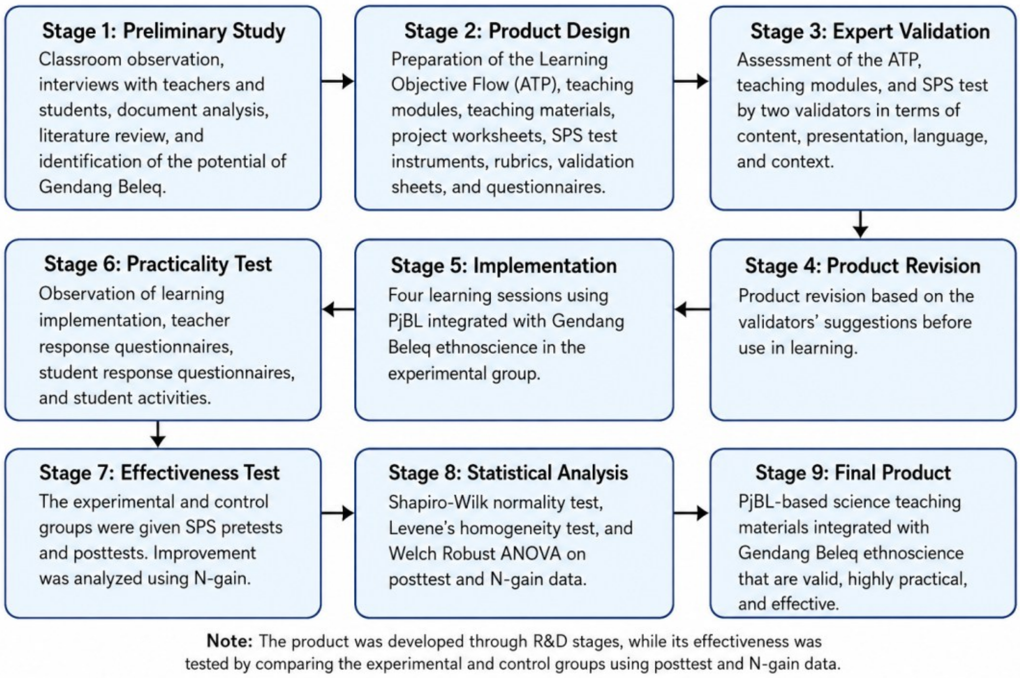

Figure 1. Research Procedure for the Development of PjBL-Based Science Teaching Materials Integrated with Gendang Beleq Ethnoscience

In general, the study consisted of nine main stages: preliminary study, product design, expert validation, product revision, learning implementation, practicality testing, effectiveness testing, statistical analysis, and final product determination. The preliminary study provided the basis for identifying product development needs. Product design resulted in a draft of the instructional tools. Expert validation and product revision ensured the feasibility of the product before use. Learning implementation was conducted to determine the practicality, implementation quality, student activities, and effectiveness of the teaching materials. The effectiveness test was conducted by comparing the experimental and control groups based on pretest, posttest, and N-gain data.

Research Subjects and Trial Groups

The study was conducted at SMP Negeri 2 Sakra in the even semester of the 2025/2026 academic year. The research subjects were eighth-grade students who studied sound concepts under the Merdeka Curriculum and the science teacher involved in the learning implementation. In this development study, the terms research subjects and trial subjects were used instead of population and sample because the main focus of the study was product development, validation, implementation, and testing.

The subjects for the effectiveness test consisted of two groups: an experimental group and a control group. The experimental group consisted of 61 students and received instruction using PjBL-based science teaching materials integrated with Gendang Beleq ethnoscience. The control group consisted of 62 students and received instruction without using the developed teaching materials. The groups were determined purposively by considering topic suitability, classroom readiness, student characteristics, and the feasibility of implementing project-based learning on sound concepts.

Product Development Procedure

The research procedure was carried out through three main stages: preliminary study, product development, and product testing. The preliminary study was conducted to obtain an initial overview of science learning conditions, teaching material needs, student characteristics, teacher readiness, and the potential integration of the local culture of Gendang Beleq into learning sound concepts. Activities at this stage included literature review, classroom observation, interviews with science teachers, interviews with students, analysis of instructional documents, and examination of the local potential of Gendang Beleq as a context for sound learning.

The product development stage was conducted by preparing a draft of the teaching materials and supporting instructional tools. Product development was aligned with Phase D learning outcomes on sound waves. The main content developed included vibration, mechanical waves, longitudinal waves, frequency, amplitude, resonance, sound reflection, reverberation, and echo. These concepts were integrated with Gendang Beleq ethnoscience through an analysis of the physical structure of the drum, membrane vibration, differences in the sound characteristics of Gendang Mama and Gendang Nina, the effect of membrane tension on frequency, the function of the drum cavity as a resonator, and the relationship between striking force and sound intensity.

The product testing stage was conducted through expert validation, product revision, learning implementation, practicality measurement, learning implementation observation, student activity observation, and effectiveness testing. Expert validation was carried out by two validators to assess the feasibility of the ATP, teaching modules, and SPS test. The validation results were used as the basis for revising the product before it was implemented in learning. After revision, the teaching materials were implemented in the experimental group to determine their practicality, implementation quality, student activities, and effectiveness in improving SPS.

Characteristics of the Developed Product

The product developed in this study was PjBL-based science teaching materials integrated with Gendang Beleq ethnoscience on sound concepts. The teaching materials were designed for four learning meetings. The first meeting focused on problem orientation and initial project design. The second meeting focused on project scheduling and experiments on membrane tension. The third meeting focused on air cavity engineering, resonance, and amplitude control. The fourth meeting focused on product showcase, evaluation, presentation, and reflection.

The main product created by students during learning was a miniature membranophone instrument made from recycled materials and designed to resemble the working principles of Gendang Beleq. Through this project, students were guided to design the instrument, select materials, prepare a work schedule, assemble the product, test sound, record data, present results, and reflect on their learning experiences. Thus, the developed teaching materials functioned as a learning resource, a project guide, and a means for developing SPS.

Research Instruments

The research instruments consisted of validation instruments, practicality instruments, observation instruments, and test instruments. The validation instruments were used to assess the feasibility of the ATP, teaching modules, and SPS test. The assessed aspects included content feasibility, presentation feasibility, language feasibility, and alignment with the ethnoscience context and project-based learning.

The practicality instruments consisted of teacher response questionnaires and student response questionnaires. These questionnaires were used to determine the ease of use, attractiveness, and benefits of the teaching materials in science learning. The observation instruments were used to measure learning implementation and student activities during the implementation of the teaching materials. Learning implementation observation covered preliminary activities, core activities based on the PjBL syntax, and closing activities. Student activity observation included activities such as observing Gendang Beleq phenomena, asking questions, discussing, designing projects, conducting experiments, recording and processing data, drawing conclusions, communicating results, and reflecting.

The test instrument was used to measure students' SPS before and after learning. The test was administered as a pretest and posttest to both the experimental and control groups. The SPS indicators measured included observing, interpreting observations, using tools and materials, applying concepts, communicating, asking questions, formulating hypotheses, and planning experiments.

Table 1. Types of Instruments and Data Collected

No.	Instrument	Data Collected	Data Source	Purpose
1	Validation sheets for ATP, teaching modules, and SPS test	Product validity scores.	Two validators	To determine product feasibility before implementation.
2	Teacher response questionnaire	Teacher responses to the teaching materials.	Science teacher	To determine product practicality from the teacher's perspective.
3	Student response questionnaire	Student responses to the teaching materials.	Students in the experimental group	To determine product practicality from the students' perspective.
4	Learning implementation observation sheet	Percentage of PjBL syntax implementation.	Observer	To determine the applicability of learning.
5	Student activity observation sheet	Percentage of student activity.	Observer	To determine students' engagement during learning.
6	SPS test	Pretest, posttest, and N-gain scores.	Experimental and control groups	To determine SPS improvement and the effectiveness of the teaching materials.

Data Collection Techniques

The research data were collected through observation, interviews, expert validation, questionnaires, and tests. Observation and interviews were used during the preliminary study to obtain information about science learning conditions, teaching material needs, student characteristics, and the potential integration of Gendang Beleq into sound learning. Expert validation was used to obtain data on product feasibility before learning implementation.

Questionnaires were used to collect teacher and student responses regarding the practicality of the teaching materials. Learning implementation observation was used to determine the applicability of the PjBL syntax during the learning process. Student activity observation was used to determine students' engagement during learning activities. Tests were used to obtain pretest and posttest SPS data from the experimental and control groups.

Data Analysis Techniques

The research data were analyzed descriptively and inferentially. Descriptive analysis was used to describe validity, practicality, learning implementation, student activities, and SPS improvement. Inferential analysis was used to test differences in posttest and N-gain scores between the experimental and control groups. Product validity data were analyzed by calculating the average score from validators' assessments. Validity assessment used a scale of 1 to 5. The validity categories are presented in Table 2.

Table 2. Criteria for Product Validity

Score Range	Category
1.00-1.80	Invalid
1.81-2.60	Less valid
2.61-3.40	Fairly valid
3.41-4.20	Valid
4.21-5.00	Highly valid

Data on practicality, learning implementation, and student activities were analyzed using percentages. The percentage categories are presented in Table 3.

Table 3. Percentage Criteria for Practicality, Learning Implementation, and Student Activity

Percentage Range	Practicality Category	Implementation Category	Activity Category
81%-100%	Highly practical	Very well implemented	Highly active
61%-80%	Practical	Implemented	Active
41%-60%	Fairly practical	Fairly implemented	Fairly active
21%-40%	Less practical	Poorly implemented	Less active
0%-20%	Not practical	Not implemented	Inactive

SPS improvement was analyzed using the N-gain score based on the comparison between pretest and posttest scores. The N-gain criteria are presented in Table 4.

Table 4. N-Gain Criteria for Science Process Skills

N-gain Value	Category
$g < 0.30$	Low
$0.30 \leq g < 0.70$	Moderate
$g \geq 0.70$	High

Before conducting the difference test, the posttest and N-gain data were tested for normality and homogeneity. The normality test was conducted using the Shapiro-Wilk test, while the homogeneity test was conducted using Levene's Test. The decision criterion was that the data were normally distributed and homogeneous if the significance value was greater than 0.05. Because the test results showed that the posttest and N-gain data were not normally distributed and were not homogeneous, the difference test was conducted using Welch Robust ANOVA. This test was selected because it is more appropriate when the assumption of homogeneity of variance is not met. A summary of the inferential statistical analysis techniques is presented in Table 5.

Table 5. Statistical Analysis Techniques for Posttest and N-Gain

Analysis Stage	Statistical Test	Data Tested	Decision Criterion
Normality test	Shapiro-Wilk	Posttest and N-gain of the experimental and control groups.	Sig. > 0.05 = normal
Homogeneity test	Levene's Test	Posttest and N-gain of the experimental and control groups.	Sig. > 0.05 = homogeneous
Difference test	Welch Robust ANOVA	Posttest and N-gain of the experimental and control groups.	Sig. < 0.05 = significantly different

Criteria for the Effectiveness of the Teaching Materials

The effectiveness of the teaching materials was determined based on three criteria: posttest achievement, N-gain improvement, and the results of Welch Robust ANOVA. The teaching materials were considered effective if the experimental group obtained higher average posttest and N-gain scores than the control group and if there was a significant difference between the two groups. Based on these criteria, this study not only assessed the theoretical feasibility of the product, but also tested the applicability and effectiveness of the teaching materials in science learning on sound concepts.

RESULTS AND DISCUSSION

Results of Product Development and Needs Analysis

This study produced PjBL-based science teaching materials integrated with Gendang Beleq ethnoscience on sound concepts to improve students' Science Process Skills (SPS). The developed product was not merely reading material, but an integrated set of instructional tools consisting of the Learning Objective Flow (ATP), teaching modules, student teaching materials, project worksheets, test blueprints, SPS test instruments, project assessment rubrics, presentation rubrics, validation sheets, learning implementation observation sheets, teacher response questionnaires, and student response questionnaires.

The developed content covered vibration, mechanical waves, longitudinal waves, frequency, amplitude, resonance, sound reflection, reverberation, and echo. These concepts were integrated with Gendang Beleq ethnoscience through an analysis of the physical structure of the drum, membrane vibration, differences in the sound characteristics of Gendang Mama and Gendang Nina, the effect of membrane tension on frequency, the function of the drum cavity as a resonator, and the relationship between striking force and sound intensity. The main product created by students during learning was a miniature membranophone instrument made from recycled materials and designed to resemble the working principles of Gendang Beleq. The developed product components are summarized in Table 6.

Table 6. Components of PjBL-Based Science Teaching Materials Integrated with Gendang Beleq Ethnoscience

Component	Product Form	Function in Learning
- Learning Objective Flow	ATP for Grade VIII Phase D science on sound concepts.	Serves as a reference for learning outcomes, objectives, materials, activities, assessment, and time allocation.
- Teaching module	PjBL teaching module integrated with Gendang Beleq ethnoscience.	Guides teachers in implementing learning over four meetings.
- Student teaching materials	Sound teaching materials integrated with Gendang Beleq ethnoscience.	Serves as a student learning resource that connects sound concepts with local Sasak culture.

Component	Product Form	Function in Learning
- Project worksheet	Planning, scheduling, testing, and project reflection worksheets.	Guides students in conducting project-based scientific activities.
- Test instrument	SPS test items based on the Gendang Beleq context.	Measures students' SPS before and after learning.
- Project and presentation rubrics	Rubrics for group performance, product quality, and scientific communication.	Assesses work processes, product quality, and student presentations.
- Validation instrument	Validation sheets for the ATP, teaching module, and SPS test.	Assesses content feasibility, presentation, language, and contextual aspects of the instructional tools.
- Practicality instrument	Observation sheets, teacher questionnaires, and student questionnaires.	Assesses implementation, ease of use, attractiveness, and product benefits.

The preliminary study showed that science learning on sound concepts was still largely dominated by teacher explanation, limited discussion, and problem drills. Experimental activities had not been implemented optimally due to limited equipment, time constraints, and the absence of teaching materials that systematically guided project activities. Interview results showed that teachers needed teaching materials that were more contextual, easy to implement, and able to connect sound concepts with local culture. Meanwhile, students were familiar with Gendang Beleq as a traditional art form of Lombok, but they did not yet understand its relationship with science concepts such as vibration, frequency, amplitude, resonance, and sound reflection. The needs analysis results are summarized in Table 7.

Table 7. Summary of Needs Analysis Results

Aspect	Initial Findings	Development Needs
- Science learning conditions	Learning was still dominated by teacher explanation, limited discussion, and problem drills.	More active and investigative project-based learning is needed.
- Teaching materials used	The teaching materials were still general and had not connected sound concepts with local culture.	Contextual teaching materials based on Gendang Beleq ethnoscience are needed.
- Student experimental activities	Sound experiments had not been implemented optimally due to limited equipment and guidance.	Simple projects using easily accessible recycled materials are needed.
- Science process skills	Students were not accustomed to designing experiments, identifying variables, recording data, and drawing conclusions.	Project worksheets and rubrics that guide SPS activities are needed.
- Local cultural potential	Students were familiar with Gendang Beleq, but it had not been used as a science learning resource.	Reconstruction of Gendang Beleq concepts into a context for sound learning is needed.
- Teacher readiness	Teachers needed practical instructional tools that could be used directly.	Integrated ATP, teaching modules, teaching materials, worksheets, instruments, and rubrics are needed.
- Student readiness	Students were interested in local culture and product-making activities, but needed clear work guidance.	Step-by-step project activities from problem orientation to product presentation are needed.

Product Validity Results

Product validity was obtained through the assessment of two validators on three main components: the ATP, teaching module, and SPS test. The assessment was conducted based on content feasibility, presentation feasibility, and language feasibility. The product was considered valid if the average score was within the range of 3.41 to 4.20. The product validation results are summarized in Table 8.

Table 8. Summary of Product Validation Results by Two Validators

No.	Validated Component	Number of Items	Mean V1	Mean V2	Combined Mean	Category
1	ATP	30	3.73	3.77	3.75	Valid
2	Teaching module	30	3.83	3.77	3.80	Valid
3	SPS test	30	3.73	3.77	3.75	Valid
	Overall mean	90	3.77	3.77	3.77	Valid

Based on Table 8, all components were categorized as valid. The teaching module obtained the highest mean score of 3.80, while the ATP and SPS test each obtained a mean score of 3.75. The overall mean validity score was 3.77, which was categorized as valid. These results indicate that the developed instructional tools were feasible for implementation after minor revisions based on the validators' suggestions. The validation results based on assessment aspects are presented in Table 9.

Table 9. Product Validation Results Based on Assessment Aspects

Component	Assessment Aspect	Number of Items	Total Score	Combined Mean	Category
- ATP	Content feasibility	12	91	3.79	Valid
	Presentation feasibility	9	67	3.72	Valid
	Language feasibility	9	67	3.72	Valid
- Teaching module	Content feasibility	12	91	3.79	Valid
	Presentation feasibility	9	70	3.89	Valid
	Language feasibility	9	67	3.72	Valid
- SPS test	Content feasibility	16	121	3.78	Valid
	Presentation feasibility	5	37	3.70	Valid
	Language feasibility	9	67	3.72	Valid

Table 9 shows that all assessment aspects were in the valid category. The presentation feasibility aspect of the teaching module obtained the highest score of 3.89. This indicates that the teaching module was organized coherently, systematically, and in accordance with the PjBL stages. No aspect was categorized as fairly valid, less valid, or invalid.

Product Practicality Results

Product practicality was analyzed based on three data sources: learning implementation observation, teacher response questionnaires, and student response questionnaires. The product was categorized as highly practical if it obtained a percentage within the range of 81% to 100%. The practicality results are summarized in Table 10.

Table 10. Summary of Product Practicality Results

No.	Practicality Data Source	Percentage (%)	Category
1	Learning implementation observation	89.75	Highly practical
2	Teacher response questionnaire	89.23	Highly practical
3	Student response questionnaire	87.36	Highly practical
	Mean product practicality	88.78	Highly practical

Based on Table 10, the mean product practicality score was 88.78%, which was categorized as highly practical. This result indicates that the developed teaching materials were easy to use, attractive to students, and useful in supporting science learning on sound concepts. Product practicality was also analyzed based on three main aspects: ease of use, attractiveness, and benefits of the teaching materials. The results are presented in Table 11.

Table 11. Product Practicality Results Based on Aspects

No.	Practicality Aspect	Percentage (%)	Category
1	Ease of use	88.13	Highly practical
2	Attractiveness	87.50	Highly practical
3	Benefits of the teaching materials	90.00	Highly practical
	Mean	88.54	Highly practical

The benefit aspect of the teaching materials obtained the highest percentage, namely 90.00%. This result indicates that the teaching materials helped students understand sound concepts through a context close to their lives. The ease of use and attractiveness aspects were also categorized as highly practical, indicating that the teaching materials could be used effectively by both teachers and students in learning.

Learning Implementation Results

Learning implementation was analyzed to determine the extent to which the PjBL syntax integrated with Gendang Beleq ethnoscience could be applied during the learning process. Observations were conducted across four meetings, from problem orientation to project presentation and reflection. The learning implementation results for each meeting are summarized in Table 12.

Table 12. Learning Implementation Results for Each Meeting

No.	Meeting	Activity Focus	Implementation (%)	Category
1	I	Problem orientation and initial project design	87.50	Very well implemented
2	II	Scheduling and membrane tension experiment	89.25	Very well implemented
3	III	Air cavity engineering and amplitude control	90.00	Very well implemented
4	IV	Product showcase, evaluation, and reflection	92.00	Very well implemented
	Mean		89.69	Very well implemented

Based on Table 12, the mean learning implementation score across four meetings was 89.69%, categorized as very well implemented. Learning implementation increased from the first to the fourth meeting. The highest percentage was found in the fourth meeting, at 92.00%, which focused on product showcase, evaluation, and reflection. Learning implementation was also analyzed based on PjBL phases. The results are presented in Table 13.

Table 13. Learning Implementation Results Based on PjBL Phases

No.	Learning Phase	Implementation (%)	Category
1	Preliminary activities	89.50	Very well implemented
2	Determining the driving question or authentic problem	88.75	Very well implemented
3	Designing the project plan	88.33	Very well implemented
4	Scheduling work stages	89.17	Very well implemented
5	Monitoring and guiding the project	90.83	Very well implemented
6	Evaluating project results	92.50	Very well implemented
7	Reflecting on and providing feedback on learning experiences	91.67	Very well implemented
8	Closing activities	91.25	Very well implemented
	Mean	90.25	Very well implemented

Based on Table 13, all learning phases were categorized as very well implemented. The phase of evaluating project results obtained the highest percentage, namely 92.50%, while the phase of designing the project plan obtained the lowest percentage, namely 88.33%. Nevertheless, all phases remained within the very well implemented category.

Student Activity Results

Student activities were observed during science learning using PjBL-based teaching materials integrated with Gendang Beleq ethnoscience. The observed activities included observing Gendang Beleq phenomena, asking questions, discussing, designing projects, conducting experiments, recording and processing data, drawing conclusions, communicating results, and reflecting. The student activity results for each meeting are presented in Table 14.

Table 14. Summary of Student Activities for Each Meeting

No.	Meeting	Learning Activity Focus	Activity (%)	Category
1	I	Problem orientation and initial project design	82.64	Highly active
2	II	Project scheduling and membrane tension experiment	86.11	Highly active
3	III	Air cavity engineering, resonance, and amplitude control	88.19	Highly active
4	IV	Product showcase, presentation, evaluation, and reflection	91.67	Highly active
	Mean		87.15	Highly active

Based on Table 14, the mean student activity score across four meetings was 87.15%, categorized as highly active. Student activities increased in each meeting, from 82.64% in the first meeting to 91.67% in the fourth meeting. This increase indicates that students became increasingly engaged in project activities, experiments, presentations, and learning reflection. The student activity results based on indicators are presented in Table 15.

Table 15. Student Activities Based on Indicators

No.	Student Activity Indicator	Percentage (%)	Category
1	Observing Gendang Beleq phenomena through pictures, videos, and teaching materials	90.28	Highly active
2	Asking questions or formulating learning problems	82.64	Highly active
3	Discussing and collaborating in groups	88.89	Highly active
4	Designing a miniature membranophone instrument project	85.42	Highly active
5	Conducting experiments or testing sound variables	89.58	Highly active
6	Recording and processing observation data	86.11	Highly active
7	Drawing conclusions based on experimental results	84.72	Highly active
8	Communicating project results through presentations	91.67	Highly active
9	Reflecting on project-based learning experiences	85.76	Highly active
	Mean	87.23	Highly active

Based on Table 15, all student activity indicators were categorized as highly active. The highest indicator was communicating project results through presentations, with a percentage of 91.67%. The lowest indicator was asking questions or formulating learning problems, with a percentage of 82.64%. These results indicate that students were actively involved in learning, although they still required guidance in formulating scientific questions independently.

Results of Science Process Skills Improvement and Teaching Material Effectiveness

The improvement in SPS was analyzed based on pretest scores, posttest scores, score differences, and N-gain in the control and experimental groups. The control group consisted of 62 students, while the experimental group consisted of 61 students. The results of SPS improvement are summarized in Table 16.

Table 16. Summary of Students' SPS Improvement in the Control and Experimental Groups

Group	N	Pretest Mean	Pretest SD	Posttest Mean	Posttest SD	Mean N-gain	N-gain (%)	Category
Control	62	15.66	15.58	67.53	16.93	0.616	61.63	Moderate
Experimental	61	23.85	13.58	78.28	6.89	0.711	71.07	High

Based on Table 16, the control group obtained a mean pretest score of 15.66, which increased to 67.53 in the posttest. The mean N-gain of the control group was 0.616, or 61.63%, categorized as moderate. The experimental group obtained a mean pretest score of 23.85, which increased to 78.28 in the posttest. The mean N-gain of the experimental group was 0.711, or 71.07%, categorized as high. Thus, the improvement in students' SPS in the experimental group was higher than that in the control group. The distribution of N-gain categories in both groups is presented in Table 17.

Table 17. Distribution of Students' SPS N-Gain Categories

Group	Low	%	Moderate	%	High	%	Total
Control	4 students	6.45%	35 students	56.45%	23 students	37.10%	62 students
Experimental	0 students	0.00%	23 students	37.70%	38 students	62.30%	61 students

Table 17 shows that in the control group, most students were in the moderate N-gain category, namely 35 students or 56.45%. In the experimental group, most students were in the high N-gain category, namely 38 students or 62.30%. No student in the experimental group was in the low category.

To strengthen the descriptive results, statistical analysis was conducted on the posttest and N-gain data. The normality test was conducted using the Shapiro-Wilk test. The results are presented in Table 18.

Table 18. Shapiro-Wilk Normality Test Results for Posttest and N-Gain Data

Variable	Group	N	Shapiro-Wilk Statistic	Sig.	Interpretation
Posttest	Control	62	0.794	0.000	Not normal
	Experimental	61	0.924	0.001	Not normal
N-gain	Control	62	0.843	0.000	Not normal
	Experimental	61	0.951	0.016	Not normal

Based on Table 18, all significance values were lower than 0.05. Therefore, the posttest and N-gain data in both the control and experimental groups were not normally distributed. Next, the homogeneity test was conducted using Levene's Test. The results are presented in Table 19.

Table 19. Levene's Homogeneity Test Results for Posttest and N-Gain Data

Variable	Levene Statistic	Sig.	Interpretation
Posttest	17.208	0.000	Not homogeneous
N-gain	11.500	0.001	Not homogeneous

Table 19 shows that the significance values for the posttest and N-gain data were lower than 0.05. Therefore, the variances between the control and experimental groups were not homogeneous. Because the data were not normally distributed and were not homogeneous, the difference test was conducted using Welch Robust ANOVA. The results are presented in Table 20.

Table 20. Welch Robust ANOVA Results for Posttest and SPS N-Gain

Variable	Group	N	Mean	SD	F	df1	df2	Sig.	Interpretation
Posttest	Control	62	67.53	16.93	21.389	1	80.910	0.000	Significantly different
	Experimental	61	78.28	6.89					
N-gain	Control	62	0.616	0.175	14.151	1	91.283	0.000	Significantly different
	Experimental	61	0.711	0.090					

Based on Table 20, the Welch Robust ANOVA results for posttest scores showed a Welch F value of 21.389 with a significance value of 0.000. This value was lower than 0.05, indicating a significant difference in SPS posttest scores between the control and experimental groups. The mean posttest score of the experimental group was 78.28, which was higher than that of the control group at 67.53.

The Welch Robust ANOVA results for N-gain scores showed a Welch F value of 14.151 with a significance value of 0.000. This value was lower than 0.05, indicating a significant difference in SPS improvement between the control and experimental groups. The mean N-gain of the experimental group was 0.711, categorized as high, while the mean N-gain of the control group was 0.616, categorized as moderate.

Based on the descriptive results and statistical analysis, the PjBL-based science teaching materials integrated with Gendang Beleq ethnoscience showed effectiveness in improving students' SPS. This effectiveness was indicated by the higher mean posttest score in the experimental group, the high N-gain category achieved by the experimental group, and the significant difference between the experimental and control groups based on Welch Robust ANOVA.

Discussion

The results of this study show that the PjBL-based science teaching materials integrated with Gendang Beleq ethnoscience on sound concepts met three main indicators of development product feasibility, namely validity, high practicality, and effectiveness in improving students' Science Process Skills (SPS). In general, the product obtained an average validity score of 3.77, categorized as valid; a practicality score of 88.78%, categorized as highly practical; a learning implementation score of 89.69%, categorized as very well implemented; a student activity score of 87.15%, categorized as highly active; and an average N-gain score of 0.711 in the experimental group, categorized as high. These findings indicate that the development of teaching materials did not only produce instructional tools that were theoretically feasible, but also applicable in classroom learning and capable of contributing to the improvement of SPS. These results are consistent with the view that SPS development requires learning that provides students with opportunities to observe, ask questions, design investigations, process data, draw conclusions, and communicate results scientifically (Almeida et al., 2024; Dávila, 2023; Ruiz et al., 2016; Zurita et al., 2024). Therefore, the teaching materials developed in this study can be understood as a response to the need for science learning that is oriented not only toward conceptual mastery, but also toward strengthening students' scientific practices through a local cultural context close to their lives.

The validity of the product, which was categorized as valid, indicates that the ATP, teaching module, and SPS test had appropriate content, presentation, language, and integration with the ethnoscience context and PjBL syntax. The teaching module obtained the highest average score, namely 3.80, while the ATP and SPS test each obtained a score of 3.75. These results indicate that the developed learning structure was systematically organized, starting from learning objectives, project activities, integration of sound concepts, and SPS assessment. Product validity is an important aspect because contextual teaching materials often face challenges in maintaining a balance between contextual relevance and scientific conceptual accuracy. Teaching materials that adopt local contexts need to be carefully designed so that they are not only culturally engaging, but also conceptually accurate, aligned with learning objectives, and supportive of students' scientific skills (Holmes et al., 2021; Salvetti et al., 2023; Tytler & Darby, 2009). In this study, the Gendang Beleq context was not positioned as a supplementary cultural illustration, but was reconstructed as a scientific context for understanding membrane vibration, frequency, amplitude, resonance, sound intensity, and sound reflection. This reconstruction strengthens the function of teaching materials as a bridge between cultural knowledge and formal science concepts, as emphasized in ethnoscience-based learning (Dewi et al., 2019; Hikmawati et al., 2021; Jannah et al., 2022; Jufrida et al., 2024).

The feasibility of the product can also be explained through the integration of the characteristics of sound concepts, Gendang Beleq, and PjBL. Sound is one of the science topics that is close to students' daily lives, but it is often understood abstractly because it involves concepts such as vibration, waves, frequency, amplitude, resonance, and sound propagation, not all of which can be directly observed. Students' difficulties in understanding sound concepts may arise when learning overemphasizes definitions, formulas, or verbal explanations without concrete experiences that connect sound phenomena with observation and inquiry (Batlolona & Jamaludin, 2024). Gendang Beleq provides a relevant context because this instrument has a membrane structure, resonance body, sound characteristics, and sociocultural functions familiar to students in Lombok. Studies on Gendang Beleq show that this instrument contains cultural value, social identity, educational value, and organological characteristics that can be used as contextual learning resources (Alditia & Nurmawanti, 2023; Apriawan & Hilmi, 2022; Munawir & Pradoko, 2021; Saputra, 2020; Sukandar et al., 2017). Therefore, the integration of Gendang Beleq into science teaching materials enables students to learn sound concepts through a cultural object that is familiar, concrete, and meaningful.

The product practicality score of 88.78%, categorized as highly practical, shows that the teaching materials were easy for teachers and students to use in the learning process. The practicality results based on aspects also showed that the teaching materials obtained high scores in ease of use, attractiveness, and benefits. The benefit aspect obtained the highest percentage, namely 90.00%, indicating that the teaching materials helped students understand sound concepts through more contextual and applicable activities. This finding supports the idea that good teaching materials need to have a clear activity structure, understandable language, directed tasks, and activity support that enables students to learn independently and collaboratively. Literature on contextual teaching materials emphasizes that the effectiveness of context in learning strongly depends on design quality, suitability to students' characteristics, the availability of teacher guidance, and the alignment among objectives, activities, and assessment (Holmes et al., 2021; Nabila et al., 2023; Salvetti et al., 2023). In this study, product practicality was strengthened by the presence of integrated ATP, teaching modules, project worksheets, rubrics, test instruments, and questionnaires, which provided teachers with clear guidance in implementing project-based learning.

The learning implementation score of 89.69% and the implementation score based on PjBL phases of 90.25% indicate that the PjBL syntax integrated with Gendang Beleq ethnoscience could be applied very well. Learning implementation increased from the first to the fourth meeting, from 87.50% to 92.00%. This increase shows that students and the teacher became increasingly familiar with project-based work patterns, starting from problem orientation, planning, scheduling, testing, product evaluation, presentation, and reflection. The project evaluation phase obtained the highest percentage, namely 92.50%, while the project planning phase obtained the lowest percentage, namely 88.33%, although it still remained in the very well implemented category. This finding is reasonable because the project planning phase required students to understand the problem, determine the tool design, select materials, predict variables, and arrange work procedures. These activities are more complex than presentation or product evaluation activities, which were carried out after students had gained direct experience. PjBL indeed requires a gradual process and teacher support in guiding students to transform authentic problems into scientific work plans that can be implemented (Ariyatun, 2021; Rahman et al., 2023; Rahayu et al., 2023; Rusmansyah et al., 2023).

Student activity, which reached 87.15% and was categorized as highly active, indicates that the teaching materials were able to encourage students' engagement in learning. Student activity increased gradually from the first to the fourth meeting. This increase suggests that project-based learning provided students with opportunities to experience a more participatory learning process. The highest activity indicator was communicating project results through presentations, with a percentage of 91.67%, while the lowest indicator was asking questions or formulating learning problems, with a percentage of 82.64%. This pattern shows that students were relatively more easily engaged in concrete activities such as observing, conducting experiments, collaborating, and presenting results, but still needed habituation in formulating scientific questions independently. This is consistent with the characteristics of SPS, which do not develop merely through task assignment, but also through habituation in scientific thinking, question scaffolding, reflection, and continuous feedback (Almeida et al., 2024; Lam-Byrne, 2023; Zurita et al., 2024). Thus, the high level of student activity in this study indicates that the teaching materials successfully created an active learning environment, although the aspects of questioning and problem formulation need to be strengthened in future implementation.

The improvement in students' SPS in the experimental group was higher than that in the control group. The experimental group obtained an average N-gain score of 0.711, or 71.07%, categorized as high, while the control group obtained an average N-gain score of 0.616, or 61.63%, categorized as moderate. The distribution of N-gain categories also showed that 62.30% of students in the experimental group were in the high category, and no student was in the low category. In contrast, in the control group, most students were in the moderate category, namely 56.45%, and 6.45% of students were still in the low category. These findings indicate that the PjBL-based teaching materials integrated with Gendang Beleq ethnoscience provided stronger learning experiences for developing SPS than learning in the control group. This improvement can be explained by the fact that learning in the experimental group directed students to engage in a more complete sequence of scientific activities, including observing Gendang Beleq phenomena, formulating problems, designing a miniature membranophone project, testing sound, recording and processing data, drawing conclusions, and communicating results. These activities align with the dimensions of SPS, which position students as actors in scientific inquiry rather than merely as recipients of information (Dávila, 2023; Ruiz et al., 2016; Zurita et al., 2024).

The effectiveness of the teaching materials was also supported by the Welch Robust ANOVA results, which showed significant differences between the experimental and control groups in both posttest and N-gain scores. The experimental group obtained a higher average posttest score of 78.28 compared with the control group, which obtained 67.53, with a Welch F value of 21.389 and a significance value of 0.000. For the N-gain data, the experimental group obtained an average score of 0.711, while the control group obtained 0.616, with a Welch F value of 14.151 and a significance value of 0.000. These results indicate that the difference in SPS improvement between the two groups was not only visible descriptively, but also statistically significant. The use of Welch Robust ANOVA was appropriate because the posttest and N-gain data were not normally distributed and were not homogeneous. Therefore, the conclusion regarding the effectiveness of the teaching materials needs to be understood proportionally: the teaching materials showed a positive and significant effect on SPS improvement, but the statistical interpretation should still consider the characteristics of the data and the quasi-experimental design used. Such caution is important because the effectiveness of contextual and project-based learning is influenced not only by the teaching material product, but also by teacher readiness, classroom dynamics, time allocation, student characteristics, and the quality of facilitation during learning (Holmes et al., 2021; Nwune et al., 2024; Salvetti et al., 2023).

The findings of this study strengthen previous research showing that the integration of ethnoscience in science learning can improve students' engagement, scientific literacy, conceptual understanding, and SPS. Ethnoscience-based learning enables students to see that science is not separate from social and cultural life, but is embedded in everyday community practices. When local knowledge is reconstructed into a scientific context, students have the opportunity to understand science concepts through experiences closer to their world (Aisyah & Khotimah, 2023; Dewi et al., 2019; Hikmawati et al., 2021; Jannah et al., 2022; Pieter & Risamasu, 2024). In the context of this study, Gendang Beleq functioned as a bridge between students' cultural experiences and sound concepts. Students did not only recognize Gendang Beleq as a traditional Sasak art form, but also analyzed it as a scientific object that has vibrating membranes, resonance cavities, sound variations, and responses to striking force. In this way, science learning became more meaningful because students could connect cultural observation with scientific reasoning.

The integration of PjBL into the teaching materials was also an important factor explaining the improvement in SPS. PjBL provides opportunities for students to learn through authentic problem-solving processes and product development. In this study, the project of creating a miniature membranophone instrument enabled students to directly experience the processes of planning, making, testing, revising, and communicating results. The project did not merely produce a physical product, but also required students to carry out scientific processes relevant to SPS indicators. The literature shows that ethnoscience-based PjBL can support critical thinking, creativity, scientific literacy, and learning outcomes because it combines local contexts with investigative and collaborative activities (Ariyatun, 2021; Martawijaya et al., 2023; Rahayu et al., 2023; Rahman et al., 2023; Rusmansyah et al., 2023). Thus, the effectiveness of the teaching materials in this study can be understood as the result of the synergy among the Gendang Beleq ethnoscience context, the PjBL structure, and the orientation toward SPS development.

The results of this study also contribute to the development of local culture-based science teaching materials, particularly for sound concepts. Sound is often taught through common examples such as guitars, tuning forks, loudspeakers, or echoes, which are scientifically relevant but may not necessarily have cultural closeness to students. The use of Gendang Beleq offers an alternative context that is more local and culturally identifiable, especially for students in Lombok. However, the use of local culture in science learning still requires careful reconstruction to avoid oversimplification or conceptual inaccuracy. Teaching materials need to explicitly show the relationship between cultural phenomena and scientific concepts, such as the relationship between membrane vibration and sound sources, membrane tension and frequency, the drum cavity and resonance, and striking force and amplitude. This principle is consistent with the view that contextual learning must maintain a balance between local relevance and disciplinary accuracy so that the context does not obscure the science concepts being studied (Holmes et al., 2021; Salvetti et al., 2023; Tytler & Darby, 2009).

Although the results of this study show that the teaching materials were valid, highly practical, and effective, several points need attention. First, the indicator of asking questions or formulating problems obtained the lowest score compared with other activity indicators. Therefore, future implementation needs to provide stronger scaffolding in the form of examples of scientific questions, guidance for identifying variables, and exercises in constructing investigative problems. Second, the posttest and N-gain data were not normally distributed and were not homogeneous. Therefore, the use of Welch Robust ANOVA was appropriate, but the generalization of the findings still needs to be made cautiously. Third, the study was conducted in a specific school and cultural context, namely eighth-grade students at SMP Negeri 2 Sakra with the cultural context of Gendang Beleq. Therefore, the application of these teaching materials in other schools or other local cultural contexts requires adaptation according to student characteristics, resource availability, teacher readiness, and the suitability of the cultural context. This is consistent with the view that the success of contextual and ethnoscience-based teaching materials is strongly influenced by design quality, implementation readiness, teacher support, and the relevance of the local context to learning objectives (Jufrida et al., 2024; Muskania et al., 2024; Nabila et al., 2023; Salvetti et al., 2023).

In general, the results of this study show that PjBL-based science teaching materials integrated with Gendang Beleq ethnoscience make a substantive contribution to science learning on sound concepts. Product validity indicates the feasibility of the instructional tools in terms of content, presentation, language, and assessment. Practicality and implementation results show that the teaching materials can be used in the learning process with the support of systematic instructional tools. The highly active student activity indicates that project-based learning and cultural contexts can create participatory learning experiences. SPS improvement and the effectiveness test results show that the teaching materials had a positive impact on students' scientific abilities. Therefore, the developed teaching materials can serve as an innovative alternative for connecting science learning, local culture, and SPS development. These findings affirm that meaningful science learning requires not only conceptual mastery, but also scientific experiences that are contextual, collaborative, and rooted in students' sociocultural environment.

CONCLUSION

This study produced PjBL-based science teaching materials integrated with Gendang Beleq ethnoscience on sound concepts, designed to improve students' Science Process Skills (SPS). The developed product consisted of instructional tools, including the Learning Objective Flow (ATP), teaching modules, student teaching materials, project worksheets, SPS test instruments, project assessment rubrics, presentation rubrics, validation sheets, learning implementation observation sheets, teacher response questionnaires, and student response questionnaires. The main characteristic of the teaching materials lies in the integration of sound concepts with the local cultural context of Gendang Beleq through a project to create a miniature membranophone instrument. Through this project, students were able to learn about vibration, frequency, amplitude, resonance, and sound reflection through concrete and contextual learning experiences.

The validation results showed that the developed teaching materials were categorized as valid, with an overall mean score of 3.77. The ATP component obtained a mean score of 3.75, the teaching module obtained a mean score of 3.80, and the SPS test obtained a mean score of 3.75. These results indicate that the developed instructional tools were feasible for use in learning after revisions based on the validators' suggestions. In terms of practicality, the teaching materials obtained an average score of 88.78%, categorized as highly practical. This practicality was supported by the learning implementation observation score of 89.75%, teacher response score of 89.23%, and student response score of 87.36%. These findings indicate that the teaching materials were easy to use, attractive, and useful in supporting science learning on sound concepts.

The implementation of PjBL-based learning integrated with Gendang Beleq ethnoscience was categorized as very well implemented, with an average score of 89.69% across four meetings. Implementation based on PjBL phases was also categorized as very well implemented, with an average score of 90.25%. Student activity during learning was categorized as highly active, with an average score of 87.15%, while the average activity score based on indicators reached 87.23%. These findings show that project-based learning using the Gendang Beleq context was able to encourage students' engagement in observing, discussing, designing projects, conducting experiments, recording and processing data, drawing conclusions, communicating results, and reflecting.

The developed teaching materials were proven to be effective in improving students' SPS. The experimental group obtained an average posttest score of 78.28 and an average N-gain score of 0.711, categorized as high, while the control group obtained an average posttest score of 67.53 and an average N-gain score of 0.616, categorized as moderate. The Welch Robust ANOVA results showed a significant difference between the experimental and control groups in both posttest and N-gain scores. Therefore, the PjBL-based science teaching materials integrated with Gendang Beleq ethnoscience can be declared valid, highly practical, very well implemented, capable of activating students, and effective in improving SPS on sound concepts.

RECOMMENDATION

The findings of this study imply that science learning can be strengthened through the development of teaching materials that integrate science concepts with local culture. Gendang Beleq, as a traditional art form of the Sasak community, can be reconstructed into a meaningful context for learning sound concepts. This integration not only introduces students to the concepts of vibration, frequency, amplitude, resonance, and sound reflection, but also fosters awareness that science can be found in community cultural practices. Therefore, ethnoscience-based teaching materials can serve as an alternative for developing science learning that is more contextual, relevant, and close to students' experiences.

The pedagogical implication of this study is the importance of using PjBL as a learning framework that provides students with opportunities to engage gradually in scientific activities. The project of creating a miniature membranophone instrument encouraged students to observe phenomena, design tools, conduct testing, record data, draw conclusions, and communicate results. Thus, science teachers can use similar teaching materials to develop SPS through investigative activities that do not depend entirely on complex laboratory facilities. Recycled materials and local cultural objects can be used as learning resources that are inexpensive, easily accessible, and contextually meaningful.

Based on the findings, science teachers are recommended to use PjBL-based teaching materials integrated with Gendang Beleq ethnoscience as an alternative for teaching sound concepts, especially in school contexts that have cultural proximity to Sasak arts. Teachers also need to provide stronger scaffolding during the stages of formulating questions and designing investigative problems, because these indicators obtained the lowest activity percentage compared with the other indicators. Scaffolding can be provided through examples of scientific questions, guidance on variable identification, exercises in formulating hypotheses, and reflective discussion before students carry out the project.

For schools, the findings of this study recommend the need to support project-based and local culture-based science learning. This support can include providing sufficient time for project activities, facilitating simple materials, building collaboration with local cultural practitioners, and strengthening learning programs that connect science with students' sociocultural environment. For curriculum and teaching material developers, this study shows that local culture can serve as a source for developing instructional tools that not only strengthen cultural identity but also support the achievement of scientific competencies.

Future studies are recommended to test these teaching materials in broader school contexts, at different educational levels, or in other science topics. Further development may also integrate simple technology, sound frequency measurement applications, or digital simulations to strengthen students' observation of acoustic phenomena. In addition, future research may examine the effects of the teaching materials on other variables, such as scientific literacy, critical thinking, creativity, collaboration, scientific attitudes, and cultural awareness. More in-depth qualitative studies are also needed to understand students' learning experiences during PjBL-based science learning integrated with Gendang Beleq ethnoscience.

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AUTHOR CONTRIBUTIONS STATEMENT

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Lalu Moh Nur Ikhsan	✓	✓			✓	✓	✓	✓		✓			✓	✓
Lovy Herayanti			✓	✓				✓	✓		✓	✓		✓
Ika Nurani Dewi		✓		✓		✓	✓			✓			✓	

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

DATA AVAILABILITY
The data that support the findings of this study are available from the corresponding author, RBP, upon reasonable request.

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