
STEM-INTEGRATED PROBLEM-BASED LEARNING WITH LOCAL WISDOM (GONG BULEUH): IMPACT ON STUDENT LEARNING OUTCOMES

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Abstract:

The purpose of this study is to implement STEM-integrated PBL based on local wisdom (Gong Buleuh) on sound wave materials and analyze its effect on improving student learning outcomes. The method used in this study is quasi-experimental with a non-equivalent control group design. This research involved two classes of XI Science at SMA Negeri 8 Jambi City, each consisting of 30 students. The experimental class used STEM-based integrated PBL based on local wisdom (Gong Buleuh), while the control class used PBL without integration. A pretest and posttest were administered to evaluate students' learning achievement. After implementation, students in the experimental class demonstrated significantly improved learning outcomes compared to those in the control class. The paired sample t-test showed a significance value of 0.000 and a large effect size (Cohen's $d = 7.76$). Furthermore, independent sample t-tests showed significant differences between the experimental class and the control class, with a significance value of 0.000 and a large effect size (Cohen's $d = 1.78$). These results suggest that incorporating local wisdom and STEM approaches into the PBL model can improve student learning outcomes and have high relevance in efforts to improve the quality of physics education in secondary schools.

Keywords: PBL, STEM, local wisdom, sound waves, learning outcomes

Abstrak:

Tujuan penelitian ini adalah mengimplementasikan PBL terintegrasi STEM berbasis kearifan lokal (Gong Buleuh) pada materi gelombang bunyi dan menganalisis pengaruhnya terhadap peningkatan hasil belajar siswa. Metode yang digunakan dalam penelitian ini adalah quasi eksperimen dengan desain non-equivalent control group design. Penelitian ini melibatkan dua kelas XI IPA SMA Negeri 8 Kota Jambi yang masing-masing terdiri dari 30 siswa. Kelas eksperimen menggunakan PBL terintegrasi berbasis STEM berbasis kearifan lokal (Gong Buleuh), sedangkan kelas kontrol menggunakan PBL tanpa integrasi. Pretest dan posttest diberikan untuk menilai prestasi belajar siswa. Setelah implementasi, siswa di kelas eksperimen menunjukkan peningkatan hasil belajar yang signifikan dibandingkan dengan siswa di kelas kontrol. Uji-t sampel berpasangan menunjukkan nilai signifikansi 0,000 dan effect size yang besar (Cohen's $d = 7,76$). Selanjutnya, uji t sampel independen menunjukkan perbedaan yang signifikan antara kelas eksperimen dan kelas kontrol, dengan nilai signifikansi 0,000 dan effect size yang besar (Cohen's $d = 1,78$). Hasil ini menunjukkan bahwa penggabungan pendekatan kearifan lokal dan STEM ke dalam model PBL dapat meningkatkan capaian pembelajaran siswa dan memiliki relevansi tinggi dalam upaya peningkatan mutu pendidikan fisika di sekolah menengah.

Kata kunci: PBL, STEM, kearifan lokal, gelombang bunyi, capaian pembelajaran

Introduction

Education in the 21st century has undergone significant changes, along with the development of innovations in various aspects of life that demand the readiness of society. Education refers to a deliberate process aimed at developing children's physical and mental potential, with the aim of equipping them to be able to face various life challenges independently (Hidayat & Abdillah, 2019). In this context, 21st century learning demands the mastery of new abilities and skills, where teachers are expected to be able to integrate learning materials into real-world situations so that students understand real-world relevance. Problem-solving skills, which are dynamic and sustainable, are one of the key competencies that students must have. Therefore, educational standards must continue to be adjusted to the demands of modern times.

In this regard, Physics is a branch of the natural sciences (science) that makes a significant contribution to the improvement of educational standards, especially in terms of producing capable and qualified students (Wijaya et al., 2023). A qualified individual can be defined as someone who has the ability to think critically, creatively, innovatively, logically and is able to show initiative in responding to various social problems that arise due to technological developments. As a result, rather than just studying formulas, physics students are required to apply the understanding of physics in daily life (Maulana, 2020). The application of this physics concept is not always easy, especially in sound wave materials that are often considered complex by students. Some concepts such as frequency, amplitude, and wave speed are abstract so they demand a deep understanding (Fatimah, 2016).

One of the appropriate and effective learning approaches to improve the quality of 21st century learning is the problem-based learning model (PBL). This model helps students build a more structured understanding of concepts and improve their memory of the material (Arifah et al., 2021). In line with that, the STEM (Science, Technology, Engineering, and Mathematics) approach creates an applicative and meaningful learning experience by integrating the four disciplines in the educational process oriented towards real-world problem-solving (Susanti et al., 2018). The integration between PBL and STEM not only encourages students to understand concepts in depth, but also bridges learning with actual situations. In addition, incorporating local wisdom in physics learning strengthens the cultural context and relevance of the material, while broadening students' perspective on science (Fahrudin & Maryam, 2022). For example, the traditional musical instrument Gong Buleuh which originated from the Kerinci culture in Jambi Province can be used as a medium for learning sound waves. The characteristics of the sound produced can be explained physically, thus helping students connect abstract concepts with real phenomena in a more contextual and meaningful way (Sepdwiko, 2020).

Several previous studies have shown that the application of the Problem-Based Learning (PBL) model integrated with STEM approaches can improve student learning outcomes (Sari & Putri, 2022; Suciana et al., 2023). However, research that specifically examines the integration of PBL and STEM with local wisdom in physics learning is still very limited. (Mashoko, 2022) emphasizes the importance of integrating cultural artifacts in physics learning to recognize science as a way of knowing that is cultural, but has not studied in depth the use of certain cultural artifacts, such as Gong Buleuh, in learning sound wave materials. In addition, the results of initial interviews with physics teachers at SMA Negeri 8 Jambi City revealed that student learning outcomes are still relatively low, and the integration of STEM approaches and elements of local wisdom has not been optimally applied. Therefore, this study aims to implement STEM-integrated PBL based on local wisdom (Gong Buleuh) on sound wave materials, as well as analyze its influence on improving student learning outcomes.

Methods

This research was conducted at SMA Negeri 8 Jambi City, located on Jalan Marsda Surya Dharma Km 8, from January to February 2025. The school was selected not only due to its willingness to collaborate in the research but also because of the characteristics of its students, who show interest in learning physics through everyday life contexts.

This study is a type of comparative quantitative research aimed at comparing the values of one or more variables across different samples or time periods (Ali et al., 2022). The population of this study includes all students of XI F MIPA SMA Negeri 8 Jambi City, which is divided into four classes, each consisting of thirty students. A total of thirty students in grades XI F3 and XI F4 participated in this study. The sampling technique used is purposive sampling, which is a sampling technique that is carried out deliberately by considering characteristics that are in accordance with the research objectives (Lenaini, 2021). Sampling is based on the equality of learning outcomes between classes and ensures that the class used has never been sampled by researchers before. After the two classes were purposively selected, they were then randomly assigned as the experimental and control groups.

The experimental method was used in the implementation of this study to assess the impact of a treatment on the variables that have been determined (Daniel & Harland, 2017). The experimental and control groups were not randomly assigned because the research design was quasi-experimental with the Nonequivalent Control Group design model (Hastjarjo, 2019). Both groups were given a pretest and a posttest as part of this design. The following table presents the research design:

Table 1. Nonequivalent Control Group research design

Pretest	Treatment	Posttest
O_1	X	O_2
O_3	-	O_4

(Abdullah et al., 2022)

Keterangan:

O_1 = Pretest in the experimental class

O_2 = Posttest in experimental class

O_3 = Pretest on the control class

O_4 = Posttest on the control class

X = Treatment given to experimental classes

- = No treatment was carried out in the control class

To measure students' initial understanding, a pretest was administered in both classes at the beginning of this study. After the initial test, each class received treatment in a different way. The experimental class was treated in the form of the use of STEM-integrated PBL learning tools based on local wisdom (Gong Buleuh), while the control class used PBL learning tools without the integration of STEM and local wisdom. This treatment was given during four meetings that discussed sound wave material. After the treatment, both classes were given a final test (posttest). After implementing various learning tools, data from the initial test and final test were analyzed to compare the learning outcomes of the two classes and measure the extent to which students' learning outcomes have improved.

Data Collection Techniques

Some of the techniques used for data collection include interviews, initial perceptions, and tests (pretest and posttest). The test is administered in two stages: the pretest assesses the student's initial knowledge, and the posttest measures their understanding after the treatment. The test used was in the form of a description of sound waves. The questions used in the control class and the experimental class had the same indicators, cognitive level, and measurement objectives. The difference lies in the presentation of the context of the question. In the experimental class, the questions were added with elements of local wisdom from Gong Buleuh to support the learning approach applied. Meanwhile, the questions in the control class used questions from Sari, (2019) without modification. This question is validated and arranged based on the cognitive domains C3 (applying) and C4 (analyzing) according to the PBL approach, in order to measure student learning outcomes in applying and analyzing sound wave concepts. Details of the question indicators can be seen in the following table.

Table 2. Learning Outcome Test Question Indicators

Indicators	Cognitive Domain	Number of Questions
Determining the speed of sound propagation in the air through experiments	C3	1
Calculating the frequency that listeners send on Doppler principle studies	C4	1
Calculating the large wire tension force on a string with an experiment	C3	1
Calculating the frequency of tones in a closed organ pipe	C3	1
Determine the intensity and intensity level of the sound.	C3	1
Total Number of Questions		5

(S. A. Sari, 2019)

Validation of Research Instruments

Instrument validation is carried out to ensure that the research device meets the standards of content, construction, and integration with the learning approach used. The validated instruments include teaching modules, student worksheets, and description test questions.

1. Validation of Teaching Modules

In this study, a validation of the teaching module for the experimental class and the control class was carried out. Both modules are structured based on ATP and the Ministry of Education and Culture's teaching modules, but apply different learning approaches. Validation is carried out to ensure the suitability of content, systematics of preparation, and integration with learning approaches. Details of the teaching module validation sheet are presented in the following table.

Table 3. Teaching Module Validation Sheet Details

No	Indicators	Statement Item	Statement Number
GENERAL INFORMATION			
1.	Identity Module	1	1
2.	Initial Competencies	1	2
3.	Pancasila Student Profile	1	3
4.	Facilities and Infrastructure	2	4,5
5.	Target Students	3	6,7,8
6.	Learning Model	1	9
7.	Teaching Materials Completeness	3	10,11,12
CORE COMPONENTS			
1.	Learning Outcomes Objectives	2	1,2
2.	Meaningful Understanding	1	3
3.	Lighter Questions	1	4
4.	Learning Activities	4	5,6,7,8
5.	Assessment	7	9,10,11,12,13
6.	Questions and Remedials	2	14,15
7.	Reflections of Teachers and Students	2	16,17
8.	Glossary	1	18
9.	Bibliography	1	19
ATTACHMENT			
1.	Student Worksheets	2	1,2
2.	Teaching Materials	1	3

(Lubis, 2024)

2. Validation of Student Work Sheets (LKPD)

For the experimental and control classes, two different types of Learner Worksheets (LKPDs) were used for validation. The LKPD in the experimental class uses a STEM-based integrated PBL approach based on local wisdom (Gong Buleuh), which is prepared by adapting STEM and local wisdom from (Farrizqi, 2024). Meanwhile, the control class LKPD was prepared using a PBL approach without the integration of STEM and local wisdom, following the teaching module of the Ministry of Education and Culture. The details of the LKPD validation sheet are presented in table 4 below.

Table 4. Details of the LKPD Validation Sheet

No	Indicators	Statement Item	Statement Number
1.	Format	3	1, 2, 3
2.	Language	5	4, 5, 6, 7, 8
3.	Content	4	9, 10, 11, 12

(Lubis, 2024)

The assessment scale on the validation sheet of the teaching module and LKPD uses a likert scale with a range of scores as shown in the following table 5.

Table 5. Teaching Module and LKPD Validation Assessment Scale

Score	Category
1	strongly disagree
2	disagree
3	agree
4	Strongly agree

(Lubis, 2024)

3. Validation of Description Test Questions

Validation of description test questions is carried out to ensure the quality and suitability of the evaluation instrument with learning objectives. In this study, validation was only carried out on experimental class questions. The validation process includes aspects of objectives, language, and question construction to ensure accuracy in measuring student learning outcomes. The details of the description test question sheet are shown in the following table.

Table 6. Details of the Description Test Question Validation Sheet

No	Indicators	Statement Item	Statement Number
1.	1 Formulation of Research Objectives	5	1, 2, 3, 4, 5
2.	Language	3	6, 7, 8
3.	Construction	3	9, 10, 11

(Lubis, 2024)

The assessment scale on the validation sheet of the description test questions uses a likert scale with the score range as shown in the following table 7.

Table 7. Assessment Scale for Validation of Description Test Questions

Score	category
1	Not suitable
2	Less Suitable
3	appropriate

(Lubis, 2024)

The data obtained from the validation sheets, both for teaching modules, LKPD, and description test questions, will be analyzed to assess the feasibility level of each instrument. The analysis was carried out using the following formula:

$$\text{Percentage} = \frac{\text{Total Score}}{\text{Maximum Score}} \times 100\%$$

Furthermore, the results of the analysis will be interpreted to determine the feasibility categories of teaching modules, LKPD, and description test questions. Interpretation is carried out based on the percentage of eligibility presented in the following table 8.

Table 8. Interpretation of Eligibility Percentages

No	category	Eligibility Percentage
1.	Very Feasible	81% - 100%
2.	Feasible	61% - 80%
3.	Quite Feasible	41% - 60%
4.	Less Feasible	21 % - 40%
5.	Not Feasible	< 20%

(Setiawan & Wiyardi, 2015)

Data Analysis Techniques

Data analysis techniques are used to process and interpret research results objectively. The analysis is carried out on samples that represent the population so that the results of the study can be applied more widely. The following are the data analysis techniques used in this study.

1. Normality Test

To use parametric statistical tests, normality tests are performed to ensure that the data has a normal distribution (Fahmeyzan et al., 2018). Since the number of samples in this study is more than fifty, the Kolmogorov-Smirnov test is used. This test was conducted using IBM SPSS Statistics 26. Significance value (Sig.) is used as one of the decision-making factors. If the Sig. is more than 0.05, the data is considered to be normally distributed. Meanwhile, if the Sig. value is below 0.05, it means that the distribution is not normal.

2. Homogeneity test

The homogeneity test aims to see the similarity of variance between the two data groups (Sianturi, 2022). This test is an important prerequisite for performing parametric statistical tests such as independent sample t-tests. The basis for decision-making in this test comes from the results of Levene. If the Sig. is more than 0.05, the data is considered homogeneous. Meanwhile, if the Sig. value is below 0.05, it means that the data is considered inhomogeneous.

3. t-test

The t-test is useful for testing for significant differences in one data group or two data groups (Mustafidah et al., 2020). This study compared the values between the experimental and control classes using independent sample t-tests and tested for changes in one group using paired sample t-tests.

a. Paired Sample t-Test

Paired t-tests are performed to ascertain whether the two groups of interrelated data differ significantly. The determination of the results refers to the value of Sig. (2-tailed). If the Sig. is more than 0.05, H_0 is accepted because there is no significant difference. Meanwhile, if the Sig. value is below 0.05, H_0 is rejected because the difference is considered significant.

b. Independent Sample t-Test

Two unrelated groups were compared using an independent sample t-test (Pradana et al., 2022). The data must have a homogeneous and normally distributed variance in order to be used in this test. Sig. (2-tailed) values are used to make decisions in this test. When the Sig. (2-tailed) is less than 0.05, then shows a significant difference, H_0 is rejected. However, if the value is greater than 0.05, then it does not show a significant difference, H_0 is acceptable (Nuryadi et al., 2017). If the variants are homogeneous, use the line "Equal variances assumed". Otherwise, use the t' test or the t-Welch test. This test is applied to data that is normally distributed but varied. The decision is based on the Sig. value on the line "Equal variances not assumed".

4. Cohen's d test

Cohen's d test is an effect size indicator used to measure the magnitude of the impact a treatment has on other variables in a study (Çavuş & Deniz, 2022). This measure is very important because it not only shows whether or not there is an impact, but it also informs the magnitude of the impact it causes. In addition, effect size allows researchers to compare the effectiveness of treatments between different studies or experiments. Classified effect size into three categories, namely: $d = 0.20 - 0.50$ indicating a small effect (low level), $d = 0.50 - 0.80$ for moderate (intermediate level) influence, and $d > 0.80$ indicating a large (high level) influence (Cohen, 1988). The formula for calculating effect size is as follows:

$$d = \frac{(M_1 - M_2)}{\sqrt{\frac{SD_1^2 + SD_2^2}{2}}}$$

Description:

d = Effect Size

M_1 = Mean of group 1

M_2 = Mean of group 2

SD_1^2 = Variance (squared standard deviation) of group 1

SD_2^2 = Variance (squared standard deviation) of group 2

Research and Discussion Results

1. Product Validation

The products validated in this study include the teaching module, student worksheets (LKPD), and essay test items. The validation was conducted by two expert lecturers in physics education who have expertise in evaluating learning tools and developing instructional modules.

1.1 Validation of Experimental Class Teaching Module

The experimental classroom teaching module was developed using a STEM-based integrated PBL model based on local wisdom (Gong Buleuh). The validation is evaluated based on three main aspects, namely general information, core components, and attachments, as shown in Table 9.

Table 9. Percentage of Validation Results of Teaching Module in Experimental Class

No	Research Aspects	Validator Eligibility		Validator Eligibility		Category
		Percentage 1		Percentage 2		
		Stage 1	Stage 2	Stage 1	Stage 2	
1.	General information	100 %	100 %	93,75 %	95,83 %	Very Feasible
2.	Core components	100 %	100 %	92,1 %	94,73%	Very Feasible
3.	Attachment	87,5 %	100 %	87,5 %	100 %	Very Feasible
	Average	95,83 %	100 %	91,11 %	96.85 %	Very Feasible

Based on the percentage of validation results, in the first stage, Validator 1 gave a score of 100% for the general information and core components, but only 87.5% for the attachment aspect. After the revision in the second stage, Validator 1's score increased to 100% for all aspects. This improvement

occurred after enhancing the wording in the attachments to make them clearer, more structured, and better support the required information. Meanwhile, in the first stage, Validator 2 gave a score of 93.75% for general information, 92.1% for core components, and 87.5% for attachments. After the second-stage revision, Validator 2's score increased to 95.83% for general information, 94.73% for core components, and 100% for attachments. This improvement occurred after the learning objectives were clarified and elaborated to make them more specific, measurable, and supportive of the overall learning process. The average eligibility percentage also increased, from 95.83% and 91.11% in the first phase to 100% and 96.85% in the second phase. Thus, the results of the eligibility percentage of both validators are in the "very feasible" category and the teaching module is declared ready for use in learning.

1.2 Validation of the Control Class Teaching Module

In contrast to the experimental class, the teaching module for the control class was developed using the Problem-Based Learning (PBL) model without the integration of STEM or local wisdom elements. The validation of the control class teaching module was evaluated based on three main aspects, as presented in Table 10 below.

Table 10. Percentage of Teaching Module Validation Results in Control Classes

No	Research Aspects	Validator Eligibility		Validator Eligibility		Category
		Percentage 1		Percentage 2		
		Stage 1	Stage 2	Stage 1	Stage 2	
1.	General information	100 %	100 %	93,75 %	95,83 %	Very Feasible
2.	Core components	100 %	100 %	92,1 %	94,73%	Very Feasible
3.	Attachment	87,5 %	100 %	87,5 %	100 %	Very Feasible
	Average	95,83 %	100 %	91,11 %	96.85 %	Very Feasible

Based on the percentage of validation results, in the first stage, Validator 1 gave a score of 100% for the general information and core components, but only 87.5% for the attachment aspect. After the revision in the second stage, Validator 1's score increased to 100% for all aspects. This improvement occurred after enhancing the wording in the attachments to make them clearer, more structured, and better support the required information. Meanwhile, in the first stage, Validator 2 gave a score of 93.75% for general information, 92.1% for core components, and 87.5% for attachments. After the second-stage revision, Validator 2's score increased to 95.83% for general information, 94.73% for core components, and 100% for attachments. This improvement occurred after the learning objectives were clarified and elaborated to make them more specific, measurable, and supportive of the overall learning process. The average eligibility percentage also increased, from 95.83% and 91.11% in the first phase to 100% and 96.85% in the second phase. Thus, the results of the eligibility percentage of both validators are in the "very feasible" category and the teaching module is declared ready for use in learning.

1.3 Validation of LKPD for Experimental Classes

The validation of the experimental class LKPD was carried out based on three aspects, namely format, language, and content, as shown in the following Table 11.

Table 11. Percentage of LKPD Validation Results in Experimental Classes

No	Research Aspects	Validator Eligibility		Validator Eligibility		Category
		Percentage 1		Percentage 2		
		Stage 1	Stage 1	Stage 2	Stage 2	
1	Format	100 %	83,33 %	83,33 %	Very Feasible	
2	Language	100 %	95 %	100 %	Very Feasible	
3	Content	100 %	93,75 %	93,75 %	Very Feasible	
	Average	100 %	90,69 %	92,36 %	Very Feasible	

Based on the percentage of validation results, validator 1 only conducted one assessment and gave a maximum score of 100% for all aspects, showing that the LKPD was assessed very well in terms

of structure and content by the validator. Meanwhile, validator 2 conducted the assessment in two stages. In the first stage, the scores given were 83.33% for the format aspect, 95% for language, and 93.75% for content. After the revision, there was an increase in the score in the language aspect to 100%, while the format and content were fixed. The increase in scores in the language aspect occurred after improvements were made in the writing of tools and materials to be more systematic and the placement of 'collecting data' with more precise and communicative sentence formulations. This caused the average score of validator 2 to increase from 90.69% in the first stage to 92.36% in the second stage. Thus, based on the validation results of the two validators, the experimental class LKPD as a whole is in the category of "very feasible" and is declared ready for use in learning

1.4 Control Class LKPD Validation

The validation of the LKPD for the control class was also assessed based on three aspects, namely format, language and content, as shown in the following table 12.

Table 12. Percentage of LKPD Validation Results in Control Class

No	Aspek Penelitian	Validator Eligibility Percentage 1	Validator Eligibility Percentage 2	Category
1.	Format	100 %	100 %	Very Feasible
2.	Language	100 %	95 %	Very Feasible
3.	Content	100 %	87,5 %	Very Feasible
	Average	100 %	94,16 %	Very Feasible

Based on the percentage of validation results, validator 1 scored 100% on all aspects, while validator 2 scored 100% for format, 95% for language, and 87.5% for content. The overall average result was at 100% for validator 1 and 94.16% for validator 2. Thus, based on the validation results of the two validators, the overall control class LKPD was in the "very feasible" category and was declared ready for use in learning.

1.5 Validation of Essay Test Items

The validation of the essay test items is assessed by considering three aspects, namely the formulation of objectives, language, and content, as shown in the following table 13.

Table 13. Percentage of Validation Results for Essay Test Items

No	Aspek Penelitian	Validator Eligibility Percentage 1	Validator Eligibility Percentage 2	Kategori
1	Formulation of Research Objectives	100 %	93,33 %	Very Feasible
2	Language	100 %	100 %	Very Feasible
3	Content	100 %	100 %	Very Feasible
	Average	100 %	97,77 %	Very Feasible

Based on the percentage of validation results, validator 1 gave a score of 100% on all aspects, while validator 2 gave a score of 93.33% on the formulation of the goal and 100% on the other two aspects. The average eligibility results of the two validators were 100% and 97.77%, respectively. Thus, essay test items are declared "very feasible" to be used in the learning evaluation process.

2. Analisis Data Data Analysis

2.1 Normality Test

The normality test aims to see if the pretest and posttest data in the experimental and distributed control classes are normal. The normality test is a prerequisite for parametric statistical analysis. Table 14 below shows the results of the normality test for each group.

Table 14. Normality Test Results on Learning Outcome Data

Tests of Normality
Kolmogorov-Smirnov ^a

		Statistic	df	Sig.
Result	Pretest (Experimental Classes)	.157	30	.057
	Posttest (Experimental Classes)	.150	30	.085
	Pretest (Control Class)	.138	30	.147
	Posttest (Control Class)	.111	30	.200*

Based on table 14, it shows that the pretest value of the experimental class is 0.057, the posttest value is 0.085, the pretest value of the control class is 0.147, and the posttest value is 0.200. All Sig. Values greater than 0.05 indicate that the distribution of the four data groups is normal.

2.2 Homogeneity Test

The homogeneity test aims to determine the similarity of variance in student learning outcome data in experimental and control classes before and after treatment. The results of the homogeneity test can be seen in the following table 15.

Table 15. Homogeneity Test Results on Learning Outcome Data

	Levene Statistic	df1	df2	Sig.
Pretest	.335	1	58	.565
Posttest	13.419	1	58	.001

Based on table 15, the significance value for the pretest data is 0.565, which means that the Sig. value is greater than 0.05. This shows that the variance of learning outcomes between the experimental class and the control class before treatment was homogeneous, or that there was no significant difference in variance between the two. Meanwhile, the significance value for the posttest data is 0.001, which indicates the Sig. value is less than 0.05. This indicates that the variance in learning outcomes between the experimental class and the control class after treatment was not homogeneous, or that there was a significant difference in variance between the two groups after the treatment was given.

2.3 Paired Sample t-Test

The Paired Sample t-Test was conducted to find out if there was a significant difference between the pretest and posttest scores in one group, both in the experimental and control classes. The following test results are shown in the following table 16.

Table 16. Paired Sample t-Test Results in Experimental and Control Classes

	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig.(2-tailed)
				Lower	Upper			
Pretest –Posttest Experimental Classes	-63,2083	8.19143	1.49554	-66.26706	-60.14960	-42.264	29	.000
Pretest –Posttest Control Class	-42.9166	11.02668	2.01319	-47.03410	-38.799924	-21.318	29	.000

Based on table 16, the Sig.(2-tailed) value for the experimental class is 0.000, which is smaller than 0.05 so H_0 is rejected. This shows that there is a significant difference between the pretest and posttest scores in the experimental class. Thus, the application of STEM-based integrated PBL learning tools based on local wisdom (Gong Buleuh) has a significant influence on improving student learning outcomes. Meanwhile, in the control class, the Sig.(2-tailed) value was also 0.000, indicating that there was a significant difference between the pretest and posttest values, although the increase was not as large as in the experimental class.

2.4 Independent Sample t-Test

Independent sample t-tests were used to determine significant differences between learning outcomes in the experimental and control classes, both before and after treatment. Here are the test results in the pretest.

Table 17. Independent Sample T-Test Results in Pretest

	t-test for Equality of Means					95% Convidence Interval of the Difference	
	t	df	Sig.(2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Equal variance assumed	-.439	58	.663	-1.04167	2.37540	-5.79655	3.71322
Equal variance not assumed	-.439	57.904	.663	-1.04167	2.37540	-5.79672	3.71339

Based on table 17, it shows that the data meets the homogeneity assumption, so the next analysis uses the Equal variance assumed line which produces a significance value (Sig.2-tailed) of 0.663, where the Sig. value is greater than 0.05. This shows that there is no significant difference between the experimental class pretest value and the control class, so H_0 is accepted. Therefore, it can be said that before the treatment was given, the initial knowledge of the students in the classroom was at a relatively similar level.

In addition, table 16 below displays the results of the Independent Sample t-test to determine the difference in posttest results between the two classes.

Table 18. Independent Sample T-Test Results in Posttest

	t-test for Equality of Means					95% Convindence Interval of the Difference	
	t	df	Sig.(2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Equal variance assumed	6.911	58	.000	19.25000	2.78522	13.67479	24.83521
Equal variance not assumed	6.911	42.055	.000	19.25000	2.78522	13.62943	24.87057

Based on table 18, it shows that the data does not meet the homogeneity assumption, so the next analysis is seen on the line Equal variance not assumed. In this line, a significance value (Sig.2-tailed) of 0.000 is obtained, which means that the Sig. value is less than 0.05. Therefore, the H_0 is rejected, which means that there is a significant difference between the results of the posttest of the experimental class and the control class.

2.5 Cohen's d Test.

The Cohen test is conducted to determine the effect size of the treatment given in one class or to measure the difference in results between two classes. The following is presented the results of the calculation of Cohen's value d to measure the magnitude of the change between the pretest and posttest scores in each class Standard Deviation

Table 19. Cohen's d Results for Pretest–Posttest in Experimental and Control Classes

	Mean	Standard Deviation	Cohen's d
Pretest (Experimental Classes)	16,71	9,39	7.76
Posttest (Experimental Classes)	79,92	6,69	
Pretest (Control Class)	17,75	9,01	3.70
Posttest (Control Class)	60,67	13,71	

Based on Table 19, Cohen's d value in the experimental class was 7.76, while in the control class it was 3.70. This value showed that there was a huge improvement in learning outcomes in both classes after treatment, but the improvement in the experimental class was much higher than in the control class. Furthermore, to see the difference in posttest results between the two classes, the Cohen's d value was calculated as shown in Table 20 below.

Table 20. Cohen's *d* Results for Posttest Between Experimental and Control Classes

	Mean	Standard Deviation	Cohen's <i>d</i>
Posttest Experimental Classes	79.92	6.69	1.78
Posttest Control Class	60.67	13.71	

Based on Table 20, the result of Cohen's *d* calculation for the comparison of posttest scores between the experimental class and the control class was 1.78. This value indicates a large difference between the two classes after the treatment given.

Conclusion

The implementation of STEM-based integrated PBL learning tools based on local wisdom (Gong Buleuh) on sound wave materials at SMA Negeri 8 Kota significantly improved student learning outcomes in experimental classes. This increase was evidenced by an increase in the average pretest score (16.71) to posttest (79.92), with a significance value of the paired sample *t*-test of 0.000 and a large effect size (Cohen's *d* = 7.76). Furthermore, the results of the independent sample *t*-test showed a significant difference in the average posttest score between the experimental class (79.92) and the control class (60.67), with a significance value of 0.000 and a large effect size (Cohen's *d* = 1.78). These findings show that integrating local wisdom and STEM approaches into the PBL model is an effective learning method in improving student learning outcomes. In addition, this research opens up opportunities to develop similar learning tools on other topics in physics or other science subjects.

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