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The Effectiveness of the Ethnophysics-Based PBL Model in Enhancing Scientific Literacy on Newton's Laws

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ABSTRACT

This study aims to examine the effectiveness of a Problem-Based Learning (PBL) model integrated with ethnophysics in enhancing students' scientific literacy on Newton's Laws. The low level of scientific literacy among students underscores the need for a contextualized learning approach through the integration of local wisdom, specifically, the use of *Becak Lawu* as an instructional context. A quasi-experimental method with a nonequivalent control group design involved two eleventh-grade classes selected through purposive sampling. Class XI-2 as the experimental class with 35 students and class XI-5 as the control class with 36 students The research instruments consisted of a questionnaire on students' responses to the science literacy of Newton's Laws material. Data were analyzed using SPSS. The results indicate that the lesson implementation reached ≥88%, categorized as very good. The experimental group achieved an N-Gain of 0.53 (moderate), while the control group obtained 0.24 (low). Item number 1 is in the moderate category, and item number 3 is in the difficult category, and student responses to the learning model reached ≥86%, also categorized as very good. These findings suggest that the ethnophysics-based PBL model is effective in improving students' scientific literacy.

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INTRODUCTION

In the 21st century, the advancement of science, technology, and communication has brought about significant changes in the competencies expected of students. These changes are reflected in the emphasis on mastering the 4C (critical thinking, communication, creative thinking, and collaboration) (Saputra, 2024, Ranggana et al., 2024). The 21st century is characterized by rapid advancements in science, technology, and communication. Digital technology plays a significant role in fostering students' creativity and innovation (D. Mangubat & L. Ramirez, 2023). To equip students for global challenges, education must go beyond the mere transmission of content knowledge and actively cultivate scientific literacy, digital competence, and problem-solving abilities (Shella et al., 2024). The necessity to strengthen literacy is also manifested in national policy through Indonesia Ministry of Education Regulation No. 78 of 2019, which underscores the significance of the National Literacy Movement in fostering lifelong learning and cultivating the Pancasila Student Profile.

Scientific literacy is one of the fundamental skills required in the modern era, especially amid the rapid advancement of science and technology (Yuniarto & Yudha, 2021). According to

PISA data from 2000 to 2022, Indonesian students' performance in scientific literacy consistently remains below the international average. This is supported by the 2022 World Population Review survey, which ranked Indonesia 62nd out of 81 countries in literacy, mathematics, and science (OECD, 2024). These data are in line with the research conducted by Wardi (2023), which found that among 72 students, 6% demonstrated very low scientific literacy competence, 44% were categorized as low, and 14% as moderate. These findings indicate that students' low interest in and limited understanding of physics contribute to their inadequate scientific literacy. Supported by research from Musa (2023), it was stated that the scientific literacy ability of eighth-grade students at SMP Negeri 1 Gorontalo in the aspect of scientific competence falls into the low category, with a student percentage of 91.16%. Meanwhile, the scientific literacy ability of eighth-grade students at SMP Negeri 2 Gorontalo in the aspect of scientific competence is 95.68%, which is still considered low. This condition is attributed to their weak scientific literacy skills and their lack of responsiveness to current issues and developments in their surrounding environment. The researcher’s observation of 37 eleventh-grade students at State Senior High School 2 Magetan revealed that 54.1% perceived physics as uninteresting due to the difficulty in comprehending the material, while 43.2% believed that the learning process placed greater emphasis on theoretical aspects rather than practical applications. Although physics encompasses everyday phenomena, its instruction rarely incorporates elements of local culture, leading to a limited understanding of concepts among students. (Sutrisna, 2021; Wulansari & Admoko, 2021).

One of the learning models that can be used is the PBL model. This model guides the learning process through problem analysis by identifying learning characteristics (Lendeon & Poluakan, 2022). However, the PBL model has limitations in enhancing students' motivation and work practices in groups, thus requiring teachers to accompany them (Pasiri, 2023). To address this, the integration of the PBL model with an ethnophysics framework has been proposed, aiming to support researchers in achieving their educational objectives. Ethnophysics is a branch of ethnoscience that focuses on the application of physics concepts within specific cultural groups (Mulyaningsih et al., 2023). Research suggests that incorporating ethnophysics into PBL, such as in the instruction of sound waves, contributes to students’ adequate conceptual understanding, though their practical abilities still require further development (Alfiah & Wasis, 2024). The integration of the PBL model with ethnophysics is expected to assist researchers in achieving the goals of their study (Wulansari & Admoko, 2021). The implementation of the Problem-Based Learning (PBL) model in fostering scientific literacy should be further developed in the context of Newton’s Laws in Physics, as it has been shown to have a positive impact on students’ learning outcomes (Mayanti et al., 2022). According to research conducted by Suryati (2024), the development of student worksheets using a local wisdom-based PBL model with the independent curriculum on colloid material can enhance critical thinking skills and improve generic science skills, and there is a positive response from students.

Ethnoscience is divided into several main categories, namely ethnobiology, ethnomathematics, and ethnophysics (Sunarti et al., 2023). Ethnophysics is a branch of ethnoscience that focuses on the application of physics concepts within specific cultural groups (Mulyaningsih et al., 2023). Ethnophysics is a branch of ethnoscience that explores the relationship between a region's cultural processes and the concepts of physics (Febrianty et al., 2023). The integration between cultural concepts and physics can be analyzed from various perspectives to serve as instructional material in the learning process. Cultural background may influence students' learning attitudes, and the process of learning physics requires students to elaborate on physical principles without disregarding local cultural values (Nurmasyitah et al., 2022).

One such local phenomenon is the “Becak Lawu," a traditional wooden cart used in Magetan. "Becak Lawu," a term used for a cart made from repurposed wood and used tires, is a traditional means of transportation commonly utilized by the communities living on the

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southeastern slopes of Mount Lawu, particularly in Plaosan District, Magetan Regency, for their daily activities (Shobariyati & Rohmah, 2022). Although it does not use an engine or chain, the Becak Lawu can move swiftly because ball bearings (klaker) are installed between its front wheels, accelerating the motion of its wooden wheels, which are covered with used tires. However, this vehicle can only be operated on downhill roads (Arby, 2023).

The topic of motion and forces, key elements in physics education since elementary school, is highly relevant to understanding such local phenomena. Motion refers to the change in an object's position over time, while force is defined as a push or pull that causes a change in the object's motion, direction, or shape. A clear understanding of these concepts is essential for grasping more advanced topics in physics (Riyadi, 2020). A solid grasp of these concepts is critical for progressing to more complex physics topics and is closely related to various real-life phenomena. Based on a survey conducted at State Senior High School 2 Magetan, 48.6% of students reported never having studied Newton's Laws in relation to the Becak Lawu phenomenon, while 24.3% were unsure, despite recognizing the vehicle's presence in their environment. This aligns with the findings of Nimunuho and Naen (2023), who found that students faced significant difficulties in understanding Newton's Laws, particularly in procedural and metacognitive aspects, as indicated by low average scores. These results highlight ongoing challenges in applying force and motion concepts to problem-solving and experimental contexts. These findings suggest that students still face considerable challenges in systematically comprehending and applying the procedural steps required to analyze or conduct experiments on force and motion concepts, particularly when contextualized within everyday phenomena such as the Becak Lawu.

Based on previous research by Aina (2023), applying problem-based learning assisted by PhET simulations significantly improved students' scientific literacy, with a high N-gain score of 0.718 in the experimental group (compared to 0.409 in the control group). A study conducted by Nadiyah (2022) stated that the Problem-Based Learning (PBL) approach combined with ethnoscience can enhance students' conceptual understanding and scientific literacy. This is also in line with the findings of Hafizah and Nurhaliza (2021), who stated that the implementation of PBL in science education can foster students' scientific process skills through problem-solving activities in addressing issues related to scientific literacy. The researchers took the initiative to investigate this problem further with the hope of training students' skills through local wisdom-based physics learning, specifically the Lawu Becak phenomenon, using a Problem-Based Learning (PBL) model.

By connecting Newton's Laws to real-life phenomena, students are able to understand physics concepts in a more applicable and meaningful manner. Ethnoscience-based learning that incorporates local phenomena serves as an effective approach to facilitate students' comprehension of physics by contextualizing abstract concepts within their immediate environment (Haspen, 2021). Therefore, this study aims to (1) evaluate the effectiveness of the ethnophysics-based PBL model on Newton's Laws in enhancing students' scientific literacy at State Senior High School 2 Magetan; (2) analyze students' scientific literacy outcomes following the implementation of the ethnophysics-based PBL model on Newton's Laws; and (3) examine students' responses toward the application of the ethnophysics-based PBL model in the context of Newton's Laws. This study is expected to broaden our understanding and contribute to the diversity of knowledge, particularly in the field of ethnophysics with a local wisdom-based approach.

RESEARCH METHOD

This study adopts a quantitative research design. Quantitative research involves the collection and analysis of data in numerical form or qualitative data that has been converted into numerical values (Sugiyono, 2010). This study employed a quasi-experimental research method, which is an experimental approach that compares a treatment group (experimental group) with a control group without the full use of randomization in sample assignment. Among the

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various types of quasi-experimental designs, this study adopts the nonequivalent control group pretest-posttest design. In this design, two groups are compared: the experimental group, which receives the treatment, and the control group, which is a conventional model. Both groups are given a pretest and posttest. The difference in the results between the two groups is used to determine the effectiveness of the treatment administered (Margono, 2007). In this study, the experimental class received treatment (X) using the application of the ethnophysics-based PBL model, while the control class received treatment (C) in the form of conventional learning usually conducted by the teacher. The types of pretests and posttests consisted of 3 open-ended questions. The procedural design of the research is as shown in:

Table 1. Design "Nonequivalent Control Group Design"

Group	Pretest	Treatment	Posttest
Experimental	O_1	X	O_2
Control	O_3	C	O_4

Source: Sugiyono (2010)

Description:

- O_1 : The initial test, or pretest, was conducted in the experimental class using the PBL learning model based on Newton's Law of ethnophysics on the scientific literacy skills of students at SMAN 2 Magetan.
- O_3 : The initial test, or pretest, was conducted on the control class using the usual/conventional learning model used in schools.
- X_1 : Learning treatment using the PBL learning model based on Newton's Law and ethnophysics on the science literacy skills of students at SMAN 2 Magetan.
- C : Learning treatment using the usual/conventional learning model carried out at school in the control class.
- O_2 : The posttest was conducted on the experimental class after receiving treatment in the form of learning using the PBL learning model based on Newton's Law of Ethnophysics on the scientific literacy skills of students at SMAN 2 Magetan.
- O_4 : The posttest was conducted on the control class using the usual/conventional learning model used in the school.

Population is a generalized area of objects or subjects that have certain qualities and characteristics determined by the researcher (Suriani et al., 2023). The total population of 9th grade classes XI at State Senior High School 2 Magetan is 350 students. From these 9 classes, a sample will be taken using the purposive sampling technique. A sample is part of the quantity and characteristics possessed by the population (Sugiyono, 2010). The ideal characteristics of a sampling method are to produce a sample that reliably represents the population, to determine the precision of research results for a specific standard deviation value, and to be simple so that it is easy to implement (Sumargo et al., 2024). The type of sampling technique used in this research is purposive sampling.

The researchers employed purposive sampling based on several considerations, including the selection of classes with equivalent learning outcomes and instruction delivered by the same teacher for the physics subject. This approach was intended to control the teacher variable as a potential factor influencing student learning outcomes. The average learning outcome for students in class XI-2 was 46.8, while in class XI-4 it was 45.1. These relatively comparable scores served as a basis for determining the sample selection (Nenyhindarwaty, 2018). This method is used by researchers with a specific criterion, such as the similarity of the supervising teachers as a primary criterion, to maintain consistency in the learning process between the experimental group and the control group that will become the samples in this study (Etikan, 2016). The data collection instruments in this study used question instruments and student response questionnaires through reliability, validity, and effectiveness tests of the instruments from the observation sheet and also the pretest and posttest question instruments. The following is an example for question number two; it encompasses the ability to critically determine frictional force and analyze the relationship between the angle of elevation and the magnitude of frictional force. This requires skills in interpreting data and quantitatively evaluating phenomena. This question falls within the realm of scientific literacy: compiling and evaluating investigative designs and critically interpreting data (Anderson & Krathwohl, 2001).

This study employed empirical instrument validity, namely:

1. **Item Difficulty Index**

The item difficulty index ranges from 0.00 to 1.00. An item with a difficulty index of 0.0 indicates that the item is too difficult, whereas an index of 1.0 indicates that the item is too easy.

$$P = \frac{B}{Js}$$

Description:
P = Difficulty index
B = Number of students who answered the item correctly
Js = Total number of students

The criteria for the item difficulty index can be seen in the following table:

Table 2. Criteria for the item difficulty index questions

Difficulty Index	Criteria
0.00 ≥ P ≥ 0.30	Difficult
0.31 ≥ P ≥ 0.70	Medium
0.71 ≥ P ≥ 1.00	Easy

Source: Solichin (2017)

2. **Reliability**

Reliability refers to the consistency of an instrument in measuring a construct. If the instrument is reliable, repeated measurements under the same conditions will yield consistent results. The reliability correlation coefficient can be examined in the following table.

Table 3. Reliability

Correlation Coefficient	Criteria
0.60 ≤ r < 0.80	High Reliability
0.40 ≤ r < 0.60	Sufficient Reliability
0.20 ≤ r < 0.40	Low Reliability
r < 0.20	Very Low Reliability

(Price, 2017)

3. **Validity**

The validity of the essay test items can be determined using the following formula:

$$r_{xy} = \frac{N\sum XY - \sum X \sum Y}{\sqrt{(N\sum X^2(\sum X)^2)(N\sum Y^2(\sum Y)^2)}}$$

Description:

r_{xy} : Correlation coefficient between variable X and variable Y
N : Number of subjects
$\sum X$: Total item score
$\sum Y$: Total test score
$\sum Y^2$: Sum of squared total scores
$\sum Y^2$: Sum of squared item scores

Pretest and posttest used essay questions applied to the first class (experimental), which was given treatment using the ethnophysics-based PBL model, and to the second class (control), which was not treated with the model. Therefore, only three questions were used for the pretest and posttest. In this study, Item 1 consists of questions with cognitive level C3 in Item 1a and

C4 in Item 1b. Item 2 includes cognitive level C3 in Item 2a, C4 in Item 2b, and C6 in Item 2c. Item 3 contains a question with cognitive level C5. A trial test of the items was also conducted in Class XI-5. Furthermore, item analysis was performed using the ANATES 4.0 application to determine the reliability, difficulty level, discrimination index, and validity of the test items.

After taking the essay test, students received a score determined by the number of questions they answered correctly. To simplify data processing, the scores obtained were presented in the form of a value using the formula (Harefa, 2023):

$$Mark = \frac{obtained\ score}{maximum\ score}\ x\ 100\%$$

Table 4. Test sheet presentation

Percentage (%)	Category
90 - 100	Very Good
70 – 80	Good
50 - 60	Enough
< 50	Not Good

A response questionnaire is a research instrument in the form of a list of questions or written statements used to measure students responses or perceptions of a particular program, learning method, or material (Sugiyono, 2013). The questionnaire is administered at the end of the study. Students complete the questionnaire by checking the statements. To analyze student responses, a Likert scale is used to determine the results of student responses. The following is a Likert scale table 5.

Table 5. Likert scale table

Answer Options	**Score**
Strongly agree (SS)	5
Agree (S)	4
Neutral (3)	3
Disagree (TS)	2
Strongly disagree (STS)	1

Source: Sugiyono (2013)

$$\boldsymbol{Mark = \frac{obtained\ score}{maximum\ score}\ x\ 100\%}$$

The categories of student response questionnaire answers can be seen based on the percentage score results obtained as follows:

Table 6. Student response questionnaire percentage table

Percentage Interval	Criteria
$P \geq 90\%$	**Very good**
$80\% \leq p < 90\%$	**Good**
$70\% \leq p < 80\%$	**Enough**
$<60\%$	**Less**

Source: Rivai and Sudjana (2013)

The improvement in students' scientific literacy outcomes can be observed from the post-instruction results, which are subject to prerequisite testing. Initially, fundamental statistical tests, including the normality test and homogeneity of variance test, were conducted. Subsequently, an independent t-test was performed for hypothesis testing purposes.

1. **Prerequisite Test Analysis**

   This test was conducted because the researcher intends to generalize the final conclusions or hypotheses (H0 or H1) obtained from the sample to the population. The following are the steps for testing if the data are parametric.

a. Data Normality Test

Data normality was tested using the Kolmogorov-Smirnov (K-S) test via SPSS (Bandur, 2022) to examine the distribution of the data.

1) Hypotheses:
   - H0: The sample is normally distributed.
   - H1: The sample is not normally distributed.

   Decision Criteria (α = 0.05):
   - If p-value is > 0.05, H0 is accepted (normal distribution), and the analysis proceeds with a paired t-test.
   - If p-value is ≤ 0.05, H0 is rejected (non-normal distribution), and the analysis proceeds with the Wilcoxon Signed Rank Test.

b. Homogeneity Test

The homogeneity of variance test was conducted to ensure that the research samples (experimental and control classes) originate from populations with equal or homogeneous variances. Homogeneity of variance is a prerequisite assumption that must be fulfilled before conducting comparative analyses such as the t-test, as it aims to generalize conclusions from the sample to the population. This test was performed using Levene's Test with the following procedures:

1. Hypotheses:
   - H0: The sample variances are homogeneous (p-value > 0.05).
   - H1: The sample variances are heterogeneous (p-value ≤ 0.05).
2. Significance level: α = 0.05
3. Statistical test: Conducted using SPSS to obtain the p-value, which serves as the basis for determining the type of t-test to be used.

2. Difference Test Analysis

The difference test was analyzed using a one-tailed paired-sample parametric t-test if the pretest and posttest scores were normally distributed.

a. Paired t-Test

The data used in the paired t-test were derived from the differences between the pretest and posttest scores of the experimental and control classes. The paired t-test can be conducted using the following steps:

1) Formulating the Hypotheses

   For testing differences in a paired t-test, a one-tailed test is used. A one-tailed test is applied when the null hypothesis (H_0) states "less than or equal to (≤)" and the alternative hypothesis (H_1) states "greater than (>)" (Sugiyono, 2013). Thus, the hypotheses for testing the difference between the experimental and control classes are as follows:
   - H_0: If the significance value of the pretest and posttest scores in both classes is equal to or greater than 0.05, there is no improvement in learning outcomes.
   - H_0: If the significance value of the pretest and posttest scores in both classes is less than 0.05, there is a significant improvement in learning outcomes.

     Decision criteria:
   - If the SPSS significance value > 0.05, H_0 is accepted.
   - If the SPSS significance value < 0.05, H_1 is accepted.

b. Normalized Gain (N-Gain).

This gain is derived from the pretest and posttest scores obtained by the students. The calculation of normalized N-gain is conducted to determine the students' science literacy abilities in each class.

$$< g >= \frac{S_{post} - S_{pre}}{C_{maks} - S_{pre}}$$

Description:

- $\langle g \rangle$ = Normalized gain
- Spost = Posttest score
- Spre = Pretest score
- Smaks = Maximum score

According to Hake (1998), as cited, the N-gain level can be determined using the following criteria:

Table 7. Classification of N-Gain Values

Effect Size	Criteria
<g> < 0,3	Low
0,7 <g≥ 0,3	Medium
<g> ≥0,7	High

(Hake, 1998)

The N-Gain values were interpreted based on the criteria proposed by Hake (1998), as presented in Table 3.6. The N-Gain value is considered acceptable if it falls within the range of g ≥ 0.3 to g ≥ 0.7, which corresponds to the high category.

RESULTS AND DISCUSSION

Improvement of Students' Science Literacy Skills

1. **Prerequisite Test**

   a. **Normality Test**

   The normality test was conducted using the Shapiro-Wilk method. Based on the data in Table 8, it can be observed that the significance level is 0.05 with a significance value (Sig.) >0.05, so it can be concluded that the data is normally distributed (Sugiyono, 2013). The following data shows the results of the normality test in Table 8. Normality Test.

Table 8. Normality Test

Group class	Shapiro-Wilk		
	Statistics	**df**	Sig.
Experimental pretest	0,967	36	**0,353***
Experimental posttest	0,952	36	**0,123***
Control pretest	0,976	35	**0,638***
Control posttest	0,949	35	**0,108***

Based on the data in Table 8, the significance value is >0.05, the pretest in the experimental class has a Shapiro-Wilk significance value of 0.353 and in the control pretest class it is 0.638. Both values are greater than 0.05, so it can be concluded that the pretest data is normally distributed. The posttest results of students in the experimental class and the control class have Shapiro-Wilk significance values of 0.123 and 0.108, respectively, meaning above 0.05, so the posttest data in the control class is also considered normal. Thus, the data meets the criteria for a normal distribution.

   b. **Homogeneity Test**

   The homogeneity test is performed to determine whether the data from the compared groups have similar variances (Zhou et al., 2023). This homogeneity of variance is a key prerequisite for applying parametric statistical analysis. The homogeneity test is performed using Levene's test, as shown in the following table.

Table 9. Homogeneity Test

Based on		Levene Statistics	Sig.
Results Pretest	Based on Mean	0,587	**0,625**
Results Posttest	Based on Mean	0,601	**0,615**

Based on Table 8, the significance value is >0.05. Therefore, it can be concluded that the data does not show a statistically significant difference between the pretest and posttest groups, which have homogeneous variances (Kozak & Piepho, 2018). Therefore, it can be concluded that the assumption of homogeneity of variance has been met in this study.

c. Reliability

Table 10. Reliability of test items

Mean	**Standard Deviation**	**XY Correlation**	**Reliability**
35,69	13,27	0,56	0,72

According to Wells and Wollack (2023), a reliability coefficient of 0.72 indicates that the test items have a high level of internal consistency. This is in line with Guilford (1956), as cited in Price (2016), who categorized reliability values ranging from 0.60 to 0.79 as high. Therefore, the test instrument used in this study can be considered reliable.

d. Validty

Table 11. Pretest posttest instrument validation

Aspect	**Validity**	**Category**
Construction	0,938	Valid
Content	0,884	Valid
Language	0,906	Valid

Instrument analysis was conducted by administering the test sheets to students. The test consisted of three open-ended essay questions. Based on the analysis, the validity results of the items are presented in Table 11. (instrument validation). The findings indicate that the construction aspect obtained the highest score of 0.938, categorized as valid. The language aspect obtained a score of 0.906, also categorized as valid. The content aspect received the lowest score of 0.884, but still categorized as valid, indicating that the content of the pretest and posttest questions aligns with the stages of scientific literacy skill indicators.

2. Variable Test

a. Paired t-test

A paired t-test, also known as a paired samples t-test, is performed to determine significant differences between the samples used (Rietveld & Van Hout, 2017). The results of the paired t-test can be seen in the following table.

Table 12. Paired t-test

		Mean	N	*Std. Deviation*	*Std. Error Mean*	*Sig.(2-tailed)*
Pair 1	Pretest-posttest Control	-19,167	36	8,296	1,383	0,000
Pair 2	Pretest-posttest Experimental	-35,714	35	9,703	1,640	0,000

The significance result is stated at 0.000 or can be interpreted as <0.05 as the significance limit for the pretest and posttest results in both the experimental and control classes (Kongkaew et al., 2019). The pretest and posttest results are presented in Figure 1.

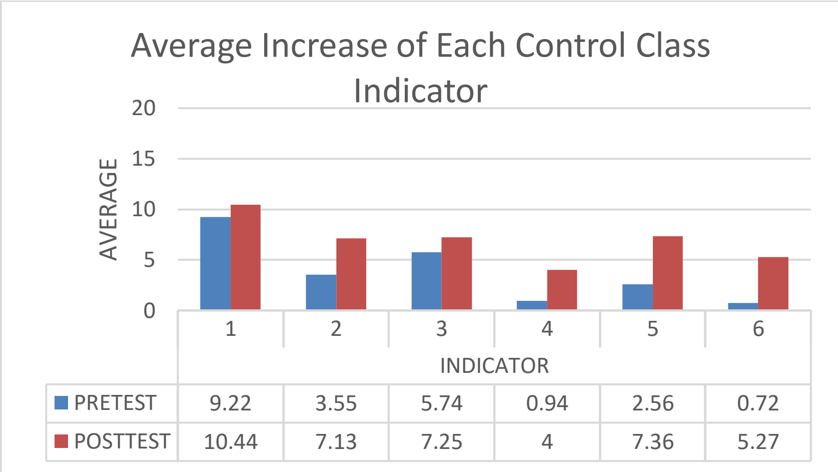

Figure 1. Average increase of each control class indicator

Based on Figure 1 and Figure 2, it can be seen that the pretest and posttest scores of students in the experimental class using ethnophysics-based PBL learning were higher than those in the control class using conventional learning.

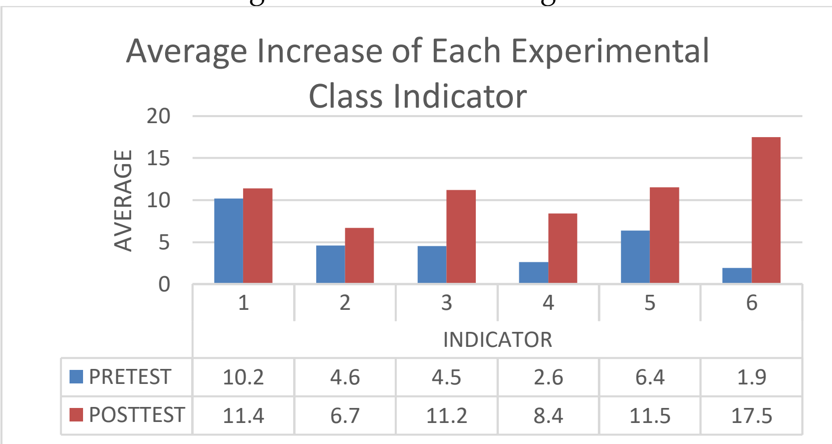

Figure 2. Average Increase of Each Experimental Class Indicator

b. N-gain test

Researchers conducted an N-Gain analysis to measure the improvement in students' scientific literacy skills after being given learning treatments in the classroom, both in the experimental class and the control class or conventional class (Shofawati et al., 2023). In the context of this study, the N-Gain calculation was used to assess the level of improvement in students' scientific literacy skills. The data can be seen in Table 11.

Table 13. Calculation of N-gain values for control and experimental classes

Group Classes	N-Gain	N-Gain (%)	Category
Control	0,24	24,36	Low
Experimental	0,53	53,08	Medium

Based on the data in Table 13 after the ethnophysics based PBL model was implemented, the experimental class showed no low level of students' scientific literacy skills in the post-test. This can be seen in Table 10 below.

Table 14. Percentage of Students Obtaining N-Gain in 2 Classes

Classes	N	Low (%)	Medium (%)	High (%)
Control	36	64	36	0
Experimental	35	0	89	11

Based on the data in Table 14, the N-Gain data was obtained at 0.24 in the control class, which is included in the low category, while in the experimental class, the value was obtained at 0.53, which is included in the medium category (Hake, 1998). In line with Darhim (2020) research, the N-Gain of $0.3 \leq x < 0.7$ is included in the medium category, which is suitable for use. The improvement of scientific literacy skills was analyzed through the results of the pretest and posttest using a paired sample t-test, which showed a significant difference between the two values, where the posttest value was higher ($p < 0.05$). This shows that learning with the ethnophysics-based Problem-Based Learning (PBL) model is effective in improving students' scientific literacy (Deta, 2023; Prahani et al., 2020).

Analyze Students' Scientific Literacy Outcomes

Item analysis is used to determine the cognitive level assessed by the test items. The analysis of the test items was analyzed quantitatively to obtain empirical data regarding the administered items. In this study, a total of three multiple-essay items were employed, each constructed based on indicators of scientific literacy skills. According to Kuswana (2012), the cognitive domain in Bloom's taxonomy encompasses six levels of thinking skills, namely remembering (C1), understanding (C2), applying (C3), analyzing (C4), evaluating (C5), and creating (C6). Figure 3 presents the item correlation results.

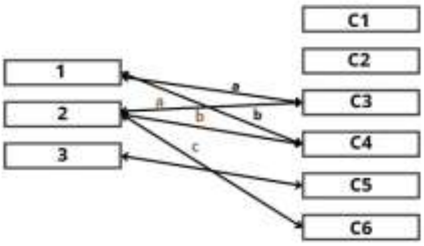

Figure 3. Item correlation

In this study, Item 1 consists of questions at the C3 cognitive level for Question 1a and C4 for Question 1b. Item 2 includes questions at the C3 cognitive level for Question 2a, C4 for Question 2b, and C6 for Question 2c. Item 3 contains questions at the C5 cognitive level. A trial test of the instrument was conducted in Class XI-5. Furthermore, item analysis was performed using the ANATES 4.0 application to determine the reliability, difficulty level, discrimination index, and validity of the test items, as presented in Table 15.

Table 15. Reliability of test Items

Mean	**Deviation Standard**	**Correlation XY**	**Reliability**
35,69	13,27	0,56	0,72

According to Wells and Wollack (2023), a reliability of 0.72 indicates a high level of consistency. Consistent with Guilford (1956) in Price (2016), reliability values between 0.60 and 0.79 are categorized as high. Therefore, the test instrument in this study is considered reliable.

Table 16. Difficulty Level of Questions.

Item No	Original Difficulty Level	(%) Estimated
1	52,44	Moderate
2	40,14	Moderate

Item No	Original Difficulty Level	(%) Estimated
3	26,19	Difficult

Based on the results presented in Table 16, the difficulty level of item number one is 52.44%, with an indicator measuring students' ability to calculate acceleration values and analyze the motion of the *Becak Lawu* based on Newton's Second and Third Laws. This item aligns with the scientific literacy competency in the domain of explaining scientific phenomena. The item is categorized at cognitive levels C3 and C4 of Bloom's Taxonomy (applying and analyzing), requiring students not only to think procedurally but also logically and systematically (Izzah et al., 2025).

The difficulty level of item number two is 40.14%, categorized as moderate, encompassing the ability to critically determine the frictional force and analyze the relationship between the elevation angle and the magnitude of frictional force. This item requires students to interpret data and evaluate phenomena quantitatively. It corresponds to the scientific literacy domain of designing and evaluating scientific investigations, as well as critically interpreting data (Anderson & Krathwohl, 2001).

For item number three, the difficulty level is recorded at 26.19%, which falls into the difficult category. Questions that are too easy tend to reduce students' motivation to make a greater effort in solving them (Kalida, 2021). According to Imania and Bariah (2019), difficult questions are still necessary in an assessment to determine the capability range of students from high- to low-achieving groups. Therefore, this item remains appropriate for use, as it serves to identify students with deeper understanding, particularly in aspects of higher-order scientific literacy skills (Werdiningsih, 2021).

Table 17. Discrimination index

Item Number	Different	t	DP (%)
1	9,33	6,30	37,33%
2	15,00	5,45	37,50%
3	8,78	5,86	25,08%

Based on Table 17. it was found that item number 1 had a discrimination index of 37.33% with a t-value of 6.30, while item number 2 had a discrimination index of 37.50% with a t-value of 5.45. Both items are categorized as good, as their values exceed the threshold of ≥ 0.30 or 30%. This is consistent with the findings of Fatimah (2019), who stated that these items are highly effective in distinguishing students based on their level of ability.

Response to Students' Science Literacy Skills

Students' scientific literacy improvement was measured through a post-learning response questionnaire using the ethnophysics-based PBL model. The questionnaire consisted of 12 statements representing the stages of PBL, rated on a Likert scale of 1–5. The statements covered aspects of interest, relevance of the material to local wisdom, conceptual understanding, information processing, collaboration, and the ability to explain and evaluate scientific phenomena. The results of students' responses to all statements are presented in Figure 4**.**

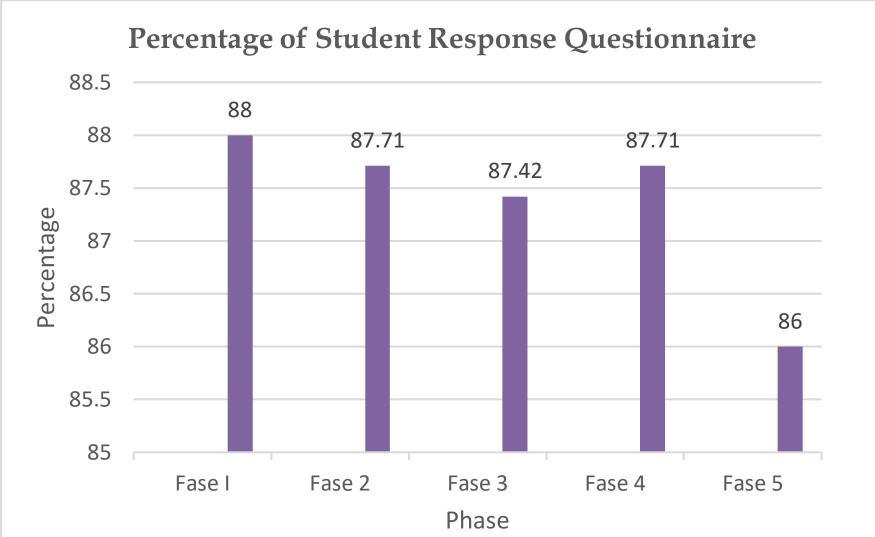

Figure 4. Percentage of student response questionnaire

Based on Figure 4, it shows that students in the experimental class have a percentage of >86%. So it can be concluded that learning with the ethnophysics-based PBL model is effective in improving students' scientific literacy skills.

DISCUSSION

Improvement of Students' Science Literacy Skills

From Table 13, the pretest scores of the experimental and control classes were 30 and 22.3, respectively, indicating a low and comparable level of initial scientific literacy. However, the N-Gain results showed a greater increase in the experimental class of 0.53, which is included in the medium category, compared to the control class of 0.24, which is included in the low category, as shown in Table 14. A total of 89% of students in the experimental class reached the medium and high categories, while in the control class, 64% were still in the low category. The integration of PBL syntax with local wisdom through the *Becak Lawu* phenomenon allows students to develop a contextual understanding of Newton's Laws. This aligns with Hmelo-Silver (2004) view that PBL facilitates active student engagement in constructing knowledge through solving real-world problems. During PBL phases, students are encouraged to observe, investigate, process data, and present solutions relevant to the local context, thus further developing critical and scientific thinking skills (Suwardani et al., 2021). Meanwhile, in the control class using the guided inquiry model, learning remained instructional, and student answers tended to contain misconceptions and lack structure. Item analysis showed that students in the experimental class were able to answer logically, construct experiments, and relate local phenomena to scientific concepts. Factors such as lack of interest in reading (Andaresta et al., 2023), limited learning resources, and low exposure to scientific content also contribute to low scientific literacy. Strategies such as introducing scientific readings before learning can significantly improve scientific literacy (Ziaurrahman et al., 2024). Ethnophysics-based PBL learning has been proven to be superior in improving students' scientific literacy compared to conventional learning.

Analyze Students' Scientific Literacy Outcomes

Based on the data presented in Table 16 regarding the average scores of students, the pretest results for item number 1 in both the control and experimental classes indicate that most students were able to answer the question adequately, although not perfectly. Their responses were still general in nature and did not concretely relate to Newton's laws. Following the implementation of conventional instruction in the control class and ethnophysics-based PBL in the experimental class, the posttest results showed an improvement in students' ability to answer all test items in the control class; however, misconceptions were still present in their responses. In contrast, the students' answers in the experimental class were more accurate, conceptually structured, and aligned with theoretical principles. The more significant improvement observed in the experimental class demonstrates that the PBL approach integrating local context (Becak Lawu) effectively supports students in understanding abstract concepts in a concrete manner. Through real-world problem-solving, students engage in an active knowledge-construction process, as described by Vygotsky's constructivist theory (Hmelo-Silver, 2004).

Referring to Figure 3, a considerable number of students in both the control and experimental classes were unable to respond adequately to the questions associated with indicators 2 and 4. This issue arose because they were not yet able to properly identify and analyze the given problems. For item number 2, students were not familiar with relating local phenomena to scientific experimentation. After conventional instruction in the control class and ethnophysics-based PBL in the experimental class, the posttest results revealed that although students in the control class were able to provide answers, their experimental designs were still simple and incomplete. Conversely, most students in the experimental class were able to design experiments with appropriate and logical steps. PBL facilitates students' direct engagement in scientific processes, including observation, planning, and evaluation. Meanwhile, the conventional learning approach tends to merely transfer information without fostering higher-order thinking skills (Savery, 2006).

Regarding test item number 3, the pretest results of both classes indicate that students were unable to answer the question correctly. Their responses were descriptive and did not reflect scientific understanding. In the posttest, many students in the control class were still unable to answer correctly, whereas many students in the experimental class answered correctly, although some still struggled to provide sequential reasoning. This limitation in the control class is attributed to the lack of student engagement in the learning process. In the PBL model, students are more actively involved in gathering information, engaging in discussions, and testing hypotheses, which leads to deeper conceptual understanding.

Response to Students' Science Literacy Skills

The implementation of the ethnophysics-based PBL model has been proven effective in improving students' scientific literacy skills, which include the ability to understand scientific concepts, think critically, and apply science in real life (OECD, 2024). The results of Figure 4, the student response questionnaire, showed an average score of ≥86%, classified as very good (Rivai & Sudjana, 2013), with positive responses to each phase of learning, from problem orientation to evaluation. This response reflects students' active affective and cognitive involvement in the learning process (Wulandari et al., 2025). Support from Student Worksheets (LKPD) and the integration of local wisdom, such as the *Becak Lawu* phenomenon, also helped students process scientific information and understand concepts contextually (Nurwulandari, 2024).

These findings align with research by Hotimah (2020), Arrozaqu (2022), and Muliarsa (2024), which concluded that integrating PBL with local contexts can improve conceptual understanding and learning outcomes. This approach is also consistent with Vygotsky's constructivism theory, which emphasizes the importance of active involvement and cultural context in the learning process (Fuada et al., 2014). Therefore, the implementation of the ethnophysics-based PBL model can be declared successful and feasible to be implemented to comprehensively improve scientific literacy in physics learning.

CONCLUSION

Based on the research above, it can be concluded that (1) the ethnophysics-based PBL model demonstrated an N-gain of 0.24 in the control class, which is considered low, and 0.53 in the experimental class, which is considered moderate; (2) item number 1 is in the Moderate category, and item number 3 is in the Difficult category; and (3) the student response rate for the ethnophysics-based PBL model was ≥86%, indicating that ethnophysics-based PBL is effective in improving students' scientific literacy. A recommendation from this study is that teachers are encouraged to implement the ethnophysics-based Problem-Based Learning (PBL) model in teaching Newton's Laws, as it has been shown to effectively improve students' scientific literacy.

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REFERENCES

Alfiah, L. C., & Wasis. (2024). Profil keterampilan pemecahan masalah peserta didik SMA terintegrasi etnofisika pada materi gelombang bunyi. *Jurnal Review Pendidikan dan Pengajaran, 7*, 8. http://journal.universitaspahlawan.ac.id/index.php/jrpp

Aina, Q., & Hariyono, E. (2023). Penerapan PhET simulations pada pembelajaran fisika untuk meningkatkan kemampuan literasi sains peserta didik SMA kelas X. *Jurnal Ilmu Pendidikan dan Pembelajaran, 1*(2), 56–65. https://doi.org/10.58706/jipp.v1n2.p56-65

Andaresta, O., Muliani, M., Safriana, S., Sakdiah, H., & Novita, N. (2023). Development of assessments to measure students' science literacy ability: Rasch modeling analysis. *Jurnal Pendidikan Fisika dan Teknologi, 9*(2), 356–365. https://doi.org/10.29303/jpft.v9i2.6092

Anderson, L. W., & Krathwohl, D. R. (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives*. Addison Wesley Longman.

Arby, M. F., & Ridhoi, R. (2023). *Becak Lawu 1970–2015: Transportasi tradisional masyarakat lereng tenggara Gunung Lawu* (Thesis). Universitas Negeri Malang.

Arrozaqu, A. J., & Setiawan, B. (2022). Penerapan model pembelajaran problem based learning berbasis kearifan lokal untuk meningkatkan hasil belajar siswa pada materi zat aditif. *PENDIPA Journal of Science Education, 6*(3), 674–681. https://doi.org/10.33369/pendipa.6.3.674-681

Bandur, A. (2022). *Penelitian kuantitatif: Metodologi, desain, dan analisis data dengan SPSS, AMOS, & NVivo*. Mitra Wacana Media.

Darhim, Prabawanto, S., & Susilo, B. E. (2020). The effect of problem-based learning and mathematical problem posing in improving students' critical thinking skills. *International Journal of Instruction, 13*(4), 103–116. https://doi.org/10.29333/iji.2020.1347a

Deta, U. A. (2023). *Kajian konseptual model glocalization (globalization of local wisdom) berbasis fenomenologi fisika: Sarana meningkatkan literasi sains peserta didik di Indonesia*. PT Mitra Edukasi dan Publikasi.

Etikan, I. (2016). Comparison of convenience sampling and purposive sampling. *American Journal of Theoretical and Applied Statistics, 5*(1), 1. https://doi.org/10.11648/j.ajtas.20160501.11

Fuada, B. I., Sarwi, & Linuwih, S. (2014). Penerapan model pembelajaran problem based learning berbasis konstruktivisme untuk meningkatkan pemahaman konsep siswa kelas VII. *Unnes Physics Education Journal, 3*(1), 11–15. https://doi.org/10.15294/upej.v3i1.3101

Hafizah, E., & Nurhaliza, S. (2021). Implementasi problem based learning (PBL) terhadap kemampuan literasi sains siswa. *Quantum: Jurnal Inovasi Pendidikan Sains, 12*(1), 1. https://doi.org/10.20527/quantum.v12i1.9497

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics, 66*(1), 64–74. https://doi.org/10.1119/1.18809

Harefa, D. (2023). Efektivitas model pembelajaran talking chips untuk meningkatkan hasil belajar siswa. *Tunas: Jurnal Pendidikan Biologi, 4*(1), 83–99. https://doi.org/10.57094/tunas.v4i1.1011

Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn? *Educational Psychology Review, 16*(3), 235–266. https://doi.org/10.1023/B:EDPR.0000034022.16470.f3

Hotimah, H. (2020). Penerapan metode pembelajaran problem based learning dalam meningkatkan kemampuan bercerita pada siswa sekolah dasar. *Jurnal Edukasi, 7*(3), 5. https://doi.org/10.19184/jukasi.v7i3.21599

Kongkaew, C., Scholfield, C. N., Supapaan, T., Mann, C., Mongkhon, P., & Chanunun, S. (2019). Impact of research-based learning on student knowledge and assessment in pharmacoepidemiology: A one-group pretest–posttest experimental study. *Thai Journal of Pharmaceutical Sciences, 43*(4), 236–241. https://doi.org/10.56808/3027-7922.3059

Kozak, M., & Piepho, H. P. (2018). What's normal anyway? Residual plots are more telling than significance tests when checking ANOVA assumptions. *Journal of Agronomy and Crop Science, 204*(1), 86–98. https://doi.org/10.1111/jac.12220

Lendeon, G. R., & Poluakan, C. (2022). Pengaruh model problem based learning (PBL) terhadap kemampuan literasi sains siswa. *SCIENING: Science Learning Journal, 3*(1), 14–21. https://doi.org/10.53682/slj.v3i1.1076

Lestari, R., Faelasofi, R., & Suminto, S. (2021). Efektivitas penggunaan modul numerasi pada pembelajaran jarak jauh. *Jurnal E-DuMath, 7*(2), 42–50. https://doi.org/10.52657/je.v7i2.1543

Limatahu, I., & Mubarok, H. (2020). CCDSR learning model: Innovation in physics learning. *IJORER: International Journal of Recent Educational Research, 1*(1), 19–29. https://doi.org/10.46245/ijorer.v1i1.13

Margono, S. (2007). *Metode penelitian pendidikan: Komponen MKDK* (Edisi ke-1). Rineka Cipta.

Maulina, D., Widyastuti, Maulina, H., & Mayasari, S. (2022). Kajian faktor intrinsik dan kemampuan literasi sains siswa SMP di Kota Bandar Lampung. *LENSA (Lentera Sains): Jurnal Pendidikan IPA, 12*(1), 1–8. https://doi.org/10.24929/lensa.v12i1.201

Mayanti, A., Poluakan, C., & Tumimomor, F. R. (2022). Pengaruh model problem based learning (PBL) menggunakan metode demonstrasi dan eksperimen pada pembelajaran fisika tentang hukum Newton. *Charm Sains: Jurnal Pendidikan Fisika, 3*(1), 9–14. https://doi.org/10.53682/charmsains.v3i1.144

Mayasari, A., Arifudin, O., & Juliawati, E. (2022). Implementasi model problem based learning (PBL) dalam meningkatkan keaktifan pembelajaran. *Jurnal Tahsinia, 3*(2), 167–175. https://doi.org/10.57171/jt.v3i2.335

Muliarsa, I. K., Sudiatmika, A. A. I. A. R., & Pujani, N. M. (2024). Problem based learning bermuatan kearifan lokal terhadap kemampuan berpikir kritis dan kreatif siswa SMP. *JIPPG, 7*, 415–425. https://doi.org/10.23887/jippg.v7i2.83804

Nadiyah, Mardiana, Iskandar, W., & Putri, F. A. (2022). Problem based learning (PBL) berbasis etnosains dan etnomatematik. *Al-Ihtirafiah: Jurnal Ilmiah Pendidikan Guru Madrasah Ibtidaiyah, 2*(2), 275–284. https://doi.org/10.47498/ihtirafiah.v2i02.1338

Nimunuho, H. Y. B., & Naen, A. B. (2023). Materi pengaruh gaya terhadap gerak. *1*(1), 45–50.

Nurmasyitah, N., Virnalita, V., & Lubis, N. A. (2022). Kajian etnofisika konsep gerak parabola pada permainan tradisional Aceh "Geulengkue Teu Peu Poe." *Jurnal Pendidikan Fisika, 10*(2), 245. https://doi.org/10.24127/jpf.v10i2.5217

Nurwulandari, N. (2024). Penerapan model PBL berbantuan LKPD terhadap kemampuan berpikir kritis pada materi gerak. *Science Edu, 7*(2), 106–111. https://scienceedu.jurnal.unej.ac.id

OECD. (2024). *PISA 2022. Perfiles Educativos, 46*(183). https://doi.org/10.22201/iisue.24486167e.2024.183.61714

Pasiri, Y. (2023). Pengaruh penggunaan model problem based learning terhadap kemampuan literasi sains siswa. *Jurnal Pendidikan dan Pembelajaran, 3*(2), 94–101. https://doi.org/10.62388/jpdp.v3i2.336

Prahani, B. K., Ramadani, A. H., Kusumawati, D. H., Suprapto, N., Madlazim, M., Jatmiko, B., Supardi, Z. A. I., Mubarok, H., Safitri, S., & Deta, U. A. (2020). ORNE learning model to improve problem-solving skills of physics bachelor candidates: An alternative learning in the COVID-19 pandemic. *Jurnal Penelitian Fisika dan Aplikasinya (JPFA), 10*(1), 71–80. https://doi.org/10.26740/jpfa.v10n1.p71-80

Price, L. R. (2017). *Psychometric methods: Theory into practice*. The Guilford Press.

Ranggana, A., Wahyudin, W., Gunarso, G., & Permatasari, E. (2024). 21st century learning trends: What educators need to know. *Edukatif: Jurnal Ilmu Pendidikan, 6*(1), 616–624. https://doi.org/10.31004/edukatif.v6i1.6142

Rietveld, T., & van Hout, R. (2017). The paired t test and beyond: Recommendations for testing the central tendencies of two paired samples in research on speech, language and hearing pathology. *Journal of Communication Disorders, 69*, 44–57. https://doi.org/10.1016/j.jcomdis.2017.07.002

Rivai, A., & Sudjana, N. (2013). *Media pengajaran (penggunaan dan pembuatannya)*. Sinar Baru Algensindo.

Riyadi, A. (2020). *Seri sains gaya dan gerak*.

Saputra, H. (2024). Penguatan kemampuan peserta didik dalam menghadapi era Society 5.0 melalui pembelajaran matematika. *Jurnal Pendidikan Bhinneka Tunggal Ika, 2*(2), 287–302. https://doi.org/10.51903/bersatu.v2i2.640

Savery, J. R. (2006). Overview of problem-based learning: Definitions and distinctions. *Interdisciplinary Journal of Problem-Based Learning, 1*(1). https://doi.org/10.7771/1541-5015.1002

Shofawati, A., Widodo, W., & Sari, D. A. P. (2023). The use of multimedia interactive to improve students’ science literacy in the new normal era. *Jurnal Pijar Mipa, 18*(1), 65–71. https://doi.org/10.29303/jpm.v18i1.3832

Solichin, M. (2017). Analisis daya beda soal, taraf kesukaran, validitas butir tes, interpretasi hasil tes, dan validitas ramalan dalam evaluasi pendidikan. *Dirasat: Jurnal Manajemen dan Pendidikan Islam, 2*(2), 192–213. https://doi.org/10.26594/dirasat.v2i2.879

Sugiyono. (2010). *Metode penelitian pendidikan: Pendekatan kuantitatif, kualitatif, dan R&D*. Alfabeta.

Sugiyono. (2013). *Metode penelitian kuantitatif, kualitatif, dan R&D*. Alfabeta.

Sugiyono. (2021). *Metode penelitian pendidikan*. IKAPI.

Sumargo, B., Budyanra, & Kurniawan, R. (2024). *Metode dan pengaplikasian teknik sampling*. PT Bumi Aksara.

Sunarti, T., Suprapto, N., Suliyanah, Satriawan, M., & Hidayatullaah, H. N. (2023). *Internalisasi nilai-nilai kearifan lokal: Strategi pembelajaran berbasis etnosains untuk meningkatkan keterampilan pemecahan masalah dan literasi sains* (N. A. Lestari, Ed.). PT Mitra Edukasi dan Publikasi.

Suriani, N., Risnita, & Jailani, M. S. (2023). Konsep populasi dan sampling serta pemilihan partisipan ditinjau dari penelitian ilmiah pendidikan. *Jurnal IHSAN: Jurnal Pendidikan Islam, 1*(2), 24–36. https://doi.org/10.61104/ihsan.v1i2.55

Suryati, S., Hatimah, H., Zohri, S. A., & Salim, A. (2024). Review LKPD PBL berbasis kearifan lokal Lombok untuk mendukung Kurikulum Merdeka pada materi koloid. *Jurnal Ilmiah IKIP Mataram, 11*(1), 10-13. https://ojspanel.undikma.ac.id/index.php/jiim/article/view/12531

Sutrisna, N. (2021). Analisis kemampuan literasi sains peserta didik SMA di Kota Sungai Penuh. *Jurnal Inovasi Penelitian, 1*(12). https://stp-mataram.e-journal.id/JIP

Suwardani, Asrial, & Yelianti, U. (2021). Analisis model pembelajaran inkuiri terbimbing terhadap keterampilan proses sains siswa pada mata pelajaran IPA SMP. *Jurnal Ilmiah Pendidikan Biologi, 7*(3), 185–194. https://doi.org/10.22437/bio.v7i3.13072

Mangubat, S. D. D., & Ramirez, I. A. L. (2023). The effects of digital learning on 21st century skills of grade 10 learners in physics. *International Journal of Science and Management Studies, 6*(6), 73–82. https://doi.org/10.51386/25815946/ijsms-v6i6p106

Triana, N. (2021). *LKPD berbasis eksperimen: Tingkatkan hasil belajar siswa*. Guepedia.

Wardani, I. U. (2022). *Belajar matematika dengan pendekatan scientific berbasis keterampilan*. CV Feniks Muda Sejahtera.

Wardi, L. Z., Jauhariyah, M. N. R. (2023). Analisis profil kompetensi literasi sains siswa SMA pada materi inti atom dan radioaktif. *Jurnal Novasi Pendidikan Fisika, 12*(2), 74–80. https://ejournal.unesa.ac.id/index.php/inovasi-pendidikan-fisika/article/view/53009

Wells, C., & Wollack, J. (2003). *An instructor's guide to understanding test reliability*. Testing & Evaluation Services, University of Wisconsin.

Wiratama, W. M. P. (2019). Handout sebagai perangkat pembelajaran praktis. *Elektronik Universitas Negeri Malang, 42*(2), 158–169. https://dx.doi.org/10.17977/um031v42i22019p158-169

Wulandari, D., Dwikoranto, & Setiani, R. (2025). Pengaruh model problem based learning terintegrasi literasi sains untuk meningkatkan keterampilan berpikir kritis peserta didik. *Inovasi Pendidikan Fisika, 14*(1), 1–5. https://doi.org/10.26740/ipf.v14n1.p1-5

Wulansari, N. I., & Admoko, S. (2021). Eksplorasi konsep fisika pada tari Dhadak Merak Reog Ponorogo. *PENDIPA Journal of Science Education, 5*(2), 163–172. https://doi.org/10.33369/pendipa.5.2.163-172

Nenyhindarwaty, A. (2018). *Analisis penentuan standar nilai kriteria ketuntasan minimal (KKM) mata pelajaran fisika kelas XI SMAN 17 Makassar* (Thesis, Fakultas Tarbiyah dan Keguruan, UIN Alauddin Makassar). https://files01.core.ac.uk/download/pdf/198226433.pdf

Yuniarto, B., & Yudha, R. P. (2021). Literasi digital sebagai penguatan pendidikan karakter menuju era Society 5.0. *Edueksos: Jurnal Pendidikan Sosial & Ekonomi, 10*(2), 176–194. https://doi.org/10.24235/edueksos.v10i2.8096

Zhou, Y., Zhu, Y., & Wong, W. K. (2023). Statistical tests for homogeneity of variance for clinical trials and recommendations. *Contemporary Clinical Trials Communications, 33*, 101119. https://doi.org/10.1016/j.conctc.2023.101119

Ziaurrahman, Z., ZA, T., & Andriansyah, A. (2024). Pengembangan e-book interaktif untuk menunjang pembelajaran diferensiasi pada mata pelajaran pendidikan agama Islam di sekolah dasar. *Jurnal Didaktika Pendidikan Dasar, 8*(1), 165–184. https://doi.org/10.26811/didaktika.v8i1.1333

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