



Analysis of Science Process Skills, Perceptions, and Learning Outcomes in the Implementation of Ethnoscience-Based Student Worksheets on the Nature of Physics and Scientific Methods

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Abstract: This study aims to examine the effectiveness of Ethnoscience-Based Student Worksheets (EbSWs) on the subject matter of the nature of physics and the scientific method. The research subjects were 10th-grade students at SMAK Sint Carolus Penfui. This is a descriptive quantitative study using tests to measure cognitive learning outcomes and Science Process Skills (SPS), while questionnaires were used to measure student perceptions (attitudes, skills, and knowledge). The results showed that EbSW were effective in optimizing students' SPS, with an overall average score of 83.90 (very skilled) and a high consistency of results (standard deviation/SD = 3.61). Student perceptions were very positive, with knowledge (average 83.7) and attitude (average 82.1) aspects categorized as very good. SPS perception results (average 77.9) were categorized as good and showed an increase in higher-level cognitive skills. Cognitive learning outcomes showed a level of mastery (mean = 80.67) with a cognitive SD of 19.07, indicating a gap in mastery of the material among students, especially in higher-order thinking skills (HOTS). Overall, EbSW are effective for understanding basic concepts and developing SPS evenly but need to be improved to address varying levels of HOTS mastery.

Keywords: Ethnoscience; Physics education; Science process skills; Secondary school

Introduction

Science education, particularly physics, plays a crucial role in preparing students to understand the universe and solve everyday problems (Darmaji et al., 2019). Physics education aims not only to transfer conceptual understanding, but also to instill scientific thinking and essential skills known as Science Process Skills (SPS) (Amnah et al., 2013).

SPS are the foundation for scientific inquiry and cover basic skills (such as observation and classification) as well as integrated skills (such as hypothesis

formulation and data interpretation) (Burns et al., 1985; Seetee et al., 2016). SPS enable students to act like scientists, building knowledge in an authentic context (Roth et al., 1993). Therefore, mastery of SPS is crucial because it equips students with the ability to think critically, solve problems, and build deep conceptual understanding.

Although the role of SPS is so vital in achieving physics learning objectives, various studies show that the level of students' SPS mastery, both at the elementary and secondary levels, still needs to be improved (Gurses et al., 2015; Aydogdu, 2017; Darmaji et al., 2019). Low

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SPS is often correlated with a shallow understanding of physics concepts. This gap is triggered by traditional learning methods that tend to be teacher-centered and do not provide opportunities for students to be actively involved in investigation-based activities (Gizaw et al., 2013). As a result, the conceptual understanding gained by students becomes detached from their real-world experiences and contexts. This condition underscores the need for learning innovations that can bridge theory and practice and stimulate students' active involvement in the science process.

To overcome the gaps caused by traditional learning, one solution that has been proposed and received considerable attention is the ethnosience approach. Ethnosience is defined as an effort to study formal science that grows and develops within local communities (Jannah et al., 2024; Sudarmin et al., 2025; Tinenti et al., 2025; Yuni S et al., 2025). This approach is relevant because it seeks to bridge formal scientific knowledge with traditionally inherited knowledge, making learning more meaningful and contextual for students (Ariani et al., 2024). Previous systematic reviews and experimental studies reinforce that the integration of ethnosience in physics learning can effectively improve students' understanding and skills (Fitri et al., 2023; Khery et al., 2025; Komarudin et al., 2025; Pieter et al., 2024). Furthermore, this study focuses on the implementation of ethnosience in materials on the nature of physics and the scientific method, which are important foundations in the physics curriculum at the secondary school level. Mastery of this material is inherently closely related to the development of SPS. The application of the ethnosience approach to this material is highly relevant because ethnosience provides a real-world context for students to practice the steps of the scientific method. However, studies that specifically examine the effectiveness of the ethnosience approach in simultaneously assessing SPS and understanding of physics concepts in basic physics and scientific method material are still limited. The novelty of this study lies in three main aspects: (1) specifically testing the effectiveness of ethnosience in physics fundamentals and scientific method material, which is rarely the main focus in ethnosience studies; (2) simultaneously measuring the impact of ethnosience on two essential outcome variables: SPS as an indicator of inquiry, and understanding of physics concepts as an indicator of cognitive outcomes; and (3) the use of explicitly identified local contexts in the development of ethnosience material.

Based on the background, literature gap analysis, and novelty described above, this study has the main objective of testing the effectiveness of a context-based ethnosience approach. Specifically, the objectives of this study are to identify and analyze (1) students' SPS, (2)

students' perceptions of attitudes, skills, and knowledge, and (3) cognitive learning outcomes in physics and scientific methods after implementing the ethnosience approach.

Method

Types of Research

This study used a descriptive quantitative approach and was conducted at SMAK Sint. Carolus Penfui, Kupang Regency, East Nusa Tenggara Province (NTT), Indonesia. The subjects of this study were 10th-grade students at SMAK Sint Carolus Penfui, and it was conducted in the odd semester of the 2025/2026 academic year.

Data Analysis

Data collection techniques used tests and questionnaires. Tests were used to obtain data on students' SPS and cognitive learning outcomes, while questionnaires were used to obtain data on students' perceptions of the implementation of Ethnosience-based Student Worksheets (EbSW).

The results of applying EbSW to the subject matter of the nature of physics and the scientific method were analyzed by measuring SPS, attitudes toward the implemented EbSW, and the cognitive learning outcomes of students during the learning process.

The SPS aspects of students during learning include formulating problems, formulating objectives, formulating hypotheses, data collection, data analysis, and formulating conclusions. Students' perceptions of the attitude aspect include attitude, process skills, and knowledge. Attitudes towards EbSW were obtained through questionnaires filled out by students. The aspects of SPS assessment and student perceptions were assessed using a Likert scale of 1 to 5. The assessment scale is shown in Table 1.

Table 1. 5-Point Likert Scale for Assessing SPS Aspects and Student Perceptions

Likert scale	SPS Students	Perceptions of Students
1	Very Poor Command	Strongly disagree
2	Lack of Mastery	Disagree
3	Sufficiently Proficient	Hesitant
4	Mastering	Agree
5	Highly Proficient	Strongly agree

The skill score is calculated using the following equation:

SPS score = (total score obtained/30) x 100
 Meanwhile, the student perception score is calculated using the following equation:

Student perception score = (total student score/75) x 100
 the scores obtained are then interpreted using the criteria shown in Table 2.

Knowledge aspects during the learning process were assessed after students used four types of EbSW. Students' knowledge of physics and scientific methods was measured using a learning outcome test consisting of 10 multiple-choice questions based on Nusa Tenggara Timur (NTT) ethnoscience discourse. Students' learning

outcomes were then calculated using the mean, median, mode, and standard deviation. Based on this average score, an analysis was conducted to determine the category of student ability using the Minimum Mastery Criteria (Kriteria Ketuntasan Minimal/KKM) for physics at Sint Carolus Penfui High School. The KKM for physics at Sint Carolus High School is 70. Based on this KKM, the category of mastery of knowledge aspects is determined, as shown in Table 3.

Table 2. Criteria for Interpreting SPS and Student Perceptions

Value Range	Criteria for Interpreting Student SPS	Criteria for Interpreting Student Perceptions
>80.00 - 100.00	Highly Skilled	Very Good
>65.00 - 80.00	Skilled	Good
>50.00 - 65.00	Quite Skilled	Pretty Good
>35.00 - 50.00	Unskilled	Not Good
≤20.00 - 35.00	Very Unskilled	Very Bad

Table 3. Criteria for Interpreting Students' Mastery of Knowledge Based on the KKM Set by Local Schools

Value Range	Criteria for Interpreting Knowledge Aspect Values
>85 - 100	Highly Proficient
>77 - 85	Mastering
70 - 77	Sufficiently Proficient
<70	Not yet Mastered

their relevance to the physics material to be taught were first identified. Based on this process, EbSW was then developed for application in the learning process. The types of EbSW regarding the scientific method and the nature of physics are shown in Table 4.

The average scores for the assessment of students' SPS during learning included problem formulation (PF), goal formulation (GF), hypothesis formulation (HF), data collection (DC), data analysis (DA), and conclusion formulation (CF). The application of four (4) EbSW on scientific methods and the nature of physics can be seen in Table 5. Meanwhile, data on SPS learning outcomes based on the central tendency score is shown in Table 6.

Result and Discussion

Science Process Skills (SPS)

Before identifying the SPS and the aspects studied in this research, the characteristics of local wisdom and

Table 4. Titles of EbSW Materials on Scientific Methods and the Nature of Physics

No. EbSW	Title of EbSW Material Scientific Methods and the Nature of Physics
01	Uncovering the essence of physics and scientific methods through the beauty of NTT Ikat weaving
02	Uncovering the characteristics of mount Lewotobi eruption material: exploring the density of volcanic rocks and ash
03	Uncovering the physical properties of natural liquids in NTT: a comparison of the density of coconut oil, honey, and sugar water
04	Measuring the hardness and density of Kolbano stone.

Based on Tables 5 and 6, it can be concluded that the low standard deviation indicates that the level of mastery of SPS among students is relatively homogeneous and evenly distributed. In addition, the assessment of each aspect of SPS also shows a high average (83.90 with SD 2.71), where the aspect of formulating conclusions (FC) has the highest average of 87.3. This high consistency and achievement comprehensively shows that EbSW is very effective in facilitating and developing all scientific abilities of students.

The results of the study confirm the success of the EbSW improvement intervention in improving students' mastery of SPS, with an overall average of 83.9, which is in the "Highly Skilled". This achievement not only

demonstrates the effectiveness of the teaching materials or methods used but also confirms that SPS can be trained and mastered optimally through a structured learning process. These findings are in line with the literature that emphasizes that guided inquiry practices, especially those involving active data exploration, are fundamental to the development of SPS (Bakti et al., 2023; Fadhillah et al., 2021; Kriswantoro et al., 2025; Loso et al., 2025; Pramitasari et al., 2024).

Furthermore, the variation data (SD = 3.61 for between students and SD = 2.71 for between SPS dimensions) shows that the level of SPS mastery is homogeneous among the research subjects, reflecting the consistency of application and understanding by all student groups (Pugu et al., 2024). This consistency in

achievement indicates that EbSW/ intervention is able to facilitate an even increase in SPS, bridging the gap in students' initial abilities (Sholikhan et al., 2020).

Although SPS mastery is generally "Highly Skilled", the analysis per skill reveals informative differences. The highest achievement in the skill of formulating conclusions (FC), at 87.3, indicates that

students are "Highly Skilled" in this aspect, which is an integrated SPSI that is trained and observed in the context of EbSW (Mulyani et al., 2017). On the other hand, the lowest average scores for Problem Formulation (PF) Skills (81.00) and Data Analysis (DA) (81.3) (although still Good/" Highly Skilled") indicate areas that require further attention.

Table 5. Results of Science Process Skills Assessment

Student Name	Aspects of Science Process Skills						Score Total	Student Grades	Category
	PF	GF	HF	DC	DA	FC			
MVN	4.5	4.25	4.25	4.5	3.75	4.5	25.75	85.8	Highly Skilled
CAB	4.5	4.25	4.25	4.5	3.75	4.5	25.75	85.8	Highly Skilled
ACP	3.5	3.75	3.75	4.5	4	4	23.5	78.3	Skilled
JRU	4.5	4.25	4.25	4.5	3.75	4.5	25.75	85.8	Highly Skilled
JVF	3.5	3.75	3.75	4.5	4	4	23.5	78.3	Skilled
MAK	3.5	3.75	3.75	4.5	4	4	23.5	78.3	Skilled
NPI	4.5	4.25	4.25	4.5	3.75	4.5	25.75	85.8	Highly Skilled
GMS	4.25	4.75	4.25	4.5	4	4.5	26.25	87.5	Highly Skilled
EEA	4	4.5	4.25	3.75	4.5	4.5	25.5	85.0	Highly Skilled
PZR	4	4.5	4.25	3.75	4.5	4.5	25.5	85.0	Highly Skilled
SALN	4.25	4.75	4.25	4.5	4	4.5	26.25	87.5	Highly Skilled
YPPM	4.25	4.75	4.25	4.5	4	4.5	26.25	87.5	Highly Skilled
YPAR	4	4.5	4.25	3.75	4.5	4.5	25.5	85.0	Highly Skilled
MKN	4	4.5	4.25	3.75	4.5	4.5	25.5	85.0	Highly Skilled
MMAS	3.5	3.75	3.75	4.5	4	4	23.5	78.3	Skilled
Amount	60.75	64.25	61.75	64.5	61	65.5		83.9	
Value	81.0	85.7	82.3	86.0	81.3	87.3		83.9	

Table 6. Data on Science Process Skills Learning Outcomes Based on Central Symptom Scores

Data Group	Mean	Standard deviation (SD)	Highest Score (Max)	Lowest Value (Min)
Student Grades	83.90	3.61	87.50	78.30
SPS (Per Column)	83.90	2.71	87.30	81.00

Slightly lower scores in problem-formulating (PF) skills may be since in many environments; people are taught to solve problems (find answers) but are rarely taught how to formulate questions (define problems). In data analysis skills, suboptimal learning outcomes in this skill may be due to its demanding nature, which requires higher-order thinking skills. Students must not only collect data but also interpret it in a new context (Nurhayati et al., 2017). The use of EbSW that relate to local phenomena should support this analytical ability, but students may still need additional scaffolding to bridge observational data to abstract scientific generalizations (Dadi et al., 2025).

This very high level of SPS mastery has significant implications for science education practices, especially in the context of culture-based learning. These results provide strong support for the integration of the ethnoscience approach into the curriculum, proving that contextual relevance (local wisdom) serves as an effective medium for training essential scientific skills (Sinulingga et al., 2025). The success of EbSW in facilitating SPS to the "Highly Skilled" category for most students (73.33%) is a replicable model for other science

subjects that require an inquiry process. For future research, it is recommended that the focus be shifted to the aspects of Problem Formulation (PF) Skills and Data Analysis (DA) Skills, which had the lowest scores. An experimental study should be conducted to compare the effectiveness of various types of scaffolding (e.g., step-by-step guidance versus trigger questions) to improve these more complex aspects of SPS (Nurhayati et al., 2025). Additionally, longitudinal studies can evaluate the retention of SPS achieved over a longer period to ensure the sustainability of the intervention's impact (Loso et al., 2025).

Reflections (Perceptions) of Students on the Implementation of Ethnoscience-Based Student Worksheets (EbSW)

Students' perceptions of the application of EbSW cover aspects of attitude, skills, and knowledge. Perceptions in terms of attitude include interest, enjoying working together, and feeling challenged to analyze information, as well as demonstrating independence by trying to complete tasks without asking for much help and reading instructions carefully. Perceptions in terms of skills include observing physics

and ethnoscience phenomena, easily searching for and collecting information, analyzing data correctly, and being able to convey observations and analysis clearly and systematically, including applying physics and ethnoscience concepts in tasks. The knowledge aspect includes a good understanding of basic physics concepts, scientific method steps, understanding and connecting physics concepts with ethnoscience practices, and students' perceptions of the application of this EbSW are very positive, covering the aspects of attitude, skills, and knowledge. In terms of attitude, students showed interest, enjoyed working together, and felt challenged to analyze information, as well as demonstrating independence by trying to complete tasks without asking for much help and reading instructions carefully.

In terms of skills, students reported that they were able to observe physical and ethnoscientific phenomena, easily search for and collect information, analyze data correctly, and clearly and systematically convey their observations and analyses, including applying physical and ethnoscientific concepts in their assignments. Finally, in terms of knowledge, students felt that they had achieved a good understanding of basic physics concepts and scientific method steps and were able to understand and connect physics concepts with ethnoscience practices, enabling them to independently conclude the results of their observations and analyses. Reflection data (perceptions) of students' attitudes, science process skills, and knowledge regarding the application of EbSW are presented in Table 7, while data on student reflection results based on central tendency scores are presented in Table 8.

Table 7. Results of Student Reflection (Perception) on Attitudes, Science Process Skills, and Knowledge Regarding the Application of EbSW

Student Name	Attitude AV					Skills SV					Questions/reflections Knowledge KV							
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5			
MVN	4	4	5	4	3	80	4	3	3	3	4	68	4	4	4	4	4	80
CAB	5	5	4	4	4	88	3	3	3	4	3	64	4	4	4	3	4	76
ACP	5	4	5	4	3	84	4	3	3	3	3	64	4	4	3	4	4	76
JRU	5	5	4	4	2	80	4	3	4	4	3	72	5	5	4	4	5	92
JVF	5	5	3	5	2	80	5	5	5	5	3	92	5	5	4	4	5	92
MBK	4	5	4	5	5	92	3	3	4	3	3	64	4	4	5	5	4	88
NPI	4	4	5	4	4	84	4	4	3	3	4	72	4	4	4	4	4	80
GMS	2	4	4	4	1	60	4	4	5	3	4	80	4	4	3	3	4	72
EEA	5	5	5	5	2	88	5	4	5	5	5	96	5	5	5	5	5	100
PZR	4	5	4	3	2	72	5	5	5	5	5	100	4	4	4	5	4	84
SALN	5	5	4	4	3	84	3	3	5	4	5	80	3	4	5	4	4	80
YPPM	4	5	4	4	2	76	3	3	4	3	4	68	4	4	3	4	5	80
YPAR	5	5	4	4	4	88	5	5	5	4	4	92	4	4	4	4	4	80
MKN	5	5	4	5	4	92	4	4	5	5	5	92	5	5	5	5	5	100
MMAS	5	4	5	4	3	84	4	3	3	3	3	64	4	4	3	4	4	76
Amount	67	70	64	63	44		60	55	62	57	58		63	64	60	62	65	
Value	89.3	93.3	85.3	84	58.7		80	73.3	82.7	76	77.3		84	85.3	80	82.7	86.7	

Description: AV (Attitude Value); SV (Skill Value); KV (Knowledge Value)

Table 8. Student Reflection Data Based on Central Symptom Scores

Reflection	Average		Standard Deviation		Highest Score (Max)		Lowest Value (Min)	
	Student	Aspect	Student	Aspect	Student	Aspect	Student	Aspect
Attitude	82.1	82.1	8.26	13.6	92	93.3	72	58.7
Skills	77.9	77.9	13.25	3.6	100	82.7	64	73.3
Knowledge	83.7	83.7	8.75	2.56	100	86.7	72	80.0

Based on the data in Tables 7 and 8, it can be revealed that the results of the students' reflections (perceptions) show a positive response to the implementation of EbSW in the three aspects measured: attitude, science process skills, and knowledge. In general, the knowledge aspect obtained an average score of 83.7 (very good), followed by the attitude aspect with

an average of 82.1 (very good) and the science process skills aspect with an average of 77.9 (good).

Perception of attitude aspects (Average = 82.1): students showed a very positive attitude, especially on the items "I feel happy working with friends in completing this EbSW" (Score = 93.3) and "I feel interested in learning the material..." (Score = 89.3). The lowest score in this aspect was found in the item "I try to

complete the tasks in the worksheet without asking for much help from others" (Score = 58.7), indicating that most students still feel the need to collaborate or ask for help, which may reflect the level of task difficulty or the social nature of the learning process.

Perception of science process skills (Average = 77.9): this aspect shows good achievement, with the highest scores on the items "I am able to analyze data or information presented in the EbSW correctly" (Score = 82.7) and "I am able to observe physical and ethnoscientific phenomena presented in the EbSW" (Score = 80.0). The slightly lower average score in this aspect (76.0) may be influenced by difficulties in gathering information and applying concepts independently, even though the ability to analyze data and observe phenomena is already strong.

Perception of knowledge aspects (Average = 83.7): students demonstrated a very strong understanding. The items "I am able to conclude the results of observations and analyses conducted using this EbSW" (Score = 86.7) and "I understand the steps of the scientific method..." (Score = 85.3) received the highest scores. This confirms that EbSW are highly effective in helping students not only understand basic concepts but also connect them to ethnoscience practices and apply the scientific method. Overall, EbSW were rated very positively by students because they successfully fostered interest and cooperation and were effective in improving understanding (knowledge) and encouraging analytical skills.

The results of student reflections consistently show very positive responses to the implementation of EbSW, confirming the effectiveness of this learning instrument in various dimensions. The high scores on items related to interest (89.3) and enjoyment of working together (93.3) in the Attitude aspect strongly support Social Constructivist Learning Theory, which emphasizes the importance of interaction and cultural context in building meaningful understanding (Pranyata, 2025). The strong connection between academic concepts and local wisdom (ethnoscience) serves as a culturally relevant bridge, which is believed to improve retention and conceptual understanding (Septina et al., 2025). Thus, these findings provide empirical evidence that integrating cultural context into EbSW is a valid strategy for improving learning outcomes and shaping positive student attitudes (Pane et al., 2022).

Although all three aspects show positive categories, there are important nuances in the students' perceptions that need to be examined further. The Science Process Skills aspect has the lowest average (77.9), although it is still in the "Good" category. This is due to the lowest score on the item about independence in completing

tasks (58.7), which contrasts with the highest score on the item about collaboration skills (93.3). This phenomenon can be interpreted in two ways: first, EbSW may promote an inherently collaborative learning process, so that students naturally tend to ask for help and discuss. This perspective is in line with the view that complex inquiry learning often requires social support (Sudiarti et al., 2025). Second, low independence on certain tasks may indicate the need for more structured scaffolding to develop autonomy in the inquiry process (Setyosari et al., 2023). Nevertheless, the high scores in data analysis (82.7) and phenomenon observation (80) in the Science Process Skills aspect, which are the core of the Scientific Method, confirm that EbSW has succeeded in guiding students toward effective investigative practices (Puspita et al., 2021). The balance between collaborative support and autonomy development is key to improving EbSW in the future.

From the perspective of Knowledge (Average 83.7), the research results convincingly show that EbSW are very effective in facilitating deep conceptual understanding. High scores in the ability to conclude observations (86.7) and understand the steps of the scientific method (85.3) reinforce the argument that an approach that connects science with local wisdom can increase students' absorption and higher-order thinking skills (Ramadani, 2025). Ethnoscience provides concrete examples that are accessible and relevant, making it easier for students to internalize abstract concepts and apply scientific reasoning (Ahsani et al., 2024). These findings suggest that future curriculum development should actively adopt learning models that link science to the local socio-cultural context (Emda, 2023). However, to complement these findings, further research is recommended to use objective tests as a comparison to measure quantitative improvements in knowledge, while also conducting in-depth interviews to explore the reasons behind the low scores for independence in the EbSW completion process.

Cognitive Learning Outcomes

Cognitive learning outcomes are used to measure students' knowledge of the subject matter of the Nature of Physics and Scientific Methods based on ethnoscience. Five questions were created based on the discourse "The Eruption of Mount Lewotobi and the Density of Volcanic Material" and five questions from the discourse "Great Researchers" presenting data from tests of the tensile strength of NTT ikat weaving. Cognitive learning outcomes are presented in Table 9. Meanwhile, cognitive learning outcome data based on central tendency values are presented in Table 10.

Table 9. Cognitive Learning Outcome Data

Student Name	Question Number										Student grades	Category
	1	2	3	4	5	6	7	8	9	10		
MVN	1	1	1	1	1	1	1	1	1	1	100	Highly proficient
CAB	0	1	1	1	1	0	0	0	0	0	40	Not yet mastered
ACP	1	1	1	1	1	1	1	1	1	1	100	Highly proficient
JRU	1	1	1	1	1	1	1	1	0	1	90	Highly proficient
JVF	1	0	1	1	1	0	1	0	0	0	50	Not yet mastered
MBK	1	1	1	0	1	0	1	1	0	0	60	Not yet mastered
NPI	1	1	1	1	1	0	1	1	0	1	80	Mastering
GMS	1	1	1	0	1	1	1	1	1	1	90	Highly proficient
EEA	1	1	1	1	1	1	1	1	0	1	90	Highly proficient
PZR	1	1	1	1	0	1	1	1	0	1	80	Mastering
SALN	1	1	1	1	1	1	1	1	1	1	100	Highly proficient
YPPM	1	1	1	1	1	1	1	1	1	1	100	Highly proficient
YPAR	0	1	1	1	0	1	1	1	0	1	70	Sufficiently proficient
MKN	1	1	1	0	0	1	1	1	0	1	70	Sufficiently proficient
MMAS	1	1	1	1	1	1	1	1	0	1	90	Highly proficient
Amount	13	14	15	12	12	11	14	13	5	12		
Learning outcomes	87	93	100	80	80	73	93	87	33	80		

Table 10. Cognitive Learning Outcome Data Based on Central Symptom Scores

Central Symptom Score	Student Grades	Question item
Average	80.67	80.67
Standard Deviation	19.07	14.44
Lowest Value (Min)	40	33.30
Highest Score (Max)	100	100

Based on Tables 9 and 10, the students' cognitive learning outcomes show mastery of the subject matter of the Nature of Physics and the Scientific Method at the "Mastering" level, with a class average score of 80.67. Although this average indicates an adequate level of mastery, the high standard deviation (SD) in student scores (19.07) and the wide range of scores, from a low of 40 to a high of 100, indicate a significant gap in mastery of the material among students. A total of 8 students (53.3%) achieved the "Sufficiently proficient", but 3 other students (20%) were still in the "Not Yet Mastered" category.

The analysis of item difficulty (average success rate in answering correctly) shows that the average success rate of students is 80.67, with a standard deviation of 14.44. The high standard deviation of these items indicates that the test instrument has a good level of difficulty variation, but there are some items that are very easy and some that are very difficult. The easiest question (average = 100) was Question No. 3 (Density measuring instruments), demonstrating students' understanding of the basic concepts of measuring instruments. The most difficult question (average = 33) was Question No. 9 (Designing further experiments). This question tests the application of the Scientific Method at a higher level, namely the ability to design experiments by identifying variables. This difficulty may indicate that although students are able to calculate

and answer conceptual questions (Questions 4 and 7), they are still weak in higher-order thinking skills, particularly in designing and modifying scientific procedures.

Thus, the EbSW has successfully facilitated basic conceptual understanding (Questions 1-5 and 7), but needs to be improved to develop students' ability to apply and visualize the steps of the Scientific Method comprehensively (especially in the aspect of experimental design tested by Question 9).

Students' cognitive learning outcomes show an adequate level of mastery of the subject matter of the Nature of Physics and the Scientific Method, with a class average of 80.67. This average, which is above the minimum passing threshold, indicates that the implemented learning methods have been effective in transferring basic knowledge. However, the standard deviation (SD) of 19.07 and the wide range of scores (40 to 100) indicate significant variation in concept mastery among students. This condition is in line with the findings of Aprillianti et al. (2022), who stated that differences in students' motivational backgrounds, self-efficacy, and learning experiences will always result in disparities in cognitive achievement. In addition, the high SD reflects that learning strategies need to be further adjusted to minimize gaps, in accordance with (Pawitra et al., 2025) recommendation regarding the need to provide different support based on each student's Zone of Proximal Development (ZPD).

Analysis of the test items provides important insights into the weaknesses and strengths of students' conceptual mastery. Questions that are conceptual and basic procedural in nature (e.g., Question No. 3: Pycnometer with an average of 100 and Question No. 7: Comparison of tensile strength with an average of 93)

were mastered well. This achievement confirms that the use of EbSW successfully helped students connect abstract physics concepts (Density) with real-world contexts (volcanic materials and local woven fabrics), an approach reinforced by Ramadani (2025), who emphasizes the importance of integrating learning materials and local wisdom. However, questions requiring higher-order thinking skills, such as Question No. 9 (Designing a follow-up experiment), were the most difficult with an average score of only 33. This finding indicates that students still struggle with the synthesis and evaluation stages (Susanto et al., 2024), particularly in identifying and controlling variables, a common challenge faced in the development of scientific skills.

Overall, although cognitive outcomes have reached the minimum proficiency level, improvement efforts should focus on strengthening the application of the Scientific Method and experimental reasoning. A strong mastery of basic physics concepts needs to be encouraged to a more applicable level. This requires a shift in the focus of learning from mere memorization or calculation to the ability to solve complex contextual problems through scientific reasoning (Naen et al., 2024). Therefore, further research or follow-up learning should focus on increasing the complexity of tasks in EbSW, particularly those that encourage students to explicitly formulate hypotheses, control variables, and design valid procedures, in line with the principles of inquiry-based learning (Wariani et al., 2023).

Conclusion

This study demonstrates that the implementation of Ethnoscience-Based Student Worksheets (EbSW) on the topic of the Nature of Physics and the Scientific Method is effective in enhancing students' science process skills (SPS), learning perceptions, and cognitive learning outcomes. The overall SPS achievement reached a high average score of 83.90 (Very Skilled) with a low standard deviation ($SD = 3.61$), indicating that EbSW not only improves students' scientific skills but also promotes relatively even mastery across learners. These findings confirm that contextualized learning materials grounded in local ethnoscience can systematically train core scientific skills such as problem formulation, data collection, data analysis, and conclusion drawing. Students' perceptions toward the implementation of EbSW were highly positive, particularly in the aspects of knowledge (mean = 83.7) and attitude (mean = 82.1), both categorized as Very Good. This suggests that ethnoscience-based learning fosters meaningful engagement, collaborative learning, and conceptual understanding by linking abstract physics concepts with familiar cultural and local phenomena. Although the

perception of SPS was slightly lower (mean = 77.9, Good category), students demonstrated strong abilities in observing phenomena and analyzing data, indicating progress toward higher-level cognitive engagement. Cognitive learning outcomes showed an average score of 80.67, categorized as Mastery, confirming that EbSW effectively supports students' understanding of basic concepts related to physics and the scientific method. However, the relatively high cognitive standard deviation ($SD = 19.07$) reveals disparities in students' mastery, particularly in higher-order thinking skills (HOTS), such as designing experiments and controlling variables. This finding highlights that while EbSW is effective for conceptual understanding and SPS development, additional instructional support is required to address varying levels of students' higher-order cognitive abilities. From a broader perspective, these results can be generalized to suggest that ethnoscience-based instructional materials have strong potential to improve science learning in secondary education, especially in contexts where local culture and everyday experiences can be integrated into scientific inquiry. Practically, this study implies that teachers can utilize ethnoscience-based worksheets as an effective pedagogical tool to develop students' SPS, increase learning motivation, and strengthen conceptual understanding. To maximize their impact, future implementations should incorporate adaptive scaffolding strategies and more complex inquiry tasks that explicitly target HOTS, thereby enabling students to progress from basic scientific understanding toward more advanced and independent scientific reasoning.

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Conflicts of Interest

The authors declare no conflict of interest.

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