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Research Artikel

**INTEGRATING THE KEN-DUREN TRADITION OF WONOSALAM
INTO ETHNO-STEM BASED BIODIVERSITY MODULE TO IMPROVE
STUDENTS' SCIENCE LITERACY**

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Abstract

This study aims to develop and evaluate the effectiveness of an Ethno-STEM-based biodiversity module integrated with the Ken-Duren Wonosalam tradition in improving the scientific literacy of tenth-grade high school students, employing a Research and Development (R&D) approach. The study follows the 4D model (Define, Design, Develop, Disseminate). The subjects were 15 tenth-grade students of Darul Ulum 1 Unggulan Jombang High School. Data was collected through three expert validations, consisting of one material expert, one media expert, and one education expert who evaluated the feasibility of the developed module. The validation results by two material experts and one media expert showed an average value of 3.79 with a "valid" category. The practicality test showed that the module was easy to use and implement in learning. The effectiveness test using the paired sample t-test produced a p-value <0.05 which indicated a significant difference between students' pretest and posttest results. The results indicate that the Ethno-STEM-based biodiversity module is associated with improved students' scientific literacy, as reflected in the pretest–posttest gains. However, because the study employed a one-group pretest–posttest design, the findings should be interpreted cautiously. The integration of the Ken-Duren local tradition appears to support more contextual and meaningful learning, highlighting its potential contribution to science education.

Keywords: Ethno-STEM, biodiversity, scientific literacy, module development

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INTRODUCTION

Science literacy skills are an important aspect in equipping students to understand natural phenomena, make evidence-based decisions, and actively participate in modern life, which is full of science and technology issues (Sunarsih et al., 2020). However, the 2022 PISA study results show that Indonesia still faces challenges in this regard, with a score of 383 for science literacy, placing it 70th out of 81 participating countries (OECD, 2023). The PISA study results show that despite various efforts to improve science literacy in Indonesia, the challenges remain enormous. It is important for all stakeholders to work together to improve the quality of science education so that Indonesian students can be more competitive at the global level (Himmah & Fadriati, 2023). In the era of rapid technological advancement and increasing availability of scientific data, science literacy has become essential not only for education but also for research, industry, and evidence-based policymaking (Xiao et al., 2023). STEM-based modules have been proven effective in improving students' science literacy, especially in understanding environmental and scientific concepts in a more practical way (Primadianningsih et al., 2023). Therefore, science learning should not focus solely on content mastery but also emphasize inquiry, reasoning (Mahmudah et al., 2022), and decision-making skills grounded in real-world contexts. In this context, science literacy can be defined as the ability to apply scientific knowledge, identify scientific questions, and draw evidence-based conclusions to understand the natural world and the changes resulting from human activities (OECD, 2023).

Previous studies (Babalola & Keku, 2024; Hong et al., 2020) have demonstrated that STEM and STEAM-based learning materials can enhance students' learning outcomes, particularly in terms of conceptual understanding and problem-solving skills

through hands-on and interdisciplinary approaches (Sari et al., 2022). Other studies have shown that integrating local contexts into learning materials increases relevance and meaningfulness, thereby supporting students' engagement and connection to scientific concepts (Muliyana & Jailani, 2023). Meanwhile, Ethno-STEM approaches, which combine indigenous knowledge with science, technology, engineering, and mathematics, have been reported to foster constructivist learning environments and improve students' engagement and conceptual comprehension (Erman & Suyatno, 2022).

The development of Ethno-STEM-based modules with the PjBL model is supported by constructivist learning theory. This is in line with the science literacy learning indicators (OECD, 2023), namely: 1) Explaining phenomena scientifically, 2) Constructing and evaluating designs for scientific investigations and critically interpreting scientific data and evidence, 3) Researching, evaluating, and using scientific information for decision-making and action. By combining theoretical understanding and practice, biodiversity learning can be developed in student process skills activities, such as observing, questioning, planning research, analysing data, evaluating, and communicating results (Radeva, 2020).

However, most existing studies (Defianti & Sakti, 2024; Pratiwi & Setiawan, 2025; Sulistina et al., 2024) focus either on STEM/STEAM-based modules or on local wisdom integration in general, without explicitly linking Ethno-STEM learning to Project-Based Learning (PjBL) models and science literacy indicators as defined by PISA. Moreover, research on Ethno STEM modules tends to emphasize conceptual understanding or cultural appreciation, while a recent study also found that Ethno-STEM integrated with a PjBL model positively affected students' scientific literacy outcomes (Muhammad Imron et al., 2025) and use scientific information for decision making is remains

limited, especially at the senior high school level.

Preliminary observations conducted at Darul Ulum 1 Unggulan Peterongan Jombang Senior High School (SMADU 1) indicate that students' science literacy skills remain relatively low. These observations were based on a diagnostic pretest administered to 12 tenth-grade students prior to the implementation of the learning intervention. The science literacy test was developed based on PISA-oriented indicators and consisted of items assessing students' ability to identify scientific issues, interpret data, and apply scientific knowledge to real-life contexts. Student scores were converted to a scale of 0–100 to facilitate interpretation (Kemdikbudristek, 2023).

The results showed an average score of 20.98, indicating limited mastery of science literacy competencies. Of the 12 students, only two achieved scores in the range of 30–50, while the remaining ten students scored below 30. These findings suggest that most students experienced significant difficulty in completing tasks requiring higher-order scientific reasoning (Yusuf & Widyaningsih, 2019). In particular, weaknesses were evident in the third indicator of science literacy, namely the ability to investigate, evaluate, and use scientific information for decision-making, including assessing the credibility and implications of scientific information in personal and societal contexts. According to science literacy (OECD, 2023), which emphasizes the ability to apply scientific knowledge, identify scientific questions, and draw evidence-based conclusions to understand the natural world and human-induced changes. The low performance observed in this preliminary assessment underscores the need for instructional approaches that more effectively support the development of these competencies (Iwan et al., 2025).

Local wisdom-based science learning is

essentially science learning that is used to help students (Azmi et al., 2023) understand science material in the context of real life (Ramdhani, 2019). However, reality shows that there are still many students who are unfamiliar with local wisdom in their area. Previous studies have reported that many students participate in indigenous or local wisdom-based activities without fully recognizing the underlying scientific (Sumarni & Kadarwati, 2020), mathematical, and technological concepts embedded within these practices (Erman & Suyatno, 2022). This finding suggests that although local wisdom is familiar to students in daily life, its potential as a medium for developing STEM-related understanding is often not explicitly explored in classroom learning.

Wonosalam is a subdistrict in Jombang Regency that has the strongest potential for tourism investment, supported by a wealth of agricultural and plantation products such as cloves, salak, bananas, cocoa, and the famous bido durian (Agastya & Ariyani, 2023). Biodiversity in Wonosalam is reflected in various aspects (Indra Sulistiyono, 2015). Durian is a leading commodity with various varieties, such as Bido, Musang King, Montong (Setiawan, 2024), Petruk, Kumbokarno, and Durian Kuning. This indicates rich biodiversity, with 26 plant species from 19 families used in the Ken-Duren tradition (Izza, 2022; Rokhmah, 2019; Wahyuni & Susilowati, 2020), an annual traditional ceremony expressing gratitude for the abundance of crops (Sulistina et al., 2024). Despite this potential, there is currently no Ethno-STEM-based learning module that systematically integrates the Ken-Duren tradition (Agastya & Ariyani, 2023; Huda et al., 2022) into biodiversity learning using a PjBL framework aligned with PISA science literacy indicators (OECD, 2023). Biodiversity is a key topic for Grade 10 students and aligns with Phase E learning outcomes in the Independent Curriculum (Sunarsih et al., 2020). It requires students not only to

understand concepts such as genetic, species, and ecosystem diversity, but also to analyze real environmental issues and propose sustainable solutions in line with the Sustainable Development Goals (SDGs) (J. Kennedy & R.L. Odell, 2024). Therefore, biodiversity learning grounded in the Wonosalam context provides an authentic opportunity to develop students' science literacy through observation, investigation, data analysis, and communication (Sudarmin et al., 2024).

Based on this gap, this study aims to develop an Ethno-STEM-based module integrated with the Project-Based Learning model using the Ken-Duren Wonosalam tradition as a contextual basis for biodiversity learning, and to examine its potential in supporting students' science literacy skills. This module is expected to contribute to improving science literacy and strengthening students' cultural awareness, and scientific attitudes. This can encourage students to be more sensitive to local, national, and global issues and enable them to create creative and

sustainable solutions based on scientific concepts. Through the Ken-Duren Wonosalam tradition, students can understand the concept of biodiversity in a more concrete and applicable way through the integration of the Ethno-STEM Approach.

METHOD

This research is Research and Development (R&D). The product developed in this study is a biodiversity learning module based on the Ethno-STEM approach, which integrates scientific concepts with the local Ken-Duren tradition of Wonosalam, Jombang. The development model used in this study is 4D which include the stage Define, Design, Develop, and Disseminate (Thiagarajan et al., 1974). The procedure for developing the Ethno-STEM-based biodiversity learning module integrated with the Ken-Duren tradition of Wonosalam Jombang followed the 4-D development model proposed by Thiagarajan et al. (1974), which includes the stages of define, design, develop, and disseminate, as described on Figure 1.

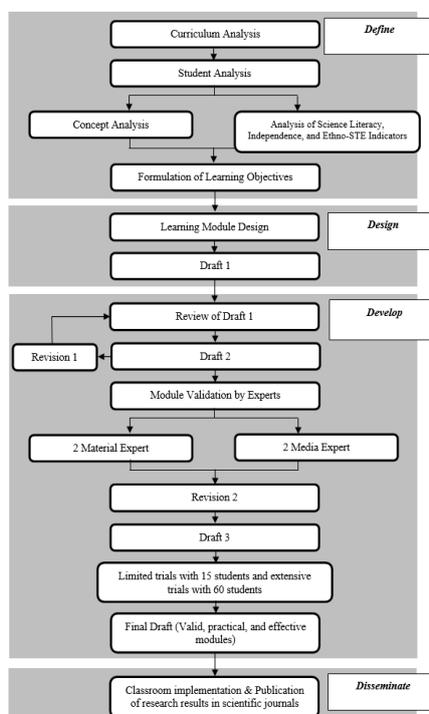


Figure 1. Research Flow Diagram Adapted from PRISMA Method

According to Firdaus et al., (2020) the use of the 4D model is very important because it offers a systematic and structured approach, ensuring that educational products are designed through clear and tested stages, thus meeting high standards of feasibility (Ardithayasa et al., 2022; Juul Jensen & Zhang, 2020; Simanjuntak & Christianus, 2024). This study employed the 4D development model to systematically design and develop an Ethno-STEM learning module. The development process was conducted in the first semester of the 2025/2026 academic year and was divided into two main phases: module development and module implementation.

The define stage focused on identifying the foundations of the module development. This stage involved curriculum analysis to examine learning outcomes and content requirements of the Independent Curriculum, student analysis to identify learners' characteristics and initial science literacy levels, concept analysis to determine key biodiversity concepts, and analysis of science literacy indicators, learning autonomy, and Ethno-STEM integration. The results of these analyses were used to formulate clear and measurable learning objectives aligned with PISA science literacy indicators.

The design stage aimed to translate the defined objectives into a structured learning module. At this stage, the learning framework, learning activities, project-based learning scenarios, assessment instruments, and learning media were designed. The initial prototype of the module (Draft 1) was produced, integrating local wisdom from the Ken-Duren Wonosalam tradition with Ethno-STEM principles and biodiversity content.

The develop stage focused on validating and refining the module. Draft 1 underwent expert review, followed by Revision 1 to produce Draft 2. The module was then validated by three experts, consisting of two subject matter experts and one media expert, to

evaluate content accuracy, instructional design, language clarity, and media quality. Based on the validation results and expert feedback, Revision 2 was conducted to generate Draft 3. Following the development stage, the module first underwent expert validation involving subject-matter, media, and educational experts to assess its content accuracy, design quality, and instructional feasibility. After revisions based on expert feedback, the revised module was then implemented in a small-scale classroom trial to evaluate its practicality and preliminary effectiveness. The results of these two stages indicated that the module met the criteria of validity, practicality, and initial effectiveness.

The disseminate stage involved implementing the final version of the module in two classes consisting of a total of 30 students to examine its effectiveness in a broader classroom context. This stage aimed to evaluate the module's applicability and its impact on students' science literacy in a real instructional setting.

These development activities were conducted at the IDB Laboratory, Faculty of Mathematics and Natural Sciences, Universitas Negeri Surabaya, while the small and large scale classroom trials were conducted at Darul Ulum 1 Unggulan Jombang Senior High School between August and November 2025. The same cohort of tenth-grade students participated in both stages of the trial, with the small-scale implementation conducted first to refine the module, followed by a large-scale implementation to evaluate its practicality and effectiveness. Prior to classroom implementation, the developed learning module underwent a content and media validation process, which was conducted as part of the development stage rather than the data collection stage.

The validation process involved three experts from the Biology Education Department at Universitas Negeri Surabaya, consisting of two subject matter experts and one

media expert. The subject matter experts evaluated the module in terms of content accuracy, conceptual coherence, alignment with curriculum learning outcomes, and integration of Ethno-STEM and science literacy indicators. The media expert assessed the visual design, layout, readability, instructional clarity, and technical quality of the module (Iwan et al., 2025). Validation was carried out using structured validation instruments based on a Likert-scale rubric, and qualitative feedback from the experts was used to revise and improve the module. The results of this validation process were used solely to determine the validity and feasibility of the module and did not constitute research data related to learning outcomes.

After the module was declared valid, it was implemented in two stages of classroom trials. The small-scale trial was conducted to examine the module's practicality and to identify potential implementation issues. Subsequently, the large-scale trial was carried out to evaluate the module's effectiveness in improving students science literacy skills.

Data collection was conducted during the implementation stage and consisted of three steps: pre-test, module implementation, and post-test. The pre-test and post-test were administered to measure changes in students' science literacy skills and to determine the effectiveness of the module. In addition, teacher and student response questionnaires were distributed after the implementation to collect data on the module's practicality, clarity, and usability in classroom learning.

Data processing techniques were applied to meet the research requirements regarding the validity, practicality, and effectiveness of the module. In this study, the data were analysed as follows:

1. Validity Analysis

Data was obtained from expert validators and analyzed using descriptive quantitative methods. The validation results were

interpreted based on the following criteria: a mean score of 3.26–4.00 indicated *very valid*, 2.51–3.25 indicated *valid*, 1.76–2.50 indicated *less valid*, and 1.00–1.75 indicated *invalid*. These criteria were used to determine the feasibility and quality of the developed module.

Table 1. Validity Criteria

Score	Description	
	Criteria	Meaning
$Va \geq 3.0$	Valid	The product can be tested
$2.0 \leq Va < 3.0$	Sufficiently Valid	There are still minor parts that need to be revised
$Va < 2.0$	Not Valid	Product requires complete revision

2. Practicality Analysis

Data was obtained from the completion of a questionnaire by observer teachers to determine the level of implementation of the module. The practical criteria are shown in Table 2.

Table 2. Practicality Criteria

Score	Description	
	Criteria	Meaning
$Pr \geq 3.0$	High	High level of implementation
$2.0 \leq Pr < 3.0$	Moderate	Moderate level of implementation
$Pr < 2.0$	Low	Low implementation rate

3. Effectiveness Analysis

Data was obtained from students' pre-test and post-test scores using a set of ten items related to biodiversity concepts. The test instruments were previously validated by expert validators to ensure content validity. Prior to hypothesis testing, the data were analyzed for normality using the Shapiro–Wilk test. The results indicated that the data were normally distributed; therefore, a paired-sample *t*-test was employed to examine differences between pretest and posttest scores. This analysis was conducted to determine the effectiveness of the developed module in improving students' science literacy.

RESULTS AND DISCUSSION

This section presents and discusses the findings of the study related to the development and implementation of the Ethno-STEM-based learning module. It first reports the results of the expert validation, practicality testing, and effectiveness evaluation based on students' learning outcomes. Subsequently, the findings are discussed in relation to relevant theories and previous studies to interpret how the developed module contributes to improving students' science literacy.

The product developed in this study is an Ethno-STEM-based biodiversity learning module integrated with the Project-Based Learning (PjBL) model, using the Ken-Duren Wonosalam tradition as a contextual learning source. The module was designed for tenth-grade senior high school students and aligned with the Independent Curriculum learning outcomes and PISA science literacy indicators. This module consists of : An introduction containing learning objectives, concept maps, and contextual problems derived from local wisdom; Core learning activities organized according to PjBL including problem orientation, project planning, investigation, data analysis, and presentation of results. The responses were analyzed using descriptive quantitative methods and interpreted based on predefined criteria: a score of 81–100% indicated very practical, 61–80% indicated practical, 41–60% indicated fairly practical, 21–40% indicated less practical, and $\leq 20\%$ indicated not practical.; Ethno-STEM integration that explicitly connects biodiversity concepts with science, technology, engineering, and mathematics aspects embedded in the Ken-Duren tradition; Student worksheets that guide observation, data collection, analysis, and scientific communication; and Science literacy assessments focusing on explaining scientific phenomena, interpreting scientific data, and using scientific evidence for decision-making.

The module emphasizes active learning, contextual inquiry, and student autonomy, enabling students to connect biodiversity

concepts with real-life environmental and cultural issues in Wonosalam. These characteristics were designed in response to previously identified learning needs, particularly related to students' higher-order science literacy skills, as indicated by preliminary observations and assessment results.

The validity data was assessed by three validators from the Biology Education Department at Surabaya State University. The validity results are presented in Table 3.

Aspect	Score
Presentation	3.79
Content	3.91
Language	3.66
Total Average	3.79

As shown in Table 3, the Ethno-STEM-based biodiversity module achieved a total average validity score of 3.79, indicating that the module meets the criteria for validity.

Practical data was obtained from the completion of the learning module implementation observation sheet and the responses of teachers and students, which were used to determine the practicality of the learning module.

The results of the observation of the implementation of the learning module were conducted to determine the practicality of the learning module that had been used by students. The observation of implementation was carried out by two observers who observed student activities during the learning process. Learning was conducted during three meetings using the module to support learning activities. The results of the observation of the implementation of the learning module showed that it was practical for training students' science literacy. The final implementation percentage was 98.48%, which is categorized as very good.

The responses from teachers and students were used to determine the practicality of the

Module learning. The teachers' responses were provided by two biology teachers at Darul Ulum 1 Unggulan Jombang Senior High School after using the module in their teaching activities. The students' responses were provided by 15 students from Grade X after using the learning Module. The responses from teachers and students to the Module covered aspects of presentation, content, and language. The results of the learning Module responses showed that it was practical for improving science literacy, with a response rate of 100% from teachers and 98.33% from students. These percentages fall into a very good category.

The responses from teachers and students after using the learning module were positive. Teachers felt that the learning module helped them deliver material in a more structured, interactive, and easy-to-understand manner, while students felt more interested and motivated to learn due to the attractive appearance and interactive features that supported their understanding of the concepts. The benefit of conducting this response is to identify the strengths and weaknesses of the learning module from the perspective of direct users, so that developers can conduct further evaluation and improvements. In addition, this response also serves as feedback that can strengthen the effectiveness of the learning module in supporting the success of the learning process in the future.

Effectiveness data was obtained from the results of the students' pre-test and post-test scores that shown in Table 4.

Table 4. Students' pre-test and post-test scores

Pre-test	Post-test
33	85
35	93
47	94
41	95
23	94
18	93
30	93
49	93

Pre-test	Post-test
20	91
28	87
18	88
25	88
27	88
30	88
30	81

The pre-test scores indicate that students' initial science literacy levels were relatively low, with scores ranging from 18 to 49, reflecting difficulties in applying scientific concepts and interpreting scientific information. In contrast, the post-test scores showed a substantial increase, ranging from 81 to 95, indicating a marked improvement after using the Ethno-STEM-based module. This consistent increase across all students suggests that the module had a strong positive effect on students' science literacy skills. The improvement can be attributed to the module's contextual approach, which allowed students to directly engage with biodiversity concepts through real-life cultural practices, and the PjBL framework, which emphasized investigation, analysis, and evidence-based reasoning. For Data Distribution Test, The Kolmogorov-Smirnov and Shapiro-Wilk data distribution test yielded the following results.

Table 5. Mormality Test

	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statis tic	df	Sig.	Statis tic	df	Sig.
Pret est	0.178	15	0.200	0.93	15	0.268
Post test	0.235	15	0.206	0.897	15	0.086

*lower bound of the true significance
^a Lilliefors Significance Correction

If the sample size is less than 50, the Shapiro Wilk test is used. In the Pre-Test, the p-value was found to be > 0.05, indicating that the pre-test and post-test data are normally distributed. The results showed that the significance values for both the pre-test and post-test scores were greater than 0.05,

indicating that the data were normally distributed. Therefore, a paired-sample t-test was deemed appropriate to analyse the difference between pre-test and post-test scores.

A hypothesis is needed to state whether the Ethno-STEM-based module on the Ken-Duren Wonosalam Jombang tradition of biodiversity affects student scores or not. If a significant difference is found between the pre-test and post-test scores, then the module used can be said to be effective.

H_0 means there is no significant difference in the science literacy of Grade X high school students before (pre-test) and after (post-test) using the Ethno-STEM-based module on the Ken-Duren Wonosalam Jombang tradition of biodiversity. Whereas H_1 means there is a significant difference in the science literacy of grade X high school students before (pre-test) and after (post-test) using the Ethno-STEM-based module on the Ken-Duren Wonosalam Jombang tradition of biodiversity.

Table 6. Paired T-Test in SPSS of Implementation of the Ethno-STEM-based module

Paired Difference									
		Mean	Std Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
					Lower	Upper			
Pair 1	Pretest-Posttest	-59.80	9.260	2.391	-64.93	-54.67	-25.0	14	0.000

In the Paired t-test, the p-value is $< 0,05$, which means the decision is to reject H_0 . The paired-sample t-test results indicated a p-value < 0.05 , leading to the rejection of H_0 . This result demonstrates a statistically significant increase in students' science literacy scores after the implementation of the Ethno-STEM-based module.

The findings of this study indicate that the Ethno-STEM-based biodiversity module contributed to an improvement in students' science literacy, as evidenced by higher post-test scores compared to pre-test results. This improvement can be attributed to the alignment between the assessment instruments and the targeted science literacy indicators, as well as the instructional design of the module, which integrated local cultural contexts through the Ken-Duren tradition. Consistent with previous studies, the use of contextual and project-based learning approaches supported students' engagement in scientific inquiry, data interpretation, and evidence-based reasoning—key components of science literacy. The integration of local wisdom also provided meaningful learning experiences that helped

students connect scientific concepts with real-world phenomena.

Despite these positive outcomes, several limitations should be acknowledged. The study employed a one-group pretest–posttest design, which restricts causal inference due to the absence of a comparison group. In addition, the sample was limited to a single school and a relatively small number of students, potentially affecting the generalizability of the findings. Nevertheless, the results suggest that Ethno-STEM-based learning holds promise for enhancing science literacy and may serve as a valuable instructional approach. Future research is recommended to involve larger and more diverse samples, employ experimental or quasi-experimental designs, and examine the long-term impact of Ethno-STEM learning on students' scientific reasoning and decision-making skills. This means that there is a significant difference in the science literacy of students before (pre-test) and after (post-test) using the Ethno-STEM-based module on the Ken-Duren Wonosalam Jombang tradition with biodiversity material.

CONCLUSION

This study aimed to develop and evaluate an Ethno-STEM-based biodiversity module integrating the Ken-Duren tradition of Wonosalam and to examine its validity, practicality, and effectiveness in supporting students' science literacy. The results indicate that the developed module met the validity criteria, as reflected by an average expert validation score of 3.79. In addition, classroom implementation showed that the module was practical to use, as evidenced by high implementation and response scores from both teachers and students.

Furthermore, the findings demonstrate an improvement in students' science literacy after the implementation of the module. The observed increase in post-test scores suggests that the Ethno-STEM approach, which integrates local cultural contexts with project-based learning, can support students in developing key science literacy competencies such as interpreting scientific data, explaining phenomena, and making evidence-based decisions. These results align with the study's objective of examining the potential of Ethno-STEM learning to enhance science literacy through contextual and meaningful learning experiences.

Therefore, this study shows that the Ethno-STEM-based biodiversity module has the potential to serve as an effective alternative learning resource in secondary biology education. The integration of local wisdom within science instruction not only supports conceptual understanding but also promotes contextual learning relevant to students' real-life experiences. Future research is recommended to involve broader samples, longer implementation periods, and comparative designs to further validate the effectiveness of Ethno-STEM-based learning across diverse educational contexts.

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