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Effectiveness of ethnoscience oriented project to improve students performance

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Abstract This study endeavors to harness this invaluable traditional wisdom and leverage it for pedagogical purposes by integrating the ethnoscience of the *sasak* tribe into science education, thereby enriching the learning experience in the realm of science. The primary objective of this investigation is to assess the effectiveness of incorporating ethnoscience of local natural pesticide, *gule beaq*, and *serbat* into science project instruction and its impact on student performance. This research adopted a preexperimental research approach, utilizing a pretest-posttest noncontrol group design, with 34 of chemistry education study program students actively participating in the science project learning of Natural Product Chemistry major. Evaluation of student performance was carried out through meticulous assessments of their practical skills and the compilation of comprehensive portfolios. Data analysis was conducted employing the N-gain method to quantify the extent of improvement. The results of this study unveiled a consistent and progressive enhancement in student laboratory performance across three successive practical sessions, with mean performance scores of 75.52, 79.60, and 87.76, respectively. The calculated N-gain values, although categorized as modest, exhibited positive increments across each practical session, registering scores of 0.015, 0.070, and 0.181 relative to the initial performance level. These empirical findings collectively underscore the potential efficacy of integrating ethnoscience into science teaching materials as a unique and impactful means to bolster student performance on execute project, thus illuminating new pathways for innovative science education.

Keywords: ethnoscience, learning performance, science project

1. Introduction

Indonesia is a nation rich in local wisdom, with values that are deeply embedded in the daily lives of its people, shaping the nation's identity. These values manifest in noble, moral, ethical, and collaborative practices that reflect the cultural richness of its communities. Integrating local wisdom into education, particularly in the science curriculum, is essential for aligning learning with the nation's cultural identity and fostering students' understanding of their heritage (Sudarmin, 2014). Science education that leverages local culture, local wisdom, or regional potential can enhance students' engagement and understanding by connecting abstract concepts to their lived experiences (Mashami et al., 2023; Parmin et al., 2022).

Research highlights that culturally responsive teaching in science education not only supports the comprehension of scientific concepts but also fosters an appreciation for students' cultural heritage. Teachers who integrate local culture into science lessons enable students to understand their cultural context better, fostering a love for their region and a commitment to preserving its cultural potential (Dewi et al., 2019; Hikmawati et al., 2020; Okechukwu et al., 2014; Parmin et al., 2022). Furthermore, the synthesis of indigenous knowledge and modern science has been recognized as a powerful tool for constructing meaningful learning experiences. Indigenous knowledge acts as a stimulus, motivating students and providing context for scientific exploration, particularly when teachers skillfully bridge cultural and scientific knowledge (Hikmawati et al., 2020; Khery et al., 2021; Mashami et al., 2023).

The original knowledge of the people is very important and has made a great contribution to the development of modern science and technology. The integration of indigenous knowledge (indigenous science) with scientific knowledge (Western science) has also been recognized. Indigenous knowledge of the community can function as a learning stimulus to motivate and help students construct knowledge; therefore, teachers/lecturers must be able to raise cultural elements to be accommodated in learning (Okechukwu et al., 2014; Parmin et al., 2022; Sudarmin, 2014).

The sociocultural environment, which often contains indigenous scientific practices, plays a significant role in science education. Integrating this environment into the curriculum not only enhances students' understanding but also encourages social responsibility and cultural preservation (Fitria and Widi, 2015; Hastuti et al., 2019). For example, in the Sasak

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community, traditional practices such as using natural pesticides, producing palm sugar (gule beaq), and making serbat (a traditional drink of palm sugar and lemongrass) are deeply rooted in local knowledge (Hikmawati et al., 2020; Khery et al., 2021; Mashami et al., 2023). These practices, characterized by variations in formulas, processes, and ingredients, present valuable opportunities for integrating ethnoscience into education.

The integration of ethnoscience into science education also aligns with global educational objectives, such as fostering sustainable development and promoting cultural diversity (Pomeroy, 1994; Widowati and Wakid, 2024; Zidny et al., 2021). By connecting students with their local heritage, ethnoscience-oriented learning contributes to the preservation of indigenous knowledge systems that are increasingly at risk of being overshadowed by globalized, standardized curricula. Moreover, this approach encourages students to address real-world problems using culturally relevant and environmentally sustainable solutions (Rist and Dahdouh-Guebas, 2006). As education moves toward a more inclusive and holistic framework, the fusion of indigenous and scientific knowledge offers a powerful strategy to develop critical thinking, innovation, and a sense of global citizenship while maintaining strong local roots (Leach and Scoones, 2003; Musah and Wangila, 2024; Zidny et al., 2020). This research contributes to these broader goals by exploring how ethnoscience can serve as a bridge between traditional wisdom and contemporary scientific inquiry, ultimately enriching the educational experience (Hastuti et al., 2019).

This study focuses on evaluating the application of ethnoscience-oriented learning using the Sasak community's practices as case studies. Specifically, it examines the use of local natural pesticides, the process of palm sugar production, and the making of serbat. By incorporating these practices into science education, this research aims to develop meaningful learning experiences that blend indigenous knowledge with scientific understanding, fostering cultural appreciation and innovative thinking among students.

2. Materials and methods

This research was conducted via a preexperimental research approach, employing a pretest–posttest noncontrol group design, as illustrated in Figure 1.

Class	Pretest	Treatment	Postest
Experiment	O1	X	O2

O1 : Students initial performance
X : Ethnoscience oriented learning
O2 : Students performance after treatment

Figure 1 Scheme of the pretest–posttest noncontrol group design.

The study included a cohort of 23 chemistry education program students actively participating in the science project learning of the natural product chemistry major. The subjects are separated into 5 groups working on their respective projects. The research activities transpired in the Chemistry Education study program of Universitas Pendidikan Mandalika from January to March in 2023. The pedagogical endeavors undertaken were structured as shown in Figure 2.

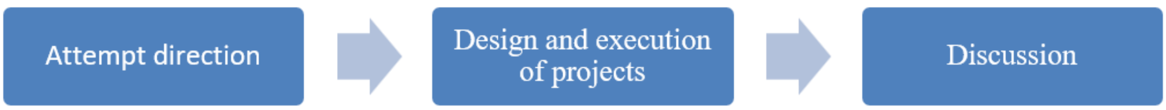

Figure 2 Scheme of the pedagogical process.

The pedagogical process spans a series of integrated learning activities. These encompassed the phases of Attempt direction (A), ethnoscience observation—during which students engaged in exploratory information gathering (A1), analyzing ethnoscience and problem definition (A2), and product ideas (A3). Subsequently, the students advanced to the design and execution of projects (B) phase, wherein they crafted observational plans (B1), gathered empirical data through observational methods (B2), and synthesized their findings into comprehensive conclusions (B3). The final phase, discussion (C), involved students presenting their project outcomes (C1), articulating arguments in favor of the excellence of their products (C2), and critically evaluating the environmental and social implications associated with their creations (C3).

The baseline project performance data (P) were derived from prior assessments conducted during laboratory activities in previous learning sessions. The criteria utilized for evaluation were consistent with the reciprocal assessment standards applied by the researchers during the P1, P2, and P3 phases. The assessment of student laboratory performance throughout the P1, P2, and P3 phases was accomplished through a combination of performance observations and portfolio evaluations.

The specific components evaluated are comprehensively detailed in Table 1, with each indicator warranting a binary scoring system of 1 (yes) and 0 (no).

Table 1 Students performance assessment indicators.

Indicator	Activities assessed	
	Observation	Portfolio
Students gather information from a variety of sources.		A1
Students make a summary		A1
Students set investigative/research variables		B1
Students raise the background of the importance of conducting an investigation/research		A2
Students formulate investigation/research objectives		A2
Students make hypotheses.		A3
Students select appropriate variables, collect relevant data, and select a form of presentation of results appropriate for a chosen investigative procedure		A3, B2
Students document pictures of observation objects.		B2
Students present observations in a chart, graph, or histogram.	C1	B2
Students compile and complete an investigative procedure.		B1, B2
Students prepare units/measuring devices to take measurements.	B2	
Students take measurements according to the measurement scale	B2	B2
Students use the appropriate measuring instruments correctly.	B2	
Students make observations and collect data with measuring instruments	B2	
Students choose laboratory equipment that is in accordance with the task at hand.	B2	
Students adopt laboratory procedures by minimizing risk.		B1
Students move materials/materials/equipment using the right way/container	B2	
Students separate substances based on their form.	B2	
Students do sample preparation.	B1	
Students make/mix materials according to certain standards/concentrations.	B2	
Students maintain work safety using glassware and hazardous chemicals	B2	
Students make observations and collect data using the five senses	B2	B2
Students convert units from a legible measure into another quantity.		B2
Students recognize objects based on their characteristics.	B2, B3	B2, B3
Students identify objects to match with specific references/reading sources.	B2, B3	B2, B3
Students identify similarities/differences between objects	B2, B3	B2, B3
Students match an object with a variety of visible characteristics.	B2, B3	B2, B3
Students make reasonable generalizations/conclusions based on observations.		B3
Students use observations to confirm or prove errors/refute existing hypotheses.		B3
Students distinguish between observations and references/literature sources.		B3, C1
Students generating idea and conduct investigations related to everyday life.		C3
Students formulate the benefits of investigation for the environment and social and promote innovation		A2, C2, C3
Students present observations in group discussions	C1, C2	C1, C2
Students demonstrate the excellence of their product/investigation results and persue idea to conduct new product	C1, C2, C3	C1, C2, C3

Student performance is analyzed via percentage, average, and N-gain techniques. The score and N-gain are interpreted consecutively by category, as presented in Table 2 and Table 3.

Table 2 Students performance category.

Score	Category
80.00-100	Excellence
60-79.99	Good
40-59.99	Poor
20-39.99	Fail

Table 3 N-gain category.

N-gain	Category
g>0.7	High
0.3≤g≤0.7	Medium
G<0.3	Low

3. Results

3.1. Student Performance

The learning activities created by students in an open-ended manner from this learning are presented in Table 4.

The performance of students in activities pertaining to attempt direction, project design and execution, and discussion across the initial, subsequent, and final project learning sessions is comprehensively depicted in Figure 3. The empirical findings indicate a noteworthy enhancement in students' overall performance across these facets of learning. This observable improvement can be attributed to students' growing familiarity with the pedagogical methodologies employed throughout the course of their studies. Notably, students also exhibited more positive attitudes during the project learning sessions. Notably, ethnoscience-oriented learning has been shown to increase student interest, motivation, and learning outcomes in the domain of science education (Fasasi, 2017; Muliadi et al., 2022; Munandar et al., 2022). This elevation in interest and motivation is highly likely to be a pivotal factor contributing to the observed performance enhancement (Lizzio et al., 2002; Shakir, 2014).

Table 4 Summary of the open ended ethnoscience-based project learning process.

Group	Attempt direction	Design and execution of projects		Discussion
I	Observing ethnoscience of *Nyamplung* (Callophyllum Inophyllum L.) as skin medication in Gunungsari village people	P1	Designing formula of facial mask based on *Nyamplung* extract	Presenting organoleptic, homogenity, spreadability, pH, stickness, water content, density, irritation on skin evaluation, and SPF data on variation of *nyamplung* extract concentration.
		P2	Designing formula of body scrub based on *Nyamplung* extract	
		P3	Designing formula sunscreen based on *Nyamplung* extract	
II	Observing ethnoscience of grilled charcoal production in Bengkaung village people	P1	Designing formula of Briket based on charcoal of coconut shell	Presentaing water content, flying matter content, ash content, and carbon content
		P2	Designing formula of activated carbon based on charcoal of coconut shell	
		P3	Designing formula of Hydroponic Planting based on charcoal of coconut shell	Presentaing the growth parameters were stem height, leaf length, number of leaves, and root length in observation for four weeks.
III	Observing tobacco production of Pejaring village farmer	P1	Designing formula of therapeutic aroma candles from tobacco tree waste.	Presenting Organoleptic test, melting point, burn time on variations in tobacco extract concentrations.
		P2	Designing formula of therapeutic massage oil from tobacco tree waste.	Presenting pH, density, and hedonic tests on variations in tobacco extract concentrations
		P3	Designing formula of therapeutic aroma body mist from tobacco tree waste.	Presenting organoleptic, homogenity, spreadability, pH, stickness, water content, density, irritation on skin evaluation on variations in tobacco extract concentrations
IV	Observing tomato production of Pringgasela village farmer	P1	Designing formula of facial mask based on Tomato waste extract.	Presenting organoleptic, homogenity, spreadability, pH, stickness, water content, density, irritation on skin evaluation, and SPF data on variation of tomato waste extract concentration.
		P2	Designing formula of face toner based on Tomato waste extract.	
		P3	Designing formula of face maosturizer based on Tomato waste extract	
V	Observing Avocado Cultivation of Aik Bual village farmer	P1	Designing formula of peel off facial mask based on avocado waste extract.	Presenting organoleptic, homogenity, spreadability, pH, stickness, water content, density, irritation on skin evaluation, and SPF data on variation of avocado waste extract concentration.
		P2	Designing formula of facial mist based on avocado waste extract.	
		P3	Designing formula of body scrub based on avocado waste extract.	

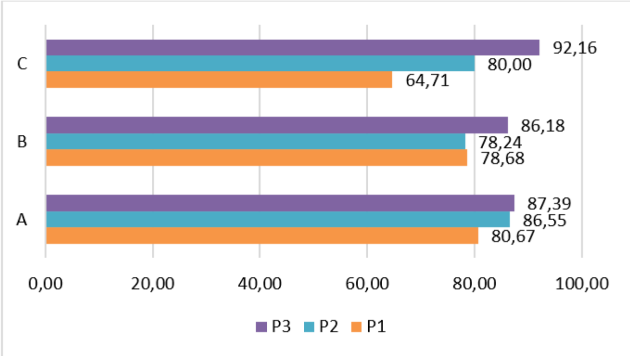

Figure 3 Student laboratory performance during (A) attempt direction; (B) designing and executing projects; and (C) discussion.

A particularly striking surge is observed in the context of discussion activities, with performance metrics of 64.71, 80.00, and 92.18 for the respective project learning sessions. This progression reflects a notable transition from good to excellent performance. During this phase, students are tasked with presenting their projects, articulating arguments in favor of their project's excellence, and critically assessing the environmental and social ramifications of their creations. This surge in performance underscores increasing confidence among students in presenting the outcomes of their experiments. Moreover, it signifies an evolving orientation toward innovative product outcomes and a heightened capacity to elucidate product development concepts and their broader positive impact on the economic and societal milieu. Discussion activities are also recognized for their potential to positively influence students' motivation and critical thinking skills in the realm of science education (Cholisoh et al., 2015). When underpinned by investment and inquiry experiences, such discussions have been shown to augment student motivation and enhance their perceptions of science learning (Gouvea et al., 2022; Hastuti et al., 2019; Rahayu et al., 2020; Sarwi et al., 2020).

Conversely, an intriguing observation emerges from the slight decline in project design and execution performance between the first and second project learning sessions, with average scores of 78.68 and 78.24, respectively, both within the "good" performance category. This decline can be attributed to students' initial challenges in formulating investigative plans that optimize laboratory equipment and measuring instruments effectively. The second project learning assignment, although theoretically less complex, posed a practical challenge because students struggled to harness laboratory resources optimally. Prior research has underscored the positive correlation between active engagement in practical laboratory activities and heightened motivation, as well as enhanced learning performance in science education (Ateş and Eryilmaz, 2011; Corter et al., 2011; Sesen and Tarhan, 2013; Shana and Abulibdeh, 2020).

3.2. Student Performance Improvement

The progression of science education has long been rooted in the pursuit of effective teaching methods that not only impart knowledge but also cultivate students' attitudes and aptitudes toward scientific inquiry. Within this context, the integration of ethnoscience-oriented learning, exemplified by the ethnoscience approach, represents a compelling and innovative pedagogical strategy. The empirical insights garnered from this study, as depicted in Figure 4, illuminate the transformative potential of this approach for student performance within the science education domain. By delving into the nuances of these findings and their relevance in both science and education, we can discern the broader implications of the ethnoscience-oriented learning approach in shaping the future of science education.

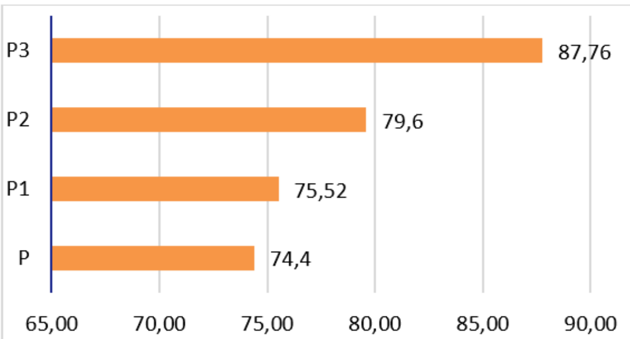

Figure 4 Student learning performance in previous experience and during ethnoscience-oriented learning at P1, P2, and P3.

Figure 4 vividly illustrates the trajectory of student performance as they engage with ethnoscience-oriented project learning across three successive stages. The discernible and commendable rise in student performance, transitioning from an initial score of 75.52 to 79.6 and ultimately culminating at 87.76, is a testament to the profound impact of this pedagogical approach. The consistent placement of student performance within the "excellence" category unequivocally highlights the efficacy of integrating ethnoscience into the learning framework. This increase in student performance can be attributed to various factors intrinsic to ethnoscience-oriented learning, including increased student engagement, heightened motivation, and a more profound connection to the subject matter. Notably, the ethnoscience approach has demonstrated its potential to enhance students' attitudes toward science learning (Fitria and Widi, 2015; Muliadi et al., 2022; Munandar et al., 2022).

Furthermore, students' enhanced performance extends across various dimensions of the learning process, encompassing attempt direction activities, project design and execution, and discussions during the learning sessions. However, it is imperative to underscore that the observed performance increases, when subjected to rigorous assessment through the N-gain technique, register within the "low" category, as elucidated in Figure 5. This assessment is conducted relative to students' initial performance, which serves as a benchmark for comparative analysis. The N-gain values associated with each project experience consistently indicate positive increases, albeit characterized by a "low" magnitude, with consecutive scores of 0.015, 0.070, and 0.181, respectively, relative to the baseline performance. These empirical outcomes collectively underscore the potential efficacy of pedagogical materials grounded in the ethnoscience of local natural pesticides, *aren* sugar (*gule beaq*), and *serbat* not only as a mechanism for enhancing student performance but also as a distinctive and impactful approach to science education.

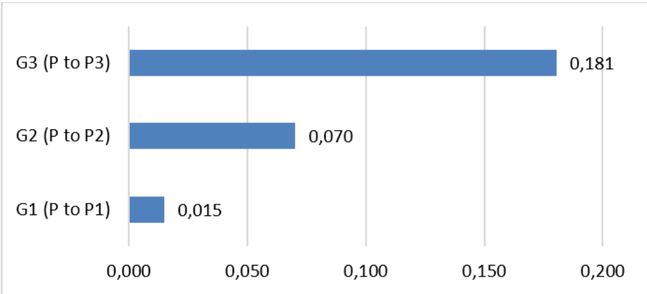

Figure 5 Student learning performance gain during ethnoscience-oriented learning in P1, P2, and P3 considering initial performance in previous learning experiences.

4. Discussion

One of the fundamental tenets of science education is to foster not only an understanding of scientific principles but also a deep-rooted appreciation for the scientific process itself. Ethnoscience-oriented learning introduces students to the rich tapestry of indigenous knowledge and its seamless integration with scientific inquiry. This approach encourages students to recognize that science is not an isolated discipline but an integral part of the cultural and societal fabric. It empowers students to appreciate the relevance of scientific concepts in everyday life, thereby fostering a more robust scientific mindset (Hastuti et al., 2019; Sarwi et al., 2020).

Moreover, the ethnoscience-oriented project approach has the potential to enhance students' attitudes toward science learning. The findings underscore that students exhibit more positive attitudes, a critical aspect of effective science education. This shift in attitude can be pivotal in igniting and sustaining students' interest in science, a factor known to significantly influence their performance. When students view science as relevant, engaging, and meaningful, they are more likely to invest themselves in the learning process, leading to improved outcomes.

In the broader landscape of science education, the integration of ethnoscience-oriented learning resonates with contemporary pedagogical trends that emphasize holistic and interdisciplinary approaches. Science is no longer confined to laboratory experiments and abstract theories; it is an ever-evolving entity that intersects with culture, society, and the environment. Ethnoscience bridges the gap between traditional knowledge and scientific exploration, illustrating how diverse cultures have developed their own sophisticated understanding of natural phenomena. This inclusivity enriches the educational experience, providing students with a more comprehensive view of science and its myriad applications (Dewi et al., 2021; Fasasi, 2017, 2017; Okechukwu et al., 2014).

The journey through ethnoscience-oriented project learning involves a series of phases, encompassing attempt direction activities, project design and execution, and discussions. These phases represent the multifaceted nature of scientific inquiry, from initial exploration and problem solving to the presentation and critical evaluation of findings. The positive trajectory in these dimensions of learning further reinforces the transformative potential of ethnoscience-oriented education.

A remarkable surge is observed in the context of discussion activities, with performance metrics reaching 64.71, 80.00, and 92.18 for the respective project sessions. This progression reflects a notable transition from a "good" to an "excellent" category of performance. In this phase, students present their projects, articulate arguments in favor of their project's excellence, and critically assess the environmental and social ramifications of their creations. This surge in performance underscores increasing confidence among students in presenting the outcomes of their experiments. Moreover, it signifies an evolving orientation toward innovative product outcomes and a heightened capacity to elucidate product development concepts and their broader positive impact on the economic and societal milieu.

Discussion activities, such as those integral to ethnoscience-oriented learning, are instrumental in increasing students' critical thinking skills. By engaging in robust discussions, students learn to analyze and evaluate scientific concepts, engage in constructive debate, and synthesize complex information. This not only deepens their understanding of science but also equips them with the skills necessary for effective problem-solving and decision-making in various contexts.

The ethnoscience-oriented project approach highlights the significance of culturally relevant and contextually grounded learning experiences. This approach recognizes that students' cultural backgrounds and experiences play a pivotal role in shaping their perspectives on science. By incorporating indigenous knowledge and cultural practices, educators can create a more inclusive and culturally sensitive learning environment (Dewi et al., 2019). This not only enhances students' sense of belonging but also empowers them to see themselves as active contributors to the scientific discourse.

In the realm of education, the ethnoscience-oriented project approach exemplifies the dynamic nature of pedagogical innovation. It challenges traditional notions of science education by demonstrating that learning can be immersive, culturally resonant, and socially impactful. This approach aligns with the broader goals of education, which include fostering critical thinking, nurturing a lifelong love of learning, and preparing students to be active and responsible citizens (Hikmawati et al., 2020; Kurniawan and Syafriani, 2021).

Furthermore, the findings elucidate the potential for ethnoscience-oriented learning to serve as a catalyst for improving science education on a broader scale. As educators and policymakers seek to reform science curricula and teaching methods, the ethnoscience-oriented project approach offers a compelling model. It shows how a contextualized and culturally relevant approach can not only enhance student performance but also reignite interest in science among students of diverse backgrounds (Fasasi, 2017; Hikmawati et al., 2020; Okechukwu et al., 2014).

A key takeaway from this study is the importance of sustained engagement and continuity in ethnoscience-oriented learning. While the observed performance improvements are notable, the low N-gain values suggest that the pedagogical approach requires further refinement. This could stem from students' initial unfamiliarity with the method, challenges in integrating indigenous knowledge with scientific content, or resource limitations. The successful implementation of ethnoscience-oriented learning also hinges on adequate laboratory facilities (Ariani and Hariyadi, 2024; Okwuobasi et al., 2024), access to culturally relevant teaching materials (Hikmawati et al., 2020; Kumalasari et al., 2021; Saro et al., 2023, 2022), and well-trained educators (Anwar and Muti'ah, 2022; Baptista and Araujo, 2019; Hikmawati et al., 2020; Kasi et al., 2022).

To address these challenges, targeted strategies are essential. First, professional development programs should equip teachers with the skills to integrate indigenous knowledge into science curricula effectively (Luft and Hewson, 2014; Penuel et al., 2007). Collaborative efforts among educational institutions, communities, and policymakers are needed to develop cost-effective, culturally relevant teaching materials and enhance laboratory facilities with simple, ethnoscience-compatible tools. Transitioning from a binary scoring system to a rubric-based assessment would allow for a more nuanced evaluation of student performance, capturing a broader spectrum of learning outcomes (Cornman et al., 2013; Hong and You, 2024).

Future studies should adopt experimental designs with control groups to better evaluate the intervention's impact compared to traditional methods. Expanding sample sizes and incorporating participants from diverse cultural and educational contexts would improve the generalizability of findings (Bordens and Abbott, 2018). Long-term implementation studies are also crucial to understanding how sustained exposure to ethnoscience-oriented learning influences students' conceptual understanding and critical thinking skills over time. These strategies could significantly enhance the scalability and effectiveness of ethnoscience-oriented learning, making it a robust model for culturally responsive science education (Kelder et al., 2003).

In conclusion, the integration of ethnoscience-oriented project learning, exemplified by the ethnoscience project approach, represents a transformative paradigm within science education. The empirical findings outlined in Figure 4 and Figure 5 not only underscore the positive impact on student performance but also emphasize the potential for enhanced attitudes and critical thinking skills. This pedagogical approach aligns with contemporary trends in education that prioritize interdisciplinary and culturally relevant learning experiences. It bridges the gap between traditional knowledge and scientific inquiry, enriching the educational journey for students (Dewi et al., 2019). Moreover, it has broader implications for science education reform, serving as a model for the development of culturally sensitive and contextually grounded curricula. As educators and researchers continue to explore the potential of ethnoscience-oriented learning, the future of science education holds promise for greater inclusivity, relevance, and impact.

5. Conclusions

The empirical investigations conducted throughout the course of this study yielded a consistent and progressive improvement in student performance over the span of three consecutive project learning sessions. This upward trajectory is substantiated by the attainment of mean performance scores, which incrementally escalated from 75.52 in the initial performance to 79.60 in the subsequent iteration, ultimately culminating at a noteworthy pinnacle of 87.76 in the final phase. Augmenting these empirical observations, the utilization of the N-gain technique to gauge student performance transformation revealed positive increases. While it is imperative to acknowledge that these increments were situated within the "low" category, the accumulation of consecutive N-gain scores of 0.015, 0.070, and 0.181 underscores the distinctive and promising capacity of implementing pedagogical materials underpinned by the ethnoscience of local natural pesticides, *gula aren*, and *serbat*. This pedagogical approach holds the potential to exert a profound and unique influence on enhancing student laboratory performance within the purview of science education, promising avenues for future exploration and refinement within the educational domain.

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Ethical considerations

Not applicable.

Conflict of Interest

The authors declare that they have no conflicts of interest.

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