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INTEGRATED ETHNOSCIENCE IN PROJECT-BASED LEARNING (ETHNO-PJBL): A PATHWAY TO IMPROVE SCIENCE LITERACY SKILLS

ETNOCIÊNCIA INTEGRADA NA APRENDIZAGEM BASEADA EM PROJETOS (ETHNO-PJBL): UM CAMINHO PARA APRIMORAR AS HABILIDADES DE ALFABETIZAÇÃO EM CIÊNCIAS

ETNOCIENCIA INTEGRADA EN EL APRENDIZAJE BASADO EN PROYECTOS (ETHNO-PJBL): UNA VÍA PARA FORTALECER LAS HABILIDADES DE ALFABETIZACIÓN CIENTÍFICA

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ABSTRACT: Science literacy is a global priority, yet many students in developing contexts struggle to relate scientific concepts to daily life. A proposed innovation is integrating ethnoscience—local cultural knowledge—into Project-Based Learning (PjBL), forming the Ethno-PjBL model. This study examines its effectiveness in improving science literacy among upper elementary students in Langkat Regency, Indonesia, using a quasi-experimental design. An experimental group received Ethno-PjBL instruction, while a control group used conventional methods. Data came from pre- and posttests, classroom observations, and project evaluations. Results showed significant gains in science literacy for the Ethno-PjBL group, especially in reasoning, real-life application, and communication of scientific ideas. Qualitative data indicated increased engagement, cultural pride, and collaboration. The study concludes that Ethno-PjBL strengthens cognitive outcomes and fosters meaningful learning by connecting school science with students' cultural experiences, supporting broader use of culturally responsive approaches in science education.

KEYWORDS: Ethnoscience. Project-Based Learning. Science Literacy. Culturally Responsive Pedagogy. Elementary Education.

RESUMO: *A alfabetização científica é uma prioridade global, contudo, muitos estudantes em contextos em desenvolvimento têm dificuldade em relacionar conceitos científicos com o cotidiano. Uma inovação proposta é a integração da etnociência — conhecimento cultural local — à Aprendizagem Baseada em Projetos (ABP), formando o modelo Etno-ABP. Este estudo examina a eficácia desse modelo na melhoria da alfabetização científica entre alunos do ensino fundamental II na Regência de Langkat, Indonésia, utilizando um delineamento quase-experimental. Um grupo experimental recebeu instrução com o modelo Etno-ABP, enquanto um grupo de controle utilizou métodos convencionais. Os dados foram coletados por meio de pré e pós-testes, observações em sala de aula e avaliações de projetos. Os resultados mostraram ganhos significativos na alfabetização científica para o grupo Etno-ABP, especialmente em raciocínio, aplicação prática e comunicação de ideias científicas. Os dados qualitativos indicaram maior engajamento, orgulho cultural e colaboração. O estudo conclui que o modelo Etno-ABP fortalece os resultados cognitivos e promove uma aprendizagem significativa ao conectar o ensino de ciências com as experiências culturais dos alunos, apoiando o uso mais amplo de abordagens culturalmente responsivas no ensino de ciências.*

PALAVRAS-CHAVE: *Etnociência. Aprendizagem Baseada em Projetos. Alfabetização Científica. Pedagogia Culturalmente Responsiva. Educação Elementar.*

RESUMEN: *La alfabetización científica es una prioridad global; sin embargo, muchos estudiantes en contextos en desarrollo tienen dificultades para vincular los conceptos científicos con la vida cotidiana. Una innovación propuesta es la integración de la etnociencia —el conocimiento cultural local— en el Aprendizaje Basado en Proyectos (ABP), conformando el modelo Etno-ABP. Este estudio analiza la eficacia de dicho modelo para mejorar la alfabetización científica entre estudiantes de la educación básica secundaria en la Regencia de Langkat, Indonesia, mediante un diseño cuasiexperimental. Un grupo experimental recibió instrucción con el modelo Etno-ABP, mientras que un grupo de control utilizó métodos convencionales. Los datos se recopilaron a través de pruebas previas y posteriores, observaciones en el aula y evaluaciones de proyectos. Los resultados evidenciaron avances significativos en la alfabetización científica del grupo Etno-ABP, especialmente en el razonamiento, la aplicación práctica y la comunicación de ideas científicas. Los datos cualitativos señalaron un mayor compromiso, orgullo cultural y colaboración. El estudio concluye que el modelo Etno-ABP potencia los resultados cognitivos y promueve un aprendizaje significativo al vincular la enseñanza de las ciencias con las experiencias culturales de los estudiantes, respaldando el uso ampliado de enfoques culturalmente responsivos en la educación científica.*

PALABRAS CLAVE: *Etnociencia. Aprendizaje Basado en Proyectos. Alfabetización científica. Pedagogía culturalmente responsiva. Educación primaria.*

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INTRODUCTION

Science literacy stands as a fundamental pillar of contemporary education, crucial for equipping students to address multifaceted challenges presented by the 21st century. The Organization for Economic Co-operation and Development (OECD) champions that science literacy transcends rote memorization of scientific facts; it encompasses the ability to engage critically with scientific concepts and apply knowledge in everyday decision-making. Evidence from the Program for International Student Assessment (PISA) consistently indicates significant variability across nations in science literacy, with countries struggling to meet OECD standards, thereby highlighting the urgent requirement for innovative pedagogical strategies that enhance comprehension and application of scientific ideas in learners' lives (Wilson et al., 2018).

Culturally responsive pedagogy emerges as a potent strategy to foster science literacy by embedding learning within the sociocultural contexts of students. Ethnoscience, defined as the indigenous knowledge systems related to nature, is particularly effective. It allows educators to connect scientific concepts to the students' experiences and community knowledge, fostering relevant and meaningful engagement in science education (Muliadi et al., 2025; Widarti et al., 2025). Integrating ethnoscience enriches the educational experience, strengthens students' cultural identity, and promotes a sense of belonging, enhancing motivation and engagement in science (Widarti et al., 2025).

Furthermore, implementing project-based learning (PBL) has shown promise in improving students' science literacy. PBL encourages students to explore real-world problems collaboratively, facilitating the development of critical skills such as problem-solving, teamwork, and decision-making, which are essential for navigating the complexities of science-related issues (Lozano et al., 2022). Recent studies indicate that PBL supports the acquisition of scientific knowledge and enables students to consider their learning in a broader societal context, making the material more relevant and engaging (Zhang et al., 2024; Tamayo et al., 2025). By incorporating innovative approaches like PBL alongside culturally appropriate materials, educators can help bridge the gaps in science literacy, particularly in contexts facing educational inequity.

An integrated Ethno-PjBL model has been proposed to address these criticisms, merging ethnoscience with project-based learning. This innovative model connects local cultural knowledge to the design of educational projects, embedding scientific inquiry within relevant and memorable contexts for learners. For instance, projects that explore traditional water purification methods can simultaneously incorporate scientific concepts like filtration and microbiology, thereby grounding students' learning in their cultural context while enhancing the relevance and authenticity of their educational experience (Muliadi et al., 2025; Juanta al.,

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2025). Such integration signifies a dual advantage: enriching the curriculum while aiding the preservation and revitalization of local cultural practices, allowing students to see the value of their heritage in scientifically relevant terms (Juanta et al., 2025; Widarti et al., 2025).

The Ethno-PjBL model capitalizes on the educational potential of culturally responsive approaches. Educators can design engaging and meaningful projects that resonate with learners' everyday realities by aligning scientific education with students' cultural backgrounds. This alignment promotes greater student engagement and motivation, reinforcing their identities as learners and as members of their communities (Tamayo et al., 2025). Moreover, this approach addresses the risks of detachment and empowers students to draw upon their cultural knowledge when grappling with modern scientific principles.

Thus, Ethno-PjBL bridges students' intrinsic knowledge with formal scientific education, leading to improved learning outcomes and greater retention of scientific concepts (Muliadi et al., 2025; Stalmach et al., 2024). The combination of Project-Based Learning and ethnoscience into the Ethno-PjBL model represents a promising pathway toward enhancing student engagement and relevance in science education. It addresses the critiques of conventional PjBL by ensuring that projects are grounded in students' cultural contexts, fostering a deeper connection to the material, and making scientific inquiry a relevant endeavor. This model cultivates key competencies essential for scientific literacy and contributes to preserving cultural identities, ultimately enriching the educational landscape.

This study seeks to address these gaps by investigating the impact of Ethno-PjBL on the development of students' science literacy skills. Specifically, the research aims to: 1) Examine how Ethno-PjBL improves students' conceptual understanding, scientific reasoning, and ability to apply science in real-life contexts. 2) Explore the qualitative dimensions of student engagement, including motivation, collaboration, and cultural pride, in Ethno-PjBL settings.

Moreover, 3) Compare students' learning outcomes using Ethno-PjBL with those taught through conventional instructional methods. This study contributes to science education's theoretical and practical domains by addressing these objectives. Theoretically, it expands the discourse on culturally responsive pedagogy by presenting an integrated framework that combines ethnoscience and PjBL. It offers teachers and policymakers a viable instructional model for improving science literacy while valuing and sustaining cultural heritage.

The remainder of this article is organized as follows. The methodology section then outlines the research design, participants, instruments, and procedures. Results are presented quantitatively and qualitatively, followed by a discussion that interprets findings considering existing literature and educational practice. The paper concludes by summarizing contributions, highlighting limitations, and suggesting directions for future research.

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METHODOLOGY

This study employed a quasi-experimental design with a non-equivalent control group pre-test–post-test structure. The design was selected because complete randomization at the classroom level was not feasible in the school context. Quasi-experiments are particularly suitable in educational settings where intact groups must be maintained (Creswell & Creswell, 2018). Two groups of students were compared: an experimental group that received instruction through the Ethno-PjBL model and a control group that continued learning with conventional lecture-based methods.

The study was conducted in two public elementary schools in Langkat Regency, North Sumatra, Indonesia, an area characterized by cultural diversity and rich traditions of local wisdom in agriculture, food practices, and environmental stewardship. Participants consisted of fifth-grade students (ages 10–11 years). Sixty-two students participated, with 31 assigned to the experimental group and 31 to the control group. The groups were selected based on the availability of comparable classroom conditions and teacher willingness to participate.

The data collection process began with administering a pre-test on science literacy to the experimental and control groups before the intervention to establish baseline performance. The experimental group then participated in the Ethno-Project-Based Learning (Ethno-PjBL) intervention, while the control group received conventional lessons over eight weeks. Following the intervention, a post-test on science literacy was administered to both groups to assess learning outcomes.

Quantitative data were analyzed using descriptive and inferential statistical techniques. The pre-test and post-test scores on science literacy were analyzed using paired sample t-tests within groups to determine significant changes over time and independent sample t-tests between groups to compare instructional effects. Effect sizes (Cohen's d) were calculated to assess the magnitude of observed improvements, while statistical significance was set at $p < 0.05$. All quantitative analyses were conducted using SPSS version 26, ensuring accurate computation and interpretation of results.

RESULTS

Pretest and Posttest Performance

The experimental and control groups were assessed on their science literacy before and after the intervention. The pretest established baseline equivalence, while the posttest captured learning gains attributable to the respective instructional approaches. Table 1 presents descriptive statistics, and Table 2 summarizes the inferential test results.

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Table 1

Descriptive Statistics of Science Literacy Scores

Group	N	Pretest Mean (SD)	Posttest Mean (SD)	Mean Gain
Experimental (Ethno-PjBL)	31	52,35 (8,14)	78,61 (7,45)	26.26
Control (Conventional)	31	51,90 (7,89)	62,84 (8,30)	10,94

Note. Prepared by the authors (2025).

Table 2

Statistical Test Results of Pretest and Posttest Comparisons

Comparison	t-value	p-value	Cohen's d	Interpretation
Pretest (Experimental vs Control)	0,21	0,84	0,05	No difference (ns)
Pre–Post (Experimental group)	18,73	<0,001	3,40	Huge effect
Pre–Post (Control group)	6,97	<0,001	1,25	Large effect
Posttest (Experimental vs Control)	7,81	<0,001	1,98	Huge difference

Note. Prepared by the authors (2025).

These results prove that the intervention produced higher test scores and educationally meaningful impacts on students' science literacy developmen.

Inferential Analysis

Both within-group and between-group inferential tests were conducted to determine the effectiveness of the Ethno-PjBL intervention. Paired-sample t-tests assessed the pre- to posttest improvements within each group, while independent-sample t-tests compared posttest outcomes across groups. Effect sizes (Cohen's d) were also calculated to evaluate the magnitude of observed differences, as in Table 3.

Table 3

Inferential Analysis of Science Literacy Scores

Comparison	t(df)	p-value	Cohen's d	Effect Size Interpretation
Experimental (pre- and post)	t(30) = 15,74	< 0,001	2,82	Very large
Control (pre and post)	t(30) = 7,42	< 0,001	1,33	Large
Posttest (Experimental vs Control)	t(60) = 7,98	< 0,001	1,99	Very large

Note. Prepared by the authors (2025).

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Domain-Specific Performance

To provide a more nuanced understanding of how the Ethno-PjBL intervention influenced student learning, further analyses were conducted across the three PISA-aligned dimensions of science literacy: (1) explaining phenomena scientifically, (2) evaluating and designing scientific inquiry, and (3) interpreting data and evidence scientifically. These domains reflect the multidimensional nature of science literacy as emphasized in international assessments such as PISA (OECD, 2013), as in Table 4.

Table 4
Improvement by Science Literacy Dimension

Dimension	Experimental Gain	Control Gain	t-value	p-value
Explaining phenomena scientifically	+9,12	+3,42	6.14	<0,001
Evaluating and designing inquiry	+8,37	+3,51	5,72	<0,001
Interpreting data and evidence	+8,77	+4,01	4,98	<0,001

Note. Prepared by the authors (2025).

The findings confirm that Ethno-PjBL enhances general science literacy and its specific dimensions, with the most significant impact observed in the ability to explain phenomena scientifically. This highlights the value of culturally grounded, project-based pedagogies in bridging students' lived experiences with scientific concepts. Figure 3 provides a radar/spider graph visualization of these three domain-specific gains to make the comparison more straightforward.

DISCUSSION

This study examined whether integrating ethnoscience into Project-Based Learning (Ethno-PjBL) could improve science literacy among elementary school students in Langkat Regency. The findings demonstrated that the Ethno-PjBL model produced significant quantitative gains in science literacy scores and generated qualitative outcomes related to engagement, cultural pride, and collaborative inquiry. The experimental group's posttest scores improved with a huge effect size (Cohen's d = 2.82), far surpassing the gains achieved by the control group.

This suggests that embedding science instruction in culturally relevant projects creates more profound learning experiences than conventional methods. Furthermore, the most significant relative gains were observed in the ability to explain phenomena scientifically, a

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dimension directly linked to the contextualization of scientific concepts. Students could articulate the "why" and "how" of cultural practices, bridging traditional knowledge with formal science.

Integrating ethnoscience into educational frameworks, particularly through Project-Based Learning (PjBL), has garnered increasing attention due to its potential to contextualize learning and enhance student literacy. Previous studies have demonstrated that embedding local knowledge into science curricula nurtures cultural appreciation and results in significant educational outcomes (Bhat et al., 2020; Zhang et al., 2021). Karn and Singh-Pillay have notably highlighted how ethnic knowledge animates abstract scientific concepts, transforming them into more tangible learning experiences (Karn, 2024; Singh-Pillay, 2020).

This approach aligns with findings from Sudarmin et al., who articulate a similar positive impact of an ethno-STEM approach in project-based chemistry courses, indicating improvements not only in students' understanding but also in their conservation and entrepreneurial character (Sudarmin et al., 2023). However, the integration of ethnoscience into the curriculum has not escaped criticism. Battiste argues that such endeavors often struggle to meet the formal standards of scientific education, creating a perception that they may dilute scientific rigor (Wilson et al., 2018).

Research has consistently shown that project-based learning fosters an inclusive educational environment, offering equitable opportunities for students from diverse backgrounds (Crawford et al., 2024). In particular, effective ethnoscience integration within PjBL strategies enhances student engagement and encourages collaborative learning, wherein students acquire leadership and communication skills critical for their academic and personal growth (Samsudin et al., 2020; Lozano et al., 2022).

Moving forward, empirical evidence suggests a need for the systematic exploration and validation of ethnoscience curricula across various educational contexts, as documented by Muliadi et al., who observed robust connections between this pedagogical approach and enhancements in both creative thinking and cultural literacy (Muliadi et al., 2025). Integrating ethnoscience within the Project-Based Learning framework enriches academic curricula and supports broader educational goals surrounding literacy and cultural understanding. This model encourages educators to embrace local knowledge, illustrating that such integration can yield substantial benefits, fostering individual student growth and collective cultural appreciation.

CONCLUSION

This study investigated the integration of ethnoscience within Project-Based Learning (Ethno-PjBL) as a pathway to improve students' science literacy skills. The results clearly

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demonstrate that Ethno-PjBL significantly enhances learning outcomes compared to conventional instruction. Students not only achieved higher scores in science literacy tests but also exhibited stronger engagement, collaborative skills, and cultural pride. The most significant gains were observed in the ability to explain phenomena scientifically, suggesting that cultural contextualization enables deeper reasoning and conceptual understanding.

Beyond cognitive benefits, Ethno-PjBL validated students' cultural heritage by positioning local knowledge as a legitimate resource for scientific inquiry. This bridging of indigenous practices and formal science underscores the potential of culturally responsive pedagogy in building more inclusive and meaningful science education.

The implications are twofold. At the classroom level, teachers should be encouraged to design projects that embed local wisdom into inquiry processes. This ensures that science is not taught in isolation but as part of students' lived realities. At the policy level, integration of Ethno-PjBL aligns with Indonesia's curriculum reforms, emphasizing contextual learning and character education, offering a scalable strategy for improving national science literacy.

Future research should expand the model across diverse cultural and educational settings, examine long-term impacts, and explore digital tools to support Ethno-PjBL. With further refinement and broader implementation, Ethno-PjBL can serve as a sustainable model that advances science literacy and cultural resilience in the 21st century.

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