Indonesian Society for Science Educators

Journal of Science Learning

journal homepage: ejournal.upi.edu/index.php/jslearning

Project-Based Ethnoscience Learning: Elevating Scientific Literacy and Communication through Nutrient Analysis of *'Jadah Tempe'*

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ABSTRACT The integration of ethnoscience in Project-Based Learning (PjBL) offers an innovative approach to linking science with local cultural contexts, such as traditional food, like *Jadah Tempe*. The purpose of this study was to determine the differences and influence between the application of the PjBL model with ethnoscience content on traditional food, *Jadah Tempe*, and the Direct Instruction model on students' scientific literacy and communication skills. This type of research is quasi-experimental, employing a research design in the form of a non-equivalent control group design. The research was conducted over three months, involving 62 grade VIII students from a junior high school in Sleman, Indonesia. Data collection employed pretest-posttest instruments that assessed scientific literacy, as well as observation sheets that evaluated communication skills. MANOVA analysis revealed significant differences between classes (Sig. < 0.05), with a strong influence of PjBL on the ethnoscience content of traditional food *Jadah Tempe*, affecting scientific literacy and communication skills (partial eta squared = 0.952). These findings underscore the importance of cultural integration and the development of 21st-century skills, thereby supporting the creation of more inclusive and relevant curricula. However, its generalizability may have limitations; therefore, future research should examine the adaptation of this model to other traditional knowledge themes.

Keywords: Communication, Ethnoscience, Nutrient analysis, Project-based learning, Scientific literacy, Traditional food

1. INTRODUCTION

In the 21st century, the education sector faces increasing demands to foster students' 21st-century skills, helping them adapt to emerging challenges. However, studies continue to reveal that many students still lack these essential skills, particularly in communication. This issue is often rooted in teacher-centered learning approaches, which limit students' opportunities to express their ideas and engage in meaningful dialogue. Moreover, there is a lack of emphasis on scientific processes during instruction, especially those that develop communication skills (Nofianti, 2019; Sintiawati et al., 2021). The deficiency in communication skills not only hinders students' ability to articulate their thoughts but also negatively impacts their scientific literacy, as it impedes the exchange of new ideas and scientific concepts (Li & Guo, 2021). Indonesia's low performance in scientific literacy is further evidenced by the 2022 PISA Results (Volume I), which showed a decline in scores compared to 2018, with average scores falling below the international mean. This score places Indonesia in the 12th lowest rank, or 69 out of 80 countries registered in the 2022 PISA assessment (OECD, 2023).

The issues related to students' low communication skills and scientific literacy have led to a growing interest in research on the implementation of innovative 21st-century learning models. Many recent studies have shifted toward student-centered approaches. One such approach is Project-Based Learning (PjBL), a model that engages students in solving problems collaboratively or independently through scientific processes in the creation of a project (Wulandari, 2021). Research on the impact of PjBL has been conducted separately about communication and scientific literacy skills. These studies have shown that PjBL has a significant positive influence on students' communication skills (Liao et al., 2023) as well as on their scientific literacy (Juleha et al., 2019; Munawaroh & Rusilowati, 2018). However, several challenges have also been identified in implementing PjBL. Some students find the problems presented in the projects too complex to solve (Dwiantoro & Basuki, 2021), and others demonstrate inadequate presentation skills due to a limited understanding of the projects they are working on (Saenab et al., 2018).

Received: 17 April 2025
Revised: 28 May 2025
Published: 30 June 2025

These challenges have encouraged further innovation by integrating ethnoscience approaches into various science learning models, including Project-Based Learning (PjBL). Ethnoscience is an interdisciplinary field that combines community-based knowledge with scientific learning (Idul & Fajardo, 2023). The ethnoscience approach bridges cultural knowledge with scientific concepts, making science learning more contextual and relevant to students' everyday lives (Asra & Akmal, 2021; Dewi et al., 2023). This is the main principle in ethnoscience learning. Ethnoscience makes abstract concepts more contextualized and meaningful by making community knowledge the central theme of learning (Prayogi et al., 2023). Studies on the integration of ethnoscience into PjBL have shown significant improvements in students' scientific literacy (Hidayah et al., 2024; Rusmansyah et al., 2023). However, research investigating its impact on students' communication skills remains limited.

Additionally, the use of traditional foods—such as *jadah tempe*—as a medium for ethnoscience integration in science education is still underexplored. The general integration of ethnoscience into learning has been shown to enhance both communication skills through culturally-based discussions and contextual group work (Pertiwi & Firdausi, 2019) and scientific literacy through a local perspective closely related to their daily lives (Hasanah et al., 2024; Rizaldi et al., 2021). This also serves as a rationale for integrating ethnoscience with project-based learning models, which emphasize active student engagement in exploring, designing, and solving real-world problems relevant to their cultural and environmental contexts (Sumarni et al., 2023).

One promising form of ethnoscience that can serve as a contextual basis for science learning is traditional food, such as Javanese tempeh. *Jadah Tempe* is a traditional Indonesian dish that combines two main components: *Jadah* (a type of sticky rice cake) and *Tempe bacem* (sweet marinated tempeh). This traditional food is made from a variety of ingredients that make it rich in nutrients. In addition to its nutritional value, *Jadah Tempe* is recognized for its ability to provide a sense of fullness and help maintain body warmth, particularly in colder climates. The preparation process of *Jadah Tempe*, documented photographically in Figure 1, illustrates its cultural significance and provides a concrete link between traditional practices and scientific inquiry.

Utilizing *Jadah Tempe* as an ethnoscientific context in science learning encourages students to investigate the food's nutrient content and functions and to assess whether it can meet the nutritional needs of adolescents. This activity guides students in connecting scientific concepts to their everyday lives. Integrating ethnoscience into project-based learning allows students to apply the knowledge they acquire to solve real-world problems

Figure 1 *Jadah Tempe* preparation process

Figure 2 *Jadah Tempe* showcases its layered composition of sticky rice (*jadah*) and marinated tempeh (*bacem*)

presented in the project. Figure 2 shows the distinctive layered structure of *Jadah Tempe*.

In this learning process, students are required to conduct in-depth literature research on *Jadah Tempe* and to share their findings through collaborative communication within their teams. Such activities foster both scientific literacy and communication skills, as students are actively engaged in inquiry, analysis, and team discussions throughout the project. Based on the research gaps identified in previous studies, this study proposes a novel experimental approach by implementing a PjBL model integrated with ethnoscience content derived from the traditional food *Jadah Tempe*, which holds strong potential for teaching the nutrient content of food.

Research on communication skills in science learning has shown that this ability is a fundamental component in developing scientific literacy. According to Mantau and Talango (2023), practical communication skills enable students to gain a deep understanding of scientific concepts, collaborate in problem-solving, and clearly articulate scientific ideas. These findings are supported by Putri et al. (2020), who stated that a learning environment that encourages active communication can enhance students' conceptual understanding by 40% compared to conventional methods. In the context of scientific literacy, a study by Pratiwi (2020) revealed that integrating real-life contexts through an ethnoscience approach can improve students' ability to explain scientific phenomena by 35%. This finding aligns with the research of Hidayanti and Wulandari (2023), which found that ethnoscience-based learning not only enhances conceptual understanding but also develops students' abilities to evaluate scientific evidence and make science-based decisions.

The PjBL model has been proven effective in fostering various 21st-century skills. Research by Astri et al. (2022) indicated that PjBL enhances students' collaboration and communication skills by 28% through project activities based on real-world problems. Additionally, PjBL has been shown to significantly improve students' problem-solving skills by encouraging independent inquiry, critical thinking, and the application of knowledge to authentic contexts (Kartini et al., 2021). Furthermore, PjBL strengthens scientific and information literacy, enabling students to search for, assess, and apply scientific information effectively during the learning process (Juleha et al., 2019). Similar findings were reported by Kamariah et al. (2023), who found a significant increase in students' scientific literacy when Problem-Based Learning (PBL) was integrated with local contexts.

Research conducted by Setiawan et al. (2023) demonstrates that the application of ethnoscience in PjBL can reduce misconceptions in understanding learning concepts, thereby improving scientific literacy. The integration of ethnoscience into PjBL presents a synergistic potential for science learning. Refine et al. (2023) found that students' oral communication skills improved through local cultural discussion activities. Research by Wally et al. (2024) demonstrated that combining PjBL with ethnoscience not only enhances communication skills but also fosters students' creative thinking. Previous studies on ethnoscience in science education by (Dewi et al., 2023 and Rizaldi et al., 2021) have identified several research gaps, including (1) limited exploration of traditional foods as ethnoscience contexts, (2) a lack of studies measuring the simultaneous impact on both scientific literacy and communication skills, and (3) the need for instructional models aligned with the curriculum.

Various studies on the application of ethnoscience in PjBL have yielded positive results, improving communication skills and scientific literacy. However, there has been no research related to the collaboration between ethnoscience and PjBL in addressing communication skills and scientific literacy simultaneously, especially in traditional food ethnoscience. Therefore, this study is designed to address these gaps through an innovative approach to the PjBL model, incorporating ethnoscience content related to traditional food, namely *Jadah Tempe*. The objective of this study was to (1) examine the differences in communication skills and scientific literacy between the PjBL model integrated with ethnoscience of traditional food *Jadah Tempe*, as well as (2) to determine the specific effect of this model on students' communication skills and scientific literacy.

2. METHOD

2.1 Research Design

The study's implementation employed a quasi-experimental design, as randomization was not feasible due to limitations in the school setting (Miller et al., 2020). The research implementation process is shown in Figure 3.

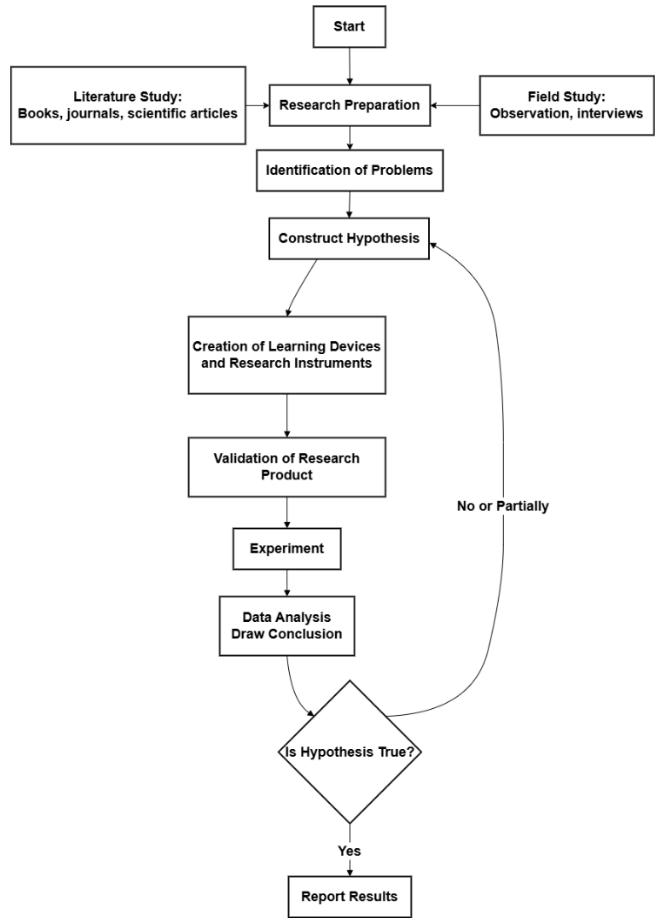

Figure 3 Research flowchart

The research design employed was a Non-Equivalent Control Group Design. This design, also known as the non-equivalent pretest-posttest control-group design, is included in one of the quasi-experiments by determining the experimental group and control group without randomization. The implementation procedure begins with administering a pretest to both classes, assigning treatment and control groups, and concludes with a post-test (Bulus, 2021). Before receiving treatment, the experimental class and control class were given pretest questions to assess their initial levels of communication skills and scientific literacy. After the pretest, the experimental class received treatment, namely learning using the ethnoscience-based PjBL model, while the control class used the direct instruction model, which was procedural and structured. After that, the experimental class and control class were given a post-test to determine the difference and effect of the results between the two treatments. The research design as shown in Table 1.

Table 1 Research design

Group	Pretest	Treatment	Post-Test
Experiment	Pretest	Ethno-PjBL	Post-test
Control	Pretest	Direct Instruction	Post-test

2.2 Research Participants

The research participants consisted of 62 eighth-grade students, divided into 31 students from the experimental class and 31 students from the control class. The participants were selected from a population of 126 grade VIII students from public junior high schools in Sleman, Indonesia, using a purposive sampling technique. This technique was employed because it aligns with the principles of the Non-Equivalent Control Group Design, which does not randomly select its participants. A purposive sampling technique was employed to select participants based on specific criteria relevant to the study's objectives (Thomas, 2022). The sample selection was obtained based on the educator's consideration with several criteria, including (1) the same average science score ($\Delta < 0.11\%$), (2) having never been taught the ethnoscience-integrated PjbL model before, and (3) equal class dynamics (about classroom climate, interaction between students, and response to teaching methods). Demographic data showed a balanced gender distribution (53% students and 47% male) with an age range of 13-14 years.

2.3 Hypothesis

This study introduces three innovative elements: (1) the use of *Jadah Tempe*, a culturally familiar traditional food rich in nutritional science content, as a contextual foundation for PjBL; (2) the simultaneous measurement of scientific literacy and communication skills using Multivariate Analysis of Variance (MANOVA); and (3) the development of a replicable instructional model for ethnoscience integration within Indonesia's Curriculum framework. Therefore, it is essential to examine the effect of implementing an ethnoscience-integrated PjBL model based on traditional food (*Jadah Tempe*) in science learning and its actual impact on students' scientific literacy and communication skills. Based on this rationale, the following research hypothesis is proposed:

1. H_0: There is no significant difference in students' scientific literacy and communication skills between those taught using the ethnoscience-integrated PjBL model based on traditional food and those taught using the direct instruction model on the topic of nutrient content in food. H_1: There is a significant difference in students' scientific literacy and communication skills between those taught using the ethnoscience-integrated PjBL model based on traditional food and those taught using the direct instruction model on the topic of nutrient content in food.
2. H_0: The ethnoscience-integrated PjBL learning model, based on the traditional food *Jadah Tempe*, has no significant effect on students' scientific literacy and communication skills regarding the topic of nutrient content in food. H_1: The ethnoscience-integrated PjBL learning model, based on the traditional food *Jadah Tempe*, has a significant effect on students' scientific literacy and communication skills regarding the topic of nutrient content in food.

2.4 Data Analysis

The impact of implementing PjBL integrated with the ethnoscience of traditional food *Jadah Tempe* on students' scientific literacy and communication skills was assessed using two data collection techniques: testing and observation. The level of students' scientific literacy was assessed from the increase in pretest–post-test scores. Students' communication skills were assessed through the discussion and presentation groups during the learning process, guided by observation sheets. The assessment was based on individual performance within the group. The instruments employed in this study included the following.

Pre-test and Post-test

The data collection technique, which involved testing, was conducted using pre- and post-test multiple-choice questions to measure students' scientific literacy. The research test indicator uses one aspect of the PISA 2018 scientific literacy framework, namely 'competence.' The three aspects —context, knowledge, and competence—are interconnected. The 'context' aspect requires individuals to be able to bring up the 'competence' aspect as well as the 'knowledge' aspect, which is influenced by the 'competence' aspect because, without the 'competence' aspect, the 'knowledge' aspect has no application (OECD, 2019). Then, the scientific literacy test indicator is summarized in 20 validated multiple-choice items (selected from an initial pool of 30 questions) that covered three core competencies from the 'competence' aspect: (1) explaining scientific phenomena, (2) evaluating scientific inquiry, and (3) interpreting scientific data.

The initial draft of the instrument consisted of 30 items. The instrument underwent empirical validation, including validity testing, reliability analysis, and calculation of the item discrimination index. The empirical validation process involved 122 ninth-grade students who had previously studied the topic of food nutrient content. Data analysis was conducted using the QUEST program, resulting in 20 items that were included in the good category, with a reliability estimate value of 0.85. Items categorized as 'good' are evaluated for suitability using the Rasch model and item difficulty index. A reliability value of $0.80 < rxy < 1.$ is considered high-quality and suitable for use (Guilford, 1956; Raymond & Siek-Toon, 1996). The test blueprint for both the pretest and post-test is presented in Table 2.

Table 3 Blueprint of scientific literacy test before & after validation

Aspect	Indicator	Number of Items	
		Before	After
Competency	Explaining scientific phenomena	15	8
	Evaluating and designing scientific investigations	8	7
	Interpreting data and scientific evidence	7	5

Table 2 Aspects and indicators of communication skills assessed through observation

Aspect	Indicator	Number of Items
Oral Communication	Eye contact	4
	Delivery of information	5
	Asking or responding	5
	Understanding of content	5
	Use of language	5
Written Communication	Completeness of data	5
	Analysis and conclusion	5
	Neatness and presentation	5

Communication Skills Observation Sheet

The observation technique was conducted using an observation sheet to assess students' communication skills, which was completed by four observers during the learning activities. Each observer observes the communication skills of 8 students. The final value of students' communication skills was obtained by averaging the values from three meetings. The instruments used were the results of researcher development that had gone through a validation stape by learning experts. The instrument covered both oral and written aspects. The indicators of communication skills assessed are presented in Table 3.

2.5 Materials

The implementation of the PjBL model, integrated with the ethnoscience of the traditional food, *Jadah Tempe*, in this study, was supported by various instructional materials. In addition to the assessment instruments used for data collection, the study employed a teaching module, student handout, and student worksheets. The teaching module functioned as a guide for delivering the learning content, which focused on the topic of nutrient content in food and was explicitly designed to integrate ethnoscientific elements into science education through the PjBL model. The handout explicitly presented the nutritional breakdown of *Jadah Tempe*'s components, enabling students to analyze traditional knowledge through scientific lenses in a quantitative manner. Figures 4-7 provides a detailed nutritional breakdown of *Jadah Tempe*'s components, highlighting how traditional ingredients contribute to its scientific analysis. Information about the nutrient content was obtained from the Fatsecret website.

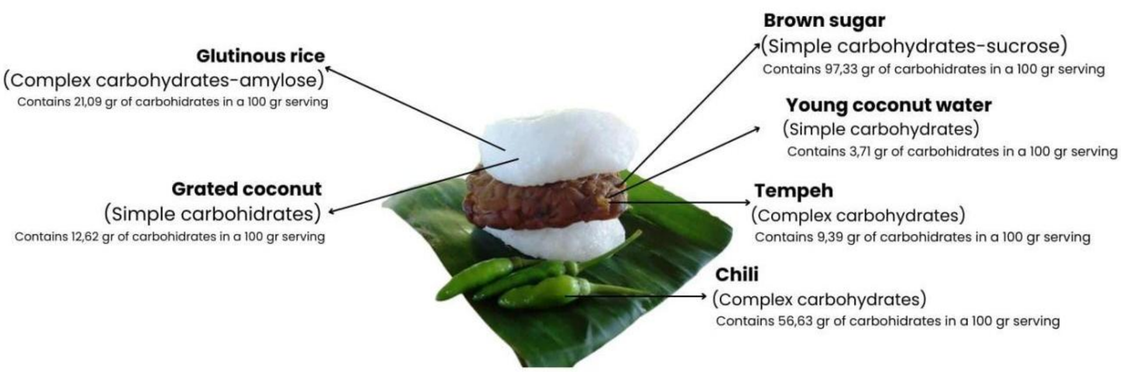

Figure 4 Carbohydrate composition of *Jadah Tempe* ingredients

Figure 5 Vitamin composition of *Jadah Tempe* ingredients

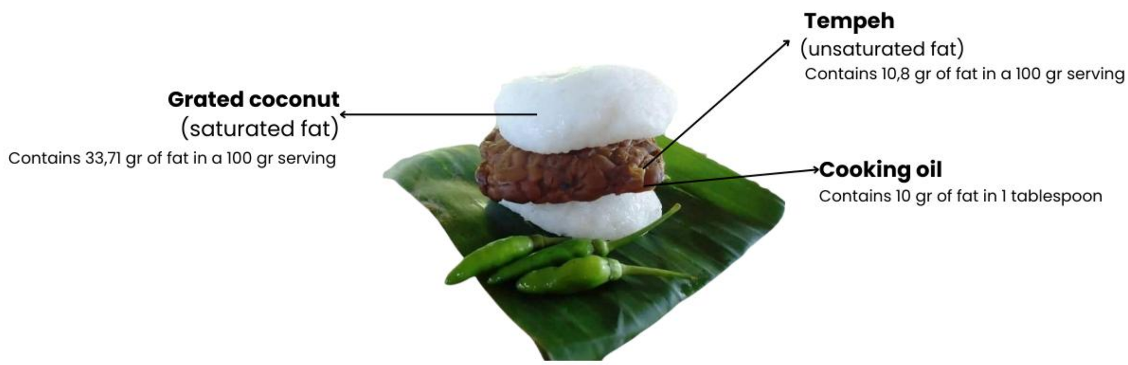

Figure 6 The fat composition of *Jadah Tempe* ingredients

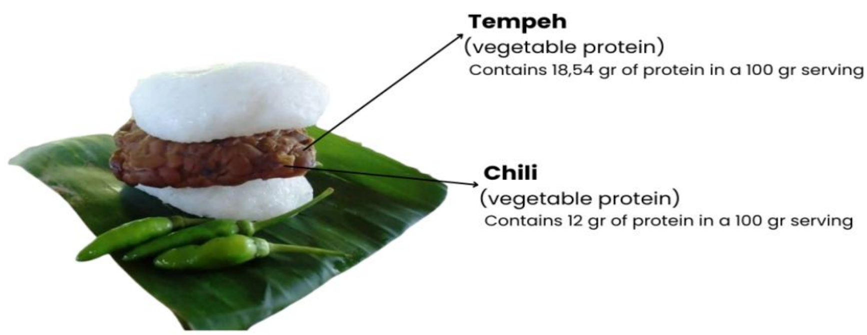

Figure 7 Protein composition of *Jadah Tempe* ingredients

The learning process utilized the student worksheet and handout as primary media. The student worksheet contained a series of activities aligned with the steps of the ethnoscience-integrated PjBL model, including formulating essential questions based on the ethnoscientific context of *Jadah Tempe*, designing an innovative project related to *Jadah Tempe*, developing a project implementation schedule, monitoring students and their project progress, assessing the outcomes of the *Jadah Tempe* innovation projects, and conducting reflections on their learning experiences. These learning steps are the result of an adaptation of the PjBL framework by (Markham et al., 2009). Meanwhile, the handout provided comprehensive information about the nutrient content of food, including definitions, classifications, functions, examples, and testing procedures. The examples were contextualized using *Jadah Tempe* to make the material more relatable and easier for students to understand. The handout also served as a key reference during the completion of worksheet activities.

2.6 Procedure

The learning process in this study was conducted over five meetings. During these sessions, several activities were carried out, starting from the administration of the pretest, followed by the implementation of the learning process across three meetings, and concluding with the post-test. The learning process was conducted in groups, with a total of 8 groups, each comprising four students. The determination of the group is determined based on the proximity of the residence to facilitate the creation of the *Jadah Tempe* innovation project. The stages and learning activities conducted throughout these meetings are described in Table 4.

Table 4 Learning phases and activities

Phase & Step	Activity Description	Time (Duration)
Pretest	Assessing students' initial scientific literacy and communication skills.	80 minutes
Session 1: Concept Exploration of *Jadah Tempe*	Students observe a case presented in the worksheet, answer discussion questions to construct concepts on nutrient content in food and formulate problems.	80 minutes
Session 2: Project Planning	Students design the innovation project and create a project timeline.	80 minutes
Session 3: Experimentation, Presentation, and Evaluation	Students conduct nutrient content tests (starch, glucose, protein, and fat) on their *Jadah Tempe* product, present the project and test results, and evaluate the project implementation.	80 minutes
Post-Test	Assessing students' final scientific literacy and communication skills.	80 minutes

3. RESULT AND DISCUSSION

3.1 Difference of Scientific Literacy and Communication Skills

Scientific Literacy Skill

One of the sample criteria in this study was having the same average science score. Based on the analysis results, the initial data on science literacy from the experimental group and the control group showed homogeneous averages (Sig. > 0.05), as evidenced in Table 5.

Table 5 t-Test for equality of science literacy score averages

	t	df	Sig.	Mean Difference	Std. Error Difference
Equal variances assumed	.000	62	1.000	.000	3.520

Based on the study's results, the data analysis outcomes for the three scientific literacy competence indicators—explaining phenomena scientifically, evaluating and designing scientific inquiry, and interpreting data and scientific evidence—are presented in Table 6.

Table 6 Scientific literacy skill scores of the experimental and control classes

Indicator	Experiment		Control	
	Pre Score	Post Score	Pre Score	Post Score
Explaining scientific phenomena	41.80	87.89	38.28	74.22
Evaluating and designing scientific investigations	32.14	88.39	40.18	74.11
Interpreting data and scientific evidence	34.38	85.63	28.75	78.75
N-Gain	0.80		0.59	
Category	High		Moderate	

The experimental group showed a 56% increase in scientific literacy (Table 5), particularly in the indicator of "evaluating and designing scientific inquiry" (post-test score of 88.39 vs. 74.11), as learning activities related to this indicator were more dominant compared to others. However, improvements across all three indicators in the experimental class outperformed the control class, with an overall N-Gain of 0.80. These findings suggest that the ethnoscience-PjBL model using the traditional food *Jadah Tempe* is more effective in enhancing students' scientific literacy skills than the direct instruction model. According to Sari et al. (2023), learning that integrates ethnoscience through models such as project-based learning can support the development of various scientific skills, with the most significant improvement observed in scientific literacy. The average gains for each of the three indicators are presented in the N-Gain values shown in Figure 8.

Based on Figure 8, the N-Gain scores for all three indicators of scientific literacy in the experimental group showed a more significant increase compared to the control group. This significant improvement across all indicators demonstrates that the ethnoscience-PjBL activities centered on the traditional food, *Jadah Tempe*, were more effective in enhancing students' scientific literacy. According to Mones et al. (2023), the PjBL model facilitates the implementation of learning through structured stages, which can effectively achieve learning objectives. Khotimah et al. (2020) state that the focus of PjBL lies in both theoretical inquiry and practical application through the development of group-based projects, which encourages students to enhance their scientific literacy by engaging in theoretical studies that support the completion of assigned projects.

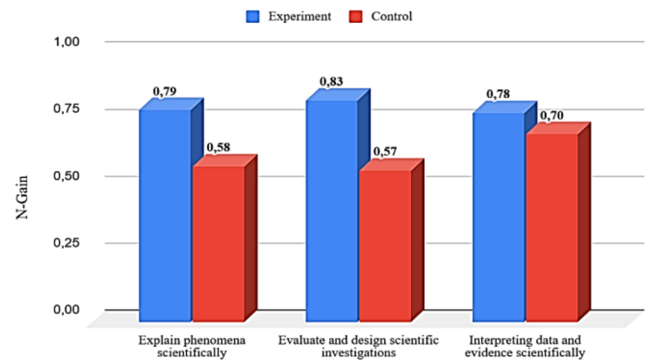

Figure 8 N-Gain of scientific literacy indicators

Integrating ethnoscience into PjBL also contributes positively to students' development of scientific literacy. The ethnoscience used in this study involves the concept of *Jadah Tempe*. This traditional food is an iconic product of the Kaliurang, Yogyakarta, Indonesia area, which is also the local environment of the students. Elfrida et al. (2023) highlight that science learning integrated with ethnoscience—drawing from local culture and knowledge—can help students better understand concepts and apply them to solve real-life problems, thus making learning more contextual. According to Parmin et al. (2022), such contextual learning encourages students to independently explore scientific facts, concepts, processes, and applications within their surrounding environment. This approach fosters the development of students' scientific literacy skills.

Communication Skills

One of the sample criteria in this study is equal class dynamics, including interactions between students (leading to communication skills). Based on the analysis results, the initial data on science literacy from the experimental group and the control group showed homogeneous averages (Sig. > 0.05), as presented in Table 7.

Based on the study's results, the analysis of N-Gain data for communication skills between the first and final meetings is presented in Table 8.

Table 7 t-Test equality of communication skills score means

	t	df	Sig.	Mean Difference	Std. Error Difference
Equal variances assumed	.885	62	.380	3.63000	4.10182

Table 8 Communication skill scores of the experimental and control classes

Indicator	Experiment		Control	
	Pre Score	Post Score	Pre Score	Post Score
Oral Communication Skill	66.78	94.74	71.88	87.34
Written Communication Skill	70.84	80.73	72.14	73.70
N-Gain	0.66		0.36	
Category	Moderate		Moderate	

The experimental group demonstrated a 21% increase in communication skills, particularly in the aspect of oral communication (post-test score 94.74 vs. 87.34). Overall, the improvement in communication skills in the experimental class was higher than that of the control class, with an N-Gain score of 0.66. This indicates that the PjBL model, integrated with the ethnoscience of traditional food, *Jadah Tempe*, is more effective in enhancing students' communication skills than the direct instruction model. The average improvement in both aspects of communication is evident from the N-Gain of each aspect presented in Figure 9.

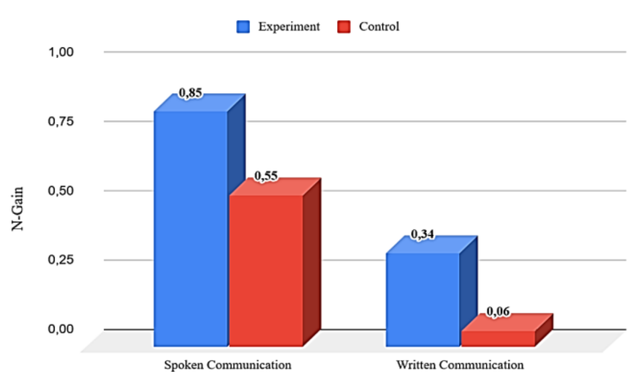

Figure 9 N-Gain of communication skill indicator

Based on the results of several analyses, it was found that the improvement in students' communication skills was more significant in the experimental class, which used the PjBL model integrated with the ethnoscience of traditional food, *Jadah Tempe*, than in the control class, which used the direct instruction model. The increase in students' oral communication aspect scores (N-Gain = 0.85) was obtained from students' activeness in discussing, expressing opinions, and participating in project presentations. This is due to a deeper understanding of the learning material, which was facilitated by the integration of traditional food—*Jadah Tempe*—into the project content, which is relevant to their cultural environment. According to Lestari and Ilhami (2022), PjBL encourages students to collaborate in finding solutions to real-world problems, which helps them develop communication within a team. Furthermore, Yuliana et al. (2021) state that the ethnoscience approach is inherently contextual, as students actively engage in completing projects related to their surrounding cultural environment. Contextual learning can enhance communication skills, particularly oral communication, as it fosters peer discussions (Astri et al., 2022).

This study also presents the results of improving the written communication aspect, which is rarely mentioned in previous studies. The study's results showed a 34% increase in written communication skills, categorized as 'moderate' based on students' ability to create science boards and complete tasks on student worksheets effectively. This increase is supported by an increase in conceptual understanding related to learning topics. According to Sholahuddin et al. (2021), the integration of PjBL, utilizing learning sources from traditional food, can improve science literacy skills and enhance conceptual understanding of learning concepts, which helps students complete tasks effectively. The findings in this study, using the context of traditional food—*Jadah Tempe*—yield the same results, where students demonstrate a better understanding of the material, enabling them to express ideas and solve problems in writing more clearly and systematically.

3.2 The Influence on Scientific Literacy and Communication Skills

Before conducting the hypothesis test regarding the effect of the PjBL model integrated with the ethnoscience of traditional food *Jadah Tempe* on scientific literacy and oral communication skills simultaneously, prerequisite tests were first carried out. The prerequisite test conducted was the Shapiro-Wilk normality test. For the scientific literacy variable, the Asymp. Sig. (2-tailed) value was 0.124 for the experimental class and 0.135 for the control class. For the communication variable, the Asymp. Sig. (2-tailed) The values were 0.458 for the experimental class and 0.168 for the control class (sig. > 0.05), indicating that the data were normally distributed.

Furthermore, the homogeneity test showed that the scientific literacy variable had an Asymp. Sig. (2-tailed) value of 0.054, and the communication variable had a value of 0.875 (sig. > 0.05), confirming that the data for each variable had equal variances. Finally, the correlation test analysis showed a Sig. (2-tailed) value of 0.001 (< 0.05), indicating a significant relationship between students' scientific literacy and oral communication skills. Additionally, the Pearson correlation coefficient was 0.546, indicating a moderate correlation between the literacy and communication variables (Sugiyono, 2012). These findings

Table 9 MANOVA test result

Effect	Value	F	Hypothesis df	Error df	Sig.	Partial Etta Square
Pillai's Trace	0.952	609.559^b	2.000	61.000	0.000	0.952
Wilks' Lambda	0.048	609.559^b	2.000	61.000	0.000	0.952
Hotelling's Trace	19.986	609.559^b	2.000	61.000	0.000	0.952
Roy's Largest Root	19.986	609.559^b	2.000	61.000	0.000	0.952

were supported by the fact that the N-Gain in both literacy and communication skills increased. As scientific literacy improved, so did communication skills. Afterward, hypothesis testing was conducted using MANOVA to test differences in students' scientific literacy and communication skills between the two groups that received different treatments. The results are presented in Table 9.

The multivariate analysis results presented in Table 7—including Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root—revealed a significance value of 0.000, indicating that the alternative hypothesis (H_1) is accepted. This confirms a statistically significant difference in students' scientific literacy and communication skills between the experimental group, taught through the PjBL model integrated with ethnoscience of the traditional food *Jadah Tempe*, and the control group, taught via direct instruction. Furthermore, the large effect size ($\eta^2 = 0.952$) demonstrates that 95.2% of the variance is attributable to the intervention, which is considered a massive effect in educational research (Cohen, 1988).

Figure 10 Student project presentation

Figure 10 shows students actively engaged in the *Jadah Tempe* project, demonstrating hands-on collaboration during nutrient analysis and cultural presentations. Figure 10 illustrates key moments of the learning process, including group presentations on traditional food science. These visuals underscore how the ethnoscience-PjBL model bridged abstract concepts and tangible cultural practices, directly supporting the quantitative improvements in literacy and communication.

This study provides novel empirical evidence on the impact of integrating local ethnoscience into project-based learning, demonstrating that this approach yields substantial improvements in both scientific literacy and communication skills. These findings align with previous studies (Zakiyah & Sudarmin, 2022), which emphasized that contextual learning rooted in ethnoscience can enhance students' 21st-century skills—particularly communication—through collaborative project engagement. The incorporation of local traditional food knowledge in science education facilitates students' acquisition of both declarative and procedural knowledge while fostering active engagement and student-centered learning (Mones et al., 2023; Wahyu, 2017). Additionally, the learning process includes scientific inquiry practices such as literature exploration, problem-solving, experimentation, and scientific reporting, which further support the development of scientific competencies (Eymur & Çetin, 2024; Toma et al., 2024).

The findings underscore the pedagogical value of reconstructing local cultural knowledge as a gateway to authentic science learning. The integration of local potentials—such as *Jadah Tempe*—enables students to engage in meaningful, culturally relevant scientific investigations, thereby bridging Indigenous knowledge systems and formal science curricula (Wilujeng et al., 2024). The laboratory validation of project outcomes, such as nutrient testing, not only strengthens conceptual understanding but also promotes scientific habits of mind. The final reporting phase, which requires students to present and communicate their findings, further enhances their communication competence, fostered through prior collaborative group discussions.

The urgency of reconstructing local potential into science education lies in the need to make learning more contextual, relevant, and inclusive. Many local traditions contain embedded scientific principles that are often overlooked in conventional curricula. Leveraging these local resources supports the decolonization of science education, making it more reflective of students' lived experiences and cultural identities (Nisa et al., 2023; Tyas et al., 2020). This approach also contributes to the preservation of intangible cultural heritage while cultivating scientifically literate citizens who can critically analyze traditional practices in light of modern scientific standards (Hastuti & Putri, 2022).

4. CONCLUSION

This study concludes that the implementation of a PjBL model integrated with ethnoscience—specifically through the exploration of traditional food, *Jadah Tempe*—has differences in results compared to the direct instruction model in improving students' scientific literacy and communication skills (Sig. <0.05). The implementation of a PjBL model integrated with ethnoscience—specifically through the exploration of traditional food—has a powerful influence on students' scientific literacy and communication skills (partial eta squared = 0.952). The integration of local cultural knowledge into inquiry-based science learning not only supports conceptual understanding but also fosters essential 21st-century competencies.

Overall, the findings indicate that the ethnoscience-enriched PjBL approach represents an effective and contextually relevant pedagogical strategy for science education, particularly in facilitating students' engagement with both declarative and procedural scientific knowledge. This model offers educators a meaningful alternative to conventional teaching methods, making science learning more culturally responsive and impactful.

The study holds important implications for science education practice. Teachers are encouraged to adopt ethnoscience-informed pedagogies to promote deeper learning and communication skills among students. Additionally, this research provides a foundation for future studies exploring the integration of other forms of indigenous knowledge within project-based or other constructivist learning models. Continued investigation in diverse cultural settings is essential to expand the applicability and scalability of ethnoscience-based instruction across broader educational contexts.

Although this study demonstrates strong effects, its generalizability may be limited to contexts with similar cultural backgrounds. Future research is recommended to examine the model's adaptability using other forms of traditional knowledge, such as herbal medicine or sustainable agriculture. Furthermore, the successful implementation of this model is highly dependent on teachers' capacity to serve as facilitators who mediate between students' cultural capital and disciplinary knowledge. Professional development programs focused on ethnoscience integration are therefore essential to scale up such innovative pedagogies in diverse educational settings.

ACKNOWLEDGMENT

We thank the "Faculty of Mathematics and Natural Sciences, Universitas Negeri Yogyakarta" for the funding that has been given to the completion of this research, with grant number B/28/UN34.13/PM01.01/2024.

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