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Effects of TPACK-Based Problem-Based Learning Integrated with Kenduri Blang Ethnoscience on Elementary Students' Critical Thinking and Collaboration Skills

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ABSTRACT

This study examined the effects of TPACK-based Problem-Based Learning (PBL) integrated with the Kenduri Blang ethnoscience on the critical thinking and collaboration skills of fifth-grade elementary school students in ecosystem learning. A quasi-experimental study using a non-equivalent control group design was conducted with 30 students, including 15 in the experimental group and 15 in the control group. Data were collected using a validated critical thinking test and a collaboration observation sheet and analyzed using descriptive statistics and independent-samples t-tests. The results showed that the experimental group outperformed the control group in both critical thinking and collaboration. The mean post-test critical thinking score was 85.40 in the experimental group and 52.53 in the control group ($t = 12.843$, $p < 0.001$). Similarly, the mean collaboration score was 16.40 in the experimental group and 12.93 in the control group ($t = 6.566$, $p < 0.001$). These findings indicate that integrating TPACK, PBL, and the Kenduri Blang ethnoscience effectively promotes higher-order thinking and collaborative learning through technology-supported and culturally relevant instruction. The findings provide practical guidance for teachers and curriculum developers seeking to integrate local ethnoscience into science learning. However, the relatively small sample, single-school setting, and short intervention period may limit the generalizability of the findings. This study contributes to the literature by demonstrating the value of combining TPACK, Problem-Based Learning, and local ethnoscience within a single instructional framework for elementary science education.

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INTRODUCTION

Ideal learning in the 21st century no longer focuses solely on content mastery but also emphasizes the development of higher-order thinking skills and socio-emotional competencies that are relevant to contemporary demands. One of the essential competencies that students must possess is critical thinking and the ability to collaborate effectively with others in order to face increasingly complex and rapidly changing life challenges (Fauzi & Wisanti, 2025). The Indonesian education curriculum has also accommodated this need by emphasizing meaningful and applicable learning experiences that foster critical and collaborative thinking, thereby preparing students to become lifelong learners.

Based on a preliminary study conducted through classroom observations in Grade V of SD Negeri 1 Simpang Mamplam, students' critical thinking skills were found to be relatively low. The observation results revealed that only 25% of students were able to provide logical reasoning for their answers, while the remaining 75% tended to respond descriptively without supporting arguments. When presented with open-ended questions, most students gave brief responses without providing reasons or supporting evidence. These findings indicate that many students still receive information passively without attempting to connect new knowledge with prior learning experiences or real-life situations. This condition highlights a specific instructional problem that requires a more contextual learning approach focused on developing critical thinking skills.

The situation is further aggravated by teacher-centered instructional practices, which provide limited opportunities for students to express opinions, question concepts, and solve problems independently. In addition, students' collaboration skills remain low. Observation data indicated that only 30% of students were able to actively participate and appreciate their peers' opinions during collaborative activities, whereas 70% were unable to assume meaningful roles or cooperate effectively. Students are not yet accustomed to working collaboratively in groups by sharing ideas, listening to others, and completing tasks collectively. A learning culture that emphasizes individual achievement rather than teamwork has hindered the development of cooperation. Consequently, students' social skills, communication abilities, and shared responsibility in the learning process have not developed optimally.

These findings indicate that classroom instruction has not fully supported the development of 21st-century competencies, particularly critical thinking and collaboration skills. If left unaddressed, these conditions may negatively affect students' learning outcomes and reduce their readiness to face real-world challenges that require analytical thinking and teamwork. Therefore, an instructional strategy that simultaneously promotes critical thinking and fosters a collaborative learning culture is urgently needed. Both competencies represent important dimensions of the Profil Pelajar Pancasila, particularly critical reasoning and mutual cooperation, which serve as fundamental pillars of Indonesia's current educational framework (Najaah, 2021; Yusniah et al., 2025). Moreover, teachers are expected to utilize technology to facilitate instructional activities while introducing innovative learning experiences that are meaningful and engaging (Miristianti et al., 2024).

In the context of 21st-century elementary science education, particularly on ecosystem topics, critical thinking and collaborative skills are essential competencies. The Problem-Based Learning (PBL) model integrated with ethnoscience offers an effective solution for enhancing students' analytical and problem-solving abilities because students are confronted with authentic situations that require group discussions and collaborative problem-solving (Verawati et al., 2025). To establish an instructional framework that aligns with the demands of the 21st century, teachers should also integrate the Technological Pedagogical Content Knowledge (TPACK) framework with ethnoscience. This integration enables teachers to balance technology, pedagogy, and content knowledge while facilitating contextual learning through authentic problems and local cultural wisdom that promote critical thinking and collaborative skills (PP & Joesidawati, 2025). Learning about ecosystems requires students not only to understand theoretical concepts but also to identify environmental problems, analyze their causes, and collaboratively develop appropriate and sustainable solutions (Meylovia & Julianto, 2023; Rizqa et al., 2025).

Previous research on the development of ethnoscience-integrated Problem-Based Learning (PBL) student worksheets (LKPD) demonstrated positive impacts on students' scientific literacy and creative thinking skills. The study emphasized that local cultural contexts enriched authentic learning problems, while the PBL structure facilitated inquiry and reasoning processes. However, its primary focus was not specifically directed toward improving critical thinking and collaboration skills among fifth-grade elementary school students (Hidayah et al., 2025).

Nevertheless, this study differs from previous research and addresses its limitations. Earlier studies primarily focused on ethnoscience-integrated PBL worksheets, whereas the present study combines the PBL model, the TPACK framework, and an ethnoscience approach within a comprehensive instructional design. This research examines not only the implementation of TPACK as an instructional framework but also the learning process employing the PBL model integrated with ethnoscience. Such integration is expected to overcome the limited active participation of students during learning and improve their ability to critically analyze information as well as collaborate effectively within teams.

The challenge remains that instructional approaches integrating technology, pedagogy, and content in elementary science education, particularly ecosystem learning, have not yet been implemented optimally. Several previous studies have demonstrated the effectiveness of the TPACK approach in improving students' critical thinking and collaboration skills. For example, the implementation of TPACK has been shown to enhance students' 4C competencies, including critical thinking and collaboration (Effendi et al., 2024). Likewise, Fitria (2022) reported that the TPACK approach promotes the development of 21st-century competencies among elementary school students, particularly critical thinking and collaborative skills. Furthermore, research has revealed that TPACK-based instructional materials improve conceptual understanding, critical thinking, active student engagement, and long-term memory retention. These findings suggest that implementing the Technological Pedagogical Content Knowledge (TPACK) approach is necessary to address current educational challenges. TPACK represents the integration of technology utilization, effective pedagogical strategies, and mastery of curriculum content to create innovative and meaningful learning experiences (Wahyuningtyas & Oktamarsetyani, 2023).

At SD Negeri 1 Simpang Mamplam, the implementation of a TPACK-based Problem-Based Learning model integrated with the ethnoscience tradition of Kenduri Blang to improve Grade V students' critical thinking and collaboration skills has not yet been optimized. Therefore, this study is important to determine the effect of

implementing a TPACK-based Problem-Based Learning model integrated with the Kenduri Blang ethnoscience approach on students' critical thinking and collaboration skills. The findings are also expected to contribute to improving the quality of elementary science education, particularly in fostering 21st-century competencies through the integration of technology into classroom instruction.

METHOD

This study employed a quantitative approach using a quasi-experimental design with a nonequivalent control group design to examine the effects of TPACK-based Problem-Based Learning (PBL) integrated with the Kenduri Blang ethnoscience on elementary students' critical thinking and collaboration skills. Two intact fifth-grade classes participated in the study. The experimental group received instruction through the TPACK-based PBL model integrated with the Kenduri Blang ethnoscience, whereas the control group received conventional teacher-centered instruction. Both groups completed pretests before the intervention and posttests after the intervention to measure changes in students' critical thinking and collaboration skills.

The study was conducted at SD Negeri 1 Simpang Mamplam, Bireuen Regency, Aceh Province, Indonesia, during the second semester of the 2025/2026 academic year. The population consisted of all fifth-grade students enrolled at the school. The sample comprised 30 students from two existing classes selected based on the school's recommendation because they had relatively similar academic characteristics. Class VA, consisting of 15 students, was assigned as the experimental group, while Class VB, consisting of 15 students, served as the control group. The equivalence of the two groups' initial abilities was examined through pretest results before the instructional intervention.

The independent variable was the implementation of the TPACK-based PBL model integrated with the Kenduri Blang ethnoscience, while the dependent variables were students' critical thinking and collaboration skills. The instructional intervention focused on ecosystem learning by integrating technological knowledge, problem-based learning activities, and local ethnoscientific knowledge derived from the Kenduri Blang tradition. Students in the experimental group were engaged in contextual problem-solving activities, collaborative discussions, investigation, and presentation of solutions supported by digital learning resources. In contrast, students in the control group learned the same topic using conventional instructional methods.

Data were collected using a critical thinking test and a collaboration skills observation sheet. The critical thinking instrument consisted of 10 multiple-choice questions and five Higher-Order Thinking Skills (HOTS)-based essay questions administered during both the pretest and posttest. Collaboration skills were assessed through classroom observations covering active participation, communication, teamwork, responsibility, and respect for peers' opinions. The observations were conducted independently by the classroom teacher and the researcher throughout the learning process.

Prior to data collection, the research instruments were examined for validity and reliability. Item validity was analyzed using the Pearson Product-Moment correlation coefficient, and all items exceeded the critical value ($r = 0.361$), indicating acceptable validity. Instrument reliability was assessed using Cronbach's Alpha, yielding coefficients of 0.886 for the critical thinking instrument and 0.894 for the collaboration observation sheet, indicating high internal consistency.

The data were analyzed using IBM SPSS. Descriptive statistics were first calculated to summarize students' performance. Assumption testing included normality and homogeneity tests to determine the suitability of parametric analysis. Differences between the experimental and control groups were examined using independent-samples *t*-tests at a significance level of 0.05. The findings were subsequently interpreted to determine the effectiveness of the TPACK-based PBL model integrated with the Kenduri Blang ethnoscience in improving students' critical thinking and collaboration skills. Considering the relatively small sample drawn from a single school and the use of intact classes without random assignment, the findings should be interpreted within the context of these methodological limitations.

RESULTS

Prerequisite Tests

The prerequisite tests were conducted to determine whether the research data met the assumptions of normality and homogeneity before hypothesis testing.

Normality Test

The normality test was conducted to determine whether the research data were normally distributed as a prerequisite for applying parametric statistical analysis. The test employed the Kolmogorov–Smirnov and Shapiro–Wilk tests. The

data were considered normally distributed when the significance value (Sig.) was greater than 0.05. The results of the normality test are presented in Table 1.

Table 1. Results of the Normality Test

Data	Kolmogorov–Smirnov Statistic	df	Sig.	Shapiro–Wilk Statistic	df	Sig.
Experimental Class Critical Thinking Pre-test	0.071	15	.200*	0.986	15	0.995
Control Class Critical Thinking Pre-test	0.133	15	.200*	0.967	15	0.818
Experimental Class Critical Thinking Post-test	0.115	15	.200*	0.978	15	0.956
Control Class Critical Thinking Post-test	0.136	15	.200*	0.943	15	0.422
Experimental Class Collaboration Pre-test	0.119	15	.200*	0.953	15	0.576
Control Class Collaboration Pre-test	0.209	15	0.077	0.935	15	0.321
Experimental Class Collaboration Post-test	0.149	15	.200*	0.950	15	0.532
Control Class Collaboration Post-test	0.137	15	.200*	0.939	15	0.373

Based on Table 1, all pre-test and post-test data for both critical thinking ability and collaboration skills in the experimental and control groups obtained significance values greater than 0.05 in both the Kolmogorov–Smirnov and Shapiro–Wilk tests. The Shapiro–Wilk significance values ranged from 0.321 to 0.995, all exceeding the 0.05 threshold. Therefore, it can be concluded that the research data were normally distributed, indicating that the normality assumption required for parametric statistical analysis (independent samples *t*-test) was satisfied.

Homogeneity of Variance Test

The homogeneity of variance test was conducted to determine whether the variances of the experimental and control groups were statistically equivalent as a prerequisite for the independent samples *t*-test. The analysis employed Levene's Test for Equality of Variances. The data were considered homogeneous if the significance value (Sig.) exceeded 0.05. The results are presented in Table 2.

Table 2. Results of the Homogeneity of Variance Test

Data	Levene Statistic	df1	df2	Sig.	Interpretation
Critical Thinking Pre-test	0.006	1	28	0.939	Homogeneous
Critical Thinking Post-test	0.377	1	28	0.544	Homogeneous
Critical Thinking Gain (Post–Pre)	0.656	1	28	0.425	Homogeneous
Collaboration Pre-test	0.195	1	28	0.662	Homogeneous
Collaboration Post-test	4.165	1	28	0.051	Homogeneous
Collaboration Gain (Post–Pre)	2.263	1	28	0.144	Homogeneous

As shown in Table 2, all variables yielded Levene's Test significance values greater than 0.05, ranging from 0.051 to 0.939. The smallest significance value was obtained for the collaboration post-test (Sig. = 0.051), which remained above the critical value of 0.05. Therefore, the variances of the experimental and control groups were homogeneous, satisfying the homogeneity assumption required for the independent samples *t*-test.

Descriptive Statistics

Descriptive statistics were used to summarize the research data by presenting the mean, standard deviation, and standard error of the mean. The descriptive statistics for both groups are shown in Table 3.

Table 3. Descriptive Statistics of the Research Results

Variable	Group	N	Mean	Std. Deviation	Std. Error Mean
Critical Thinking Post-test	Experimental	15	85.40	6.822	1.761
	Control	15	52.53	7.190	1.856
Critical Thinking Gain (Post–Pre)	Experimental	15	44.27	9.067	2.341
	Control	15	11.60	7.069	1.825
Collaboration Post-test	Experimental	15	16.40	1.724	0.445
	Control	15	12.93	1.100	0.284
Collaboration Gain (Post–Pre)	Experimental	15	5.87	1.598	0.413
	Control	15	2.33	0.976	0.252

Based on Table 3, the mean post-test score for critical thinking in the experimental group (M = 85.40) was substantially higher than that of the control group (M = 52.53). Likewise, the mean gain score for critical thinking was considerably

greater in the experimental group (44.27) than in the control group (11.60). A similar pattern was observed for collaboration skills, where the experimental group achieved a higher mean post-test score (M = 16.40) than the control group (M = 12.93). Furthermore, the collaboration gain score in the experimental group (5.87) markedly exceeded that of the control group (2.33). These findings indicate that the implementation of the TPACK-based Problem-Based Learning (PBL) model integrated with the ethnoscience of *Kenduri Blang* had a greater positive effect on improving students' critical thinking skills and collaboration skills compared with conventional learning.

Hypothesis Testing (Independent Samples T-Test)

Hypothesis testing was conducted using the Independent Samples T-Test to compare the mean scores of the experimental group and the control group. The decision criterion was that H_0 would be rejected (and H_1 accepted) if the Sig. (2-tailed) value was less than 0.05, indicating a statistically significant difference between the two groups. The results of the t-test are presented in Table 4 below.

Table 4. Independent Samples T-Test Results

Independent Samples Test										
		Levene's Test		t-test for Equality of Means						
		F	Sig.	T	df	Sig.	Mean Difference	Std. Error Difference	95%	
									Lower	Upper
Exp. Post-test	Equal variances assumed	0,377	0,544	12,843	28	0,000	32,867	2,559	27,625	38,109
	Equal variances not assumed			12,843	27,923	0,000	32,867	2,559	27,624	38,109
Exp. Gain (Post–Pre)	Equal variances assumed	0,656	0,425	11,004	28	0,000	32,667	2,969	26,586	38,747
	Equal variances not assumed			11,004	26,428	0,000	32,667	2,969	26,570	38,764
Ctrl. Post-test	Equal variances assumed	4,165	0,051	6,566	28	0,000	3,467	0,528	2,385	4,548
	Equal variances not assumed			6,566	23,777	0,000	3,467	0,528	2,376	4,557
Ctrl. Gain (Post–Pre)	Equal variances assumed	2,263	0,144	7,310	28	0,000	3,533	0,483	2,543	4,523
	Equal variances not assumed			7,310	23,171	0,000	3,533	0,483	2,534	4,533

To provide a clearer understanding of the Independent Samples T-Test results, the calculated t-values are summarized in Table 5 below.

Table 5. Calculated t-Test Results

Variable	t-value	df	Sig. (2-tailed)	Mean Difference	Interpretation
Critical Thinking Post-test	12.843	28	0.000	32.867	H_1 accepted (Significant effect)
Critical Thinking Gain Score (Post–Pre)	11.004	28	0.000	32.667	H_1 accepted (Significant effect)
Collaboration Post-test	6.566	28	0.000	3.467	H_2 accepted (Significant effect)
Collaboration Gain Score (Post–Pre)	7.310	28	0.000	3.533	H_2 accepted (Significant effect)

Based on the results presented in the tables above, the answers to the research questions and hypotheses can be explained more clearly as follows. The Independent Samples T-Test results indicate that there were significant differences between the experimental group and the control group in both critical thinking and collaboration skills. For critical thinking skills, the post-test comparison yielded a t-value of 12.843 with a significance value of 0.000 (< 0.05), while the gain score comparison (post-test minus pre-test) produced a t-value of 11.004 with a significance value of 0.000. These findings demonstrate that the treatment implemented in the experimental group had a significant positive effect on students' critical thinking skills. Therefore, H_1 is accepted.

Similarly, for collaboration skills, the post-test comparison resulted in a t-value of 6.566 with a significance value of 0.000 (< 0.05), and the gain score comparison yielded a t-value of 7.310 with a significance value of 0.000. These results indicate a significant difference in collaboration skills between the experimental and control groups after the intervention. Consequently, H_2 is accepted. Overall, the findings suggest that the implemented learning intervention was effective in significantly improving students' critical thinking and collaboration skills compared to conventional learning practices in the control group.

H1: Effect on Critical Thinking Skills
The hypothesis testing using the Independent Samples *t*-Test indicated that the post-test data on critical thinking skills yielded a calculated *t* value of 12.843, with df = 28 and Sig. (2-tailed) = 0.000 (< 0.05). Similarly, for the gain score data, the calculated *t* value was 11.004 with Sig. (2-tailed) = 0.000 (< 0.05). The mean difference was 32.867 for the post-test and 32.667 for the gain score. Therefore, H_1 was accepted and H_{01} was rejected, indicating that the implementation of the TPACK-based Problem-Based Learning (PBL) model integrated with the *Kenduri Blang* ethnoscience significantly improved the critical thinking skills of fifth-grade elementary school students compared with conventional instruction.

H2: Effect on Collaboration Skills
The Independent Samples *t*-Test results for the post-test data on collaboration skills showed a calculated *t* value of 6.566, with df = 28 and Sig. (2-tailed) = 0.000 (< 0.05). For the gain score data, the calculated *t* value was 7.310 with Sig. (2-tailed) = 0.000 (< 0.05). The mean difference was 3.467 for the post-test and 3.533 for the gain score. Therefore, H_2 was accepted and H_{02} was rejected, indicating that the implementation of the TPACK-based PBL model integrated with the *Kenduri Blang* ethnoscience had a significant positive effect on the collaboration skills of fifth-grade elementary school students compared with the control group.

H_{01}: No Effect on Critical Thinking Skills
The Independent Samples *t*-Test results demonstrated that the post-test data on critical thinking skills produced a calculated *t* value of 12.843, with df = 28 and Sig. (2-tailed) = 0.000 (< 0.05). Likewise, the gain score data yielded a calculated *t* value of 11.004 with Sig. (2-tailed) = 0.000 (< 0.05). The mean difference was 32.867 for the post-test and 32.667 for the gain score. Accordingly, H_{01} was rejected and H_1 was accepted, indicating that the TPACK-based PBL model integrated with the *Kenduri Blang* ethnoscience had a significant effect on the critical thinking skills of fifth-grade elementary school students compared with conventional instruction.

H_{02}: No Effect on Collaboration Skills
The Independent Samples *t*-Test results for the post-test data on collaboration skills showed a calculated *t* value of 6.566, with df = 28 and Sig. (2-tailed) = 0.000 (< 0.05). The gain score analysis also yielded a calculated *t* value of 7.310 with Sig. (2-tailed) = 0.000 (< 0.05). The mean difference was 3.467 for the post-test and 3.533 for the gain score. Therefore, H_{02} was rejected and H_2 was accepted, indicating that the implementation of the TPACK-based PBL model integrated with the *Kenduri Blang* ethnoscience had a significant effect on the collaboration skills of fifth-grade elementary school students compared with the control group.

DISCUSSION

Based on the findings of this study, a more comprehensive discussion is presented to provide a clearer and more systematic interpretation of the results, as follows.

The Effect of the TPACK-Based Problem-Based Learning Model Integrated with the "Kenduri Blang" Ethnoscience on Improving the Critical Thinking Skills of Fifth-Grade Elementary School Students
Based on the results of the hypothesis testing using the Independent Samples t-Test, the findings indicate a highly significant effect of the TPACK-based Problem-Based Learning (PBL) model integrated with the "Kenduri Blang" ethnoscience approach on improving the critical thinking skills of fifth-grade elementary school students. The statistical analysis revealed that the post-test critical thinking scores yielded a calculated t-value of 12.843 with df = 28 and a significance value of 0.000 (Sig. 2-tailed < 0.05). Similarly, the gain score analysis produced a calculated t-value of 11.004 with a significance value of 0.000 (Sig. 2-tailed < 0.05). The mean difference of 32.867 for the post-test scores and 32.667 for the gain scores indicates that H_1 was accepted, demonstrating that the TPACK-based PBL model integrated with the "Kenduri Blang" ethnoscience approach had a significant positive effect on students' critical thinking skills compared with conventional instruction. These numerical findings provide strong empirical evidence for rejecting H_0 and accepting H_1.

The findings further revealed that students in the experimental class, who were taught using the TPACK-based PBL model integrated with the "Kenduri Blang" ethnoscience approach, experienced a more active, contextualized, and intellectually stimulating learning environment. Rather than merely receiving information from the teacher, students actively engaged in solving authentic problems related to their real-life experiences and the local tradition of "Kenduri Blang." The statistical improvement in critical thinking skills was reflected in students' ability to formulate meaningful questions, construct logical arguments, and relate ecosystem concepts to cultural practices embedded in the "Kenduri Blang" tradition. In contrast, students in the control group, who received conventional instruction, tended to remain passive. Learning activities were predominantly teacher-centered, relying heavily on lectures and

memorization. Consequently, students' critical thinking skills were limited to recalling information without conducting deeper analysis.

Previous studies have consistently reported that TPACK-based Problem-Based Learning significantly improves students' critical thinking skills (Adelia & Satianingsih, 2025). Likewise, the implementation of Problem-Based Learning integrated with ethnoscience has been shown to enhance students' critical thinking abilities (Oktapia et al., 2024). Conceptually, critical thinking skills are effectively developed when students are engaged in authentic problem-based learning situations. PBL is grounded in constructivist philosophy, which emphasizes that knowledge is actively constructed by learners through meaningful experiences in solving real-world problems. The pedagogical framework of PBL encourages students to move beyond passive reception of knowledge by investigating problems and formulating appropriate solutions, thereby fostering analytical thinking and independent learning (Harahap et al., 2025). Through the process of problem identification and analysis, students are guided to think openly, logically, and rationally when drawing conclusions based on valid evidence (Maylia et al., 2024). PBL operationalizes authentic problem-solving through students' active involvement in identifying, analyzing, and resolving real-life issues under the guidance of teachers acting as facilitators. This process contributes to the development of twenty-first-century competencies (4C skills), particularly critical thinking, while generating practical solutions relevant to everyday life (Syamsinar, 2024). Furthermore, PBL encourages students to think critically, reason systematically, and collaborate in solving unfamiliar problems by applying their knowledge and real-life experiences (Permatasari & Muchsini, 2024). PBL also integrates metacognitive awareness, knowledge, and self-regulation with problem-solving processes, enabling learners to monitor and regulate their own thinking (Rachmi et al., 2025). Fundamentally, PBL positions authentic problems encountered by students as the primary starting point for learning, requiring learners to seek appropriate solutions to real-life situations (Irawan, 2025).

The TPACK (Technological Pedagogical Content Knowledge) framework further strengthens these cognitive processes by ensuring that instructional content is delivered through appropriate pedagogical strategies supported by relevant technologies. TPACK represents a strategic integration of technological tools, effective pedagogical methods, and scientific content knowledge (Wahyuningtyas & Oktamarsetyani, 2023). This integration enables students to utilize digital technologies, such as educational videos and online learning platforms, when analyzing problems, thereby creating an innovative learning environment that supports deeper conceptual understanding (Phillips et al., 2026).

Moreover, integrating the "Kenduri Blang" ethnoscience approach provides meaningful contextualization by connecting scientific concepts with students' local cultural knowledge. Ethnoscience serves not only as a bridge between scientific knowledge and indigenous cultural practices but also as a means of fostering character values while helping students understand science through their immediate environment (Munawwarah & Alqadri, 2025). The "Kenduri Blang" tradition embodies ecological values associated with environmental conservation and sustainable ecosystem management (Marpaung & Harahap, 2024). Learning materials that incorporate this local wisdom have proven effective in facilitating students' understanding of abstract scientific concepts because learners analyze ecosystem relationships directly through familiar cultural experiences (Supriatna & Quthbi, 2021).

The findings of the present study are consistent with previous research highlighting the effectiveness of this instructional approach while offering a novel contribution through its unique combination of methods. Similar results were reported by Adelia & Satianingsih (2025), who demonstrated that TPACK-based Problem-Based Learning significantly improved students' critical thinking skills. Likewise, research conducted by Oktapia et al (2024) confirmed that ethnoscience-integrated PBL effectively enhances scientific literacy and critical thinking. However, the present study contributes a distinctive innovation by simultaneously integrating TPACK, Problem-Based Learning, and the local cultural tradition of "Kenduri Blang," thereby enriching the overall learning experience. This finding is further supported by previous studies indicating that TPACK plays a crucial role in developing twenty-first-century competencies (4C skills), particularly critical thinking (Effendi et al., 2024). Through TPACK, teachers are able to design more innovative, interactive, and student-centered learning experiences by utilizing diverse digital media and educational technologies, ultimately encouraging greater student engagement (Yani et al., 2025). Furthermore, TPACK represents an integrated knowledge framework combining technological, pedagogical, and content knowledge, enabling teachers to select technologies that align with instructional objectives and subject characteristics, thereby creating more effective and meaningful learning experiences (Irdalisa et al., 2022). TPACK-based instruction has also been found to enhance higher-order thinking skills (HOTS) by promoting analysis, evaluation, and problem-solving, all of which are closely associated with critical and creative thinking (Nisfah et al., 2022). In addition, ethnoscience connects students' indigenous knowledge with scientific knowledge, making learning more meaningful and relevant to their daily experiences while supporting teachers in fostering students' critical thinking abilities (Sari et al., 2023). Ethnoscience integrates local cultural values into science instruction, allowing students to understand scientific

concepts through familiar cultural contexts, thereby stimulating critical thinking (Aisyah & Khotimah, 2023). Furthermore, ethnoscience encourages students to analyze authentic problems within their communities, promoting problem-solving skills that directly contribute to the development of critical thinking abilities (Tsaniyah & Fadly, 2024).

The Effect of the TPACK-Based Problem-Based Learning Model Integrated with the "Kenduri Blang" Ethnoscience Approach on Improving the Collaboration Skills of Fifth-Grade Elementary School Students

Hypothesis testing on the collaboration skills variable also confirmed the significant effectiveness of the TPACK-based Problem-Based Learning (PBL) model integrated with the "Kenduri Blang" ethnoscience approach in improving the critical thinking and collaboration skills of fifth-grade elementary school students. Descriptive statistical analysis revealed a calculated t-value of 6.566 with df = 28 and a Sig. (2-tailed) value of 0.000 < 0.05. Furthermore, the gain score analysis of collaboration skills produced a calculated t-value of 7.310 with Sig. (2-tailed) = 0.000 < 0.05. The mean difference of 3.467 in the post-test and 3.533 in the gain score indicates that the experimental class demonstrated significantly higher collaboration skills than the control class. Therefore, H_1 was accepted, indicating that the TPACK-based PBL model integrated with the "Kenduri Blang" ethnoscience approach had a significant effect on the collaboration skills of fifth-grade students compared to the control group. These statistical findings conclusively support the acceptance of H_2 and the rejection of H_{02}. Based on the findings, learning in the experimental class, which implemented the TPACK-based PBL model integrated with the "Kenduri Blang" ethnoscience approach, became more active, contextual, and collaborative. Students' collaboration skills developed substantially, demonstrating greater ability to work cooperatively, distribute responsibilities, and appreciate their peers' contributions. Group discussions became more dynamic, as students complemented one another's ideas and jointly developed solutions. Previous research has similarly shown that the implementation of TPACK enhances students' critical thinking, creativity, and collaboration skills (Effendi et al., 2024).

From a theoretical perspective, the PBL model provides an ideal framework for fostering students' social skills, particularly collaboration. Collaboration is defined as a proactive process in which two or more learners combine their knowledge, expertise, and resources to achieve shared objectives (Scoular et al., 2025). The design of PBL requires students to investigate the root causes of problems collectively, allowing structured interaction and role distribution to emerge naturally (Syamsinar, 2024). Such learning conditions create an educational ecosystem that effectively promotes the development of students' collaborative abilities within the context of contemporary education (Wardani, 2023). PBL encourages students to think critically, reason logically, and collaborate in solving authentic problems by utilizing their knowledge and real-life experiences (Permatasari & Muchsini, 2024). Moreover, Problem-Based Learning produces meaningful learning experiences by connecting theoretical concepts with practical applications and encouraging students to generate authentic solutions.

Problem-Based Learning is an instructional model that requires students' direct and active engagement in solving real-world problems, thereby making learning more meaningful (Maharani, 2024). As a student-centered approach, PBL promotes critical thinking, reasoning, and collaboration in addressing novel problems grounded in learners' real-life experiences (Permatasari & Muchsini, 2024). Furthermore, PBL creates opportunities for collaboration and the development of students' twenty-first-century competencies while encouraging teachers to design creative learning experiences based on authentic and contextual problems (Marisa & Santi, 2025; Wardani, 2023).

Within these collaborative interactions, the implementation of the TPACK framework provides technological support that facilitates effective teamwork and communication. The utilization of various digital applications and technologies has been shown to enhance collaboration skills by facilitating the exchange of ideas and enabling discussions beyond spatial limitations (Barokah & Untung, 2024). This environment encourages students to appreciate one another's perspectives while actively participating both physically and intellectually in group activities (Hermawan et al., 2025). The integration of instructional technology with appropriate pedagogical strategies transforms learning into a meaningful process in which theoretical knowledge is collaboratively applied among peers (R. Ismail et al., 2024).

Furthermore, the collaborative dimension of this learning model is strengthened through the social values embedded in the "Kenduri Blang" ethnoscience approach. "Kenduri Blang" is not merely a ceremonial tradition but also serves as a forum for deliberation and represents the authentic practice of mutual cooperation among farming communities in achieving shared agricultural goals (Attas & Anoegrajekti, 2021). Integrating these local cultural values into classroom learning not only supports the adaptation of scientific and technological knowledge but also strengthens emotional cohesion and teamwork among students (I. A. Ismail et al., 2024). From the perspective of ecological sociology, this local wisdom plays a crucial role in reinforcing collective responsibility and social cohesion, values that are naturally internalized into students' soft skills (Marpaung & Harahap, 2024).

The findings of this study are consistent with previous literature while offering novelty through the integration of local cultural philosophy. Earlier studies have demonstrated that the TPACK framework significantly enhances the collaboration and communication components of twenty-first-century skills (Effendi et al., 2024). In addition, integrating TPACK-based instructional materials within the PBL framework has been proven to maximize student engagement and participation (Rerung et al., 2017). The ethnoscience approach not only facilitates science learning but also develops students' collaborative skills, cultural identity, and scientific attitudes by connecting learning with authentic social and cultural experiences (Munawwarah & Alqadri, 2025). Likewise, integrating ethnoscience into classroom instruction has been found to improve critical thinking, creativity, collaboration, and communication skills required in the twenty-first century (Nurhasnah et al., 2022). The novelty of the present study lies in the fact that the improvement of students' collaboration skills is achieved not solely through educational technology but also through the philosophical values of the "Kenduri Blang" tradition, which serves as a cultural guideline for teamwork among students.

Research Limitations

This study has several limitations that should be acknowledged to ensure that its findings are interpreted appropriately and to provide direction for future research. First, the study was limited to fifth-grade science instruction focusing specifically on the ecosystem topic. Consequently, the findings cannot be generalized to other subjects or educational levels. Second, the participants consisted solely of fifth-grade students from State Elementary School 1 Simpang Mamplam; therefore, differences in social, cultural, and educational contexts in other schools may produce different outcomes. Finally, the "Kenduri Blang" ethnoscience approach may not be directly applicable to other regions because of differences in local cultural traditions and environmental conditions.

CONCLUSION

Based on the findings of this study, it can be concluded that the TPACK-based Problem-Based Learning (PBL) model integrated with the ethnoscience of Kenduri Blang had a significant effect on improving the critical thinking skills of fifth-grade elementary school students ($t = 12.843$; Sig. $= 0.000 < 0.05$). This improvement was reflected in students' active participation in analyzing ecosystem-related problems, constructing logical arguments, and proposing solutions based on the context of local culture. Furthermore, the implementation of the TPACK-based PBL model integrated with the ethnoscience of Kenduri Blang also had a significant effect on enhancing students' collaboration skills ($t = 6.566$; Sig. $= 0.000 < 0.05$). This was demonstrated by students' increased ability to work effectively in teams, share ideas, respect their peers' opinions, and complete group tasks collaboratively. These findings indicate that integrating technology, pedagogy, content knowledge, and local cultural values through ethnoscience-based PBL provides meaningful learning experiences that foster both critical thinking and collaboration skills among elementary school students.

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