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Students' higher-order thinking skills (HOTS) in exploring Jambi's local wisdom through project-based learning

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ABSTRACT

In the era of 21st-century education, higher education institutions are expected not only to transmit knowledge but also to cultivate students' Higher-Order Thinking Skills (HOTS). One promising approach to achieving this goal is integrating local wisdom into the learning process through the Project-Based Learning (PjBL) model. This study aimed to explore Jambi's local wisdom through PjBL and analyze its impact on students' HOTS achievement. The research employed a quasi-experimental design with a non-equivalent pre-test and post-test experimental group design. The sample consisted of 27 Biology Education students at the University of Jambi, selected through purposive sampling. HOTS were measured using multiple-choice tests for analyzing and evaluating skills, and a holistic assessment rubric for the creating skill. Students' HOTS scores were analyzed using a paired-sample t-test, while the effect size was calculated using Cohen's d. The results showed that the exploration of Jambi's local wisdom through project-based learning had a large effect on improving students' HOTS, as indicated by the t-test results [$t(20) = 23.972$; $p < 0.001$; $d = 5.2$]. The greatest improvement occurred in the creating indicator (49.22%), followed by evaluating (31.48%) and analyzing (20.14%). These findings indicate that integrating Jambi's local wisdom into the PjBL model is effective in developing students' HOTS and supports contextual learning aligned with the principles of Education for Sustainable Development (ESD). Therefore, project-based learning that incorporates local wisdom can serve as a transformational strategy in curriculum development that meets the demands of 21st-century skills.

INTRODUCTION

In the 21st century, higher education institutions are not only responsible for the transmission of knowledge but also play a crucial role in fostering students' Higher-Order Thinking Skills (HOTS), such as the abilities to analyze, evaluate, and generate innovative solutions (Gupta & Mishra, 2021; Miterianifa et al., 2021). These competencies are essential for addressing a range of global challenges, including environmental degradation, climate change, overexploitation of natural resources, and food security crises (Yennita et al., 2023). Therefore, learning in higher education must be designed contextually to produce graduates who are critical, creative, and reflective thinkers. The Ethnobiology course, which examines the interactions between humans and biodiversity within diverse cultural contexts (Baptista, 2018; Turner et al., 2022), holds considerable potential as a medium for developing students' HOTS. By integrating local wisdom into ethnobiology learning, students not only gain conceptual understanding of ecological and cultural dimensions but also actively engage in exploring traditional practices related to biodiversity conservation and the sustainable use of natural resources.

Jambi Province possesses a wealth of indigenous knowledge encompassing traditional resource management, medicinal plant utilization, and sustainable agricultural practices. However, this potential remains largely untapped within higher education learning environments. Observations indicate that most instructional activities are still centered on knowledge transmission, classroom discussions, and laboratory work, with limited opportunities for field-based exploration. As a result, students have few opportunities to engage directly with local communities in exploring and documenting indigenous knowledge, which hampers the development of higher-order thinking skills. Preliminary assessments using HOTS-based questions revealed low performance, with scores of 66.67% for analytical thinking, 52.47% for evaluative skills, and only 33.58% for creative thinking. Moreover, many students perceive indigenous knowledge as static and irrelevant to modern science, diminishing their appreciation of cultural and ecological values and weakening biodiversity conservation awareness rooted in local wisdom. This condition highlights a significant gap between the rich potential of Jambi's local wisdom and current higher education learning strategies. Therefore, a collaborative, contextual, and experience-based learning model is urgently needed to bridge academic knowledge with indigenous practices and foster students' HOTS.

Responding this need, Project-Based Learning (PjBL) has the potential to serve as an effective strategy for integrating local wisdom from Jambi into the learning process. As an inquiry-based approach, PjBL actively engages students in designing, implementing, and evaluating projects aligned with learning objectives (Guo et al., 2020; Markula & Aksela, 2022; Quinapallo-Quintana & Baldeón-Zambrano, 2024). Applied in Ethnobiology courses, PjBL enables students to conduct mini-research and document local practices such as medicinal plant use and culture-based conservation efforts. Through this process, students not only acquire factual knowledge but also develop analytical, critical, and creative thinking skills, as well as innovative problem-solving abilities, which are core components of higher-order thinking skills (Billah et al., 2019; Lesman et al., 2023). Students also gain the opportunity to study traditional practices of Jambi communities in the sustainable management of biodiversity while exploring their potential for adaptation in modern contexts. This effort aligns with the goals of preserving and revitalizing local wisdom in Indonesia and serves as an educational strategy to address the challenges posed by globalization and modernization (Alimah, 2019; Ramdiah et al., 2020).

Previous studies have highlighted the importance of integrating local wisdom into biology education. Adnyana (2016) reported that traditional Balinese agricultural practices, such as the *Tri Hita Karana* philosophy and *Subak* irrigation system, effectively enhance ecological concept understanding and promote critical thinking. Sudirgayasa et al., (2021) demonstrated that the Lembu Putih Taro Ecotourism site could serve as a meaningful and contextual setting for biology learning, encompassing taxonomy, genetics, animal morphology/physiology, and ecology. Additionally, Husen et al., (2024) found that the *Momorong* tradition in Ternate effectively developed students' collaborative skills in the topic of plant growth and development. Simultaneously, numerous studies indicate that the application of PjBL significantly improves students' analytical thinking (Dewi et al., 2021; Mahardika et al., 2025), critical thinking (Aristin & Purnomo, 2022; Jeniver et al., 2023; Ramadhani et al., 2024), creative thinking (Pramesti et al., 2022; Sucilestari et al., 2023; Yu, 2024), and problem-solving skills (Doyan et al., 2024; Ilma et al., 2023; Ndiung & Menggo, 2024). Despite these findings, research specifically exploring the implementation of PjBL for the integration of Jambi's local wisdom in ethnobiology courses remains scarce. This study aims to address this research gap by examining how the implementation of PjBL can support students in developing higher-order thinking skills through the exploration of Jambi's indigenous knowledge.

Based on the above rationale, this study aims to explore Jambi's local wisdom in ethnobiology learning through the application of Project-Based Learning (PjBL) and to analyze its impact on the development of students' Higher-Order Thinking Skills (HOTS). The outcomes of this research are expected to contribute to the development of more contextual, innovative, and locally rooted learning models that can enhance the quality of higher education.

METHODS

Research Design

This study is quasi-experimental research with a non-equivalent pre-test and post-test experimental group design (Bernard, 2011; Leedy & Ormrod, 2021) as shown in Table 1. In this design, the experimental group receives an intervention in the form of the implementation of Jambi's local wisdom exploration activities through the Project-Based Learning model during the ethnobiology course. The students' HOTS before and after the intervention are then compared. The research was conducted at the Undergraduate Program of Biology Education, Faculty of Teacher Training and Education, Universitas Jambi, from March to October 2024.

Table 1.
The Research Design

Class	Pre-test	Treatment	Post-test
Experiment	O_1	X_1	O_2

Description:
X_1: Exploring Jambi's local wisdom through Project-Based Learning
O_1: Test before treatment
O_2: Test after treatment

Population and Samples

The population of this study comprises fifth-semester biology education students at Universitas Jambi during the 2023/2024 academic year, totaling 87 students distributed across three classes. The sample was selected using the purposive sampling technique, with the criteria being students enrolled in the ethnobiology course and belonging to classes that are normally and homogeneously distributed. By employing this method, the research sample consists of 27 biology education students from Universitas Jambi who were enrolled in the ethnobiology course during the even semester of the 2023/2024 academic year.

Instrument

The assessment of students' HOTS was conducted using a combination of multiple-choice tests and project-based evaluations. Each component contributed 50% to the final HOTS score. The multiple-choice test consisted of 35 items designed to measure analyzing (C4) and evaluating (C5) skills, based on Bloom's revised taxonomy (Krathwohl, 2002; Subali, 2019; Wilson, 2016). Meanwhile, the creating skill (C6) was assessed through students' project output (docu mentary video on Jambi's local wisdom). The project was evaluated using an analytic rubric on a four-point scale, referencing creative thinking indicators such as fluency, flexibility, originality, and elaboration (Almeida et al., 2008; Torrance, 1974). Instrument validity was tested using Pearson's correlation ($p < 0.05$), and reliability was confirmed with a Cronbach's Alpha of 0.71 (good category).

Procedure

The research procedure broadly consists of five main steps: 1) Conducting a problem analysis, which includes the analysis of ethnobiology course learning outcomes, initial student abilities, teaching models/methods used so far, and student learning style preferences. 2) Determining the teaching strategy/model as a solution and outlining it in the research design. 3) Administering a pre-test to evaluate students' initial HOTS before applying the treatment. 4) Applying the treatment in the form of implementing Jambi local wisdom exploration activities through Project-Based Learning with the following syntax (Halvorsen et al., 2018; Hamidah et al., 2020; Lucas, 2021): (a) students formulated essential questions related to local wisdom practices in Jambi to guide their research; (b) designing a plan and creating a schedule, including conducting preliminary observations, selecting of field sites, identifying key informants, reviewing relevant literature, preparing research instruments, and constructing a project timeline; (c) executing and monitoring the project, each group conducted field research, collected data through interviews and participatory observation, and documented and analyzed their findings under the supervision of the lecturer; (d) presenting and evaluating the results, groups compiled their findings into 5–7 minute documentary videos, which were presented in class and evaluated using a rubric assessing creativity; and (e) evaluating the experience, students submitted written reflections on their learning process, challenges encountered, and insights gained from conducting the project. 5) Administering a post-test to measure students' HOTS after the treatment and to compare the results with the pre-test scores.

Data Analysis Techniques

The students' HOTS scores were analyzed using prerequisite and hypothesis tests with SPSS 27 software. The prerequisite test conducted was the Shapiro-Wilk normality test, while the hypothesis test utilized the paired-sample t-test. The extent of the impact of the implementation of Jambi local wisdom exploration activities through project-based learning on students' HOTS was determined based on the effect size score for the t-test (Cohen's d) (Becker, 2000; Ellis, 2010) as shown in Table 2.

Table 2.
Criteria Effect Size for Cohen's d

No	Cohen's d	Effect size
1	0.2—0.4	Small
2	0.5—0.7	Medium
3	≥0.8	Large

RESULTS AND DISCUSSION

Higher education adopts an Outcome-Based Education (OBE) approach, shifting the focus from mere knowledge transmission to the development of 21st-century skills. Among these essential skills are the abilities to analyze, evaluate, and create, which are collectively referred to as Higher Order Thinking Skills. This study investigates students' HOTS achievement following the implementation of project-based learning in exploring local wisdom in Jambi. The outcomes of this exploration were documented in a video documentary with theme "Uncovering Jambi's Local Wisdom Heritage: A Visual Journey." Figure 1 presents the distribution of students' HOTS scores before and after the intervention.

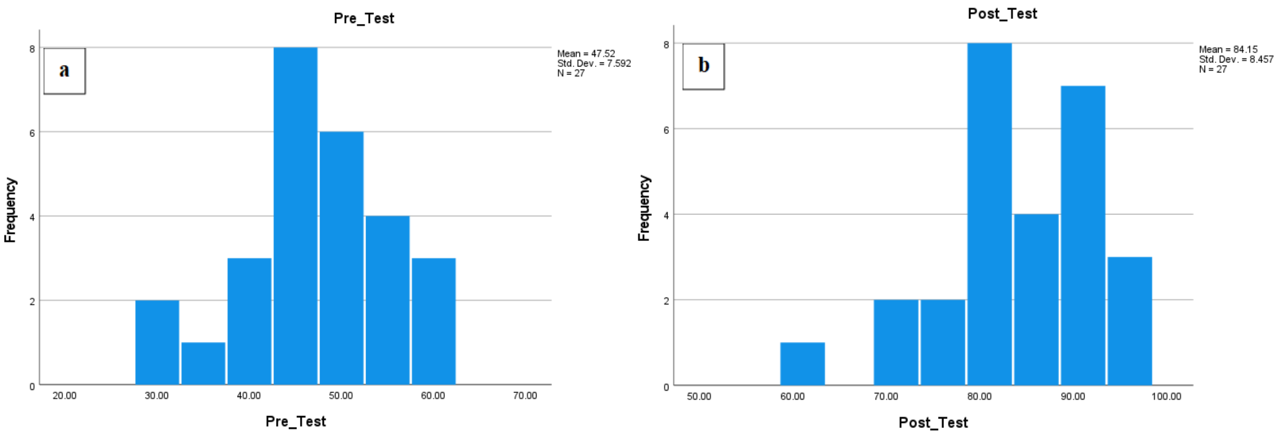

Figure 1. Distribution of students' HOTS scores in the pre-test (a) and post-test (b).

The descriptive statistics presented in Figure 1 show the HOTS scores of 27 students before and after participating in the exploration of Jambi's local wisdom through project-based learning. The results indicate that the average HOTS score before the intervention was 47.52 (SD = 7.59), while the post-intervention score increased to 84.15 (SD = 8.45), reflecting a mean gain of 36.63 points. These findings suggest a substantial improvement in students' HOTS following the intervention. Before conducting hypothesis testing, a Shapiro–Wilk test was performed to assess the normality of the data distribution (see Table 3).

Table 3.
Result of Normality Test

Data	Shapiro-Wilk			Description
	Statistic	df	Sig.	

Difference score of pre-test and post-test	0.942	27	0.139	Normally

The results of the Shapiro-Wilk test in Table 3 indicate that the students' HOTS data are normally distributed [W(27) = 0.942, p = 0.139]. Therefore, the students' HOTS data were analyzed using parametric statistics (paired sample t-test), as presented in Table 4.

Table 4.
Results of Data Analysis Using Paired Sample t-test

Data	t	df	Sig. (2-tailed)	Cohens' d	Description
Students' HOTS score	-27.920	26	<0,001	5.3	High Impact

Table 4 shows a statistically significant difference between the average HOTS scores before (M = 47.33; SD = 8.36) and after (M = 83.62; SD = 9.39) the intervention [t(20) = 23.972; p < 0.001; d = 5.2]. indicating a very large effect size. These results confirm that project-based learning activities involving the exploration of Jambi's local wisdom had a substantial impact on students' higher-order thinking skills. Further analysis of HOTS indicators revealed improvement across all components, including analyze, evaluate, and create skills. Figure 2 presents the comparative data.

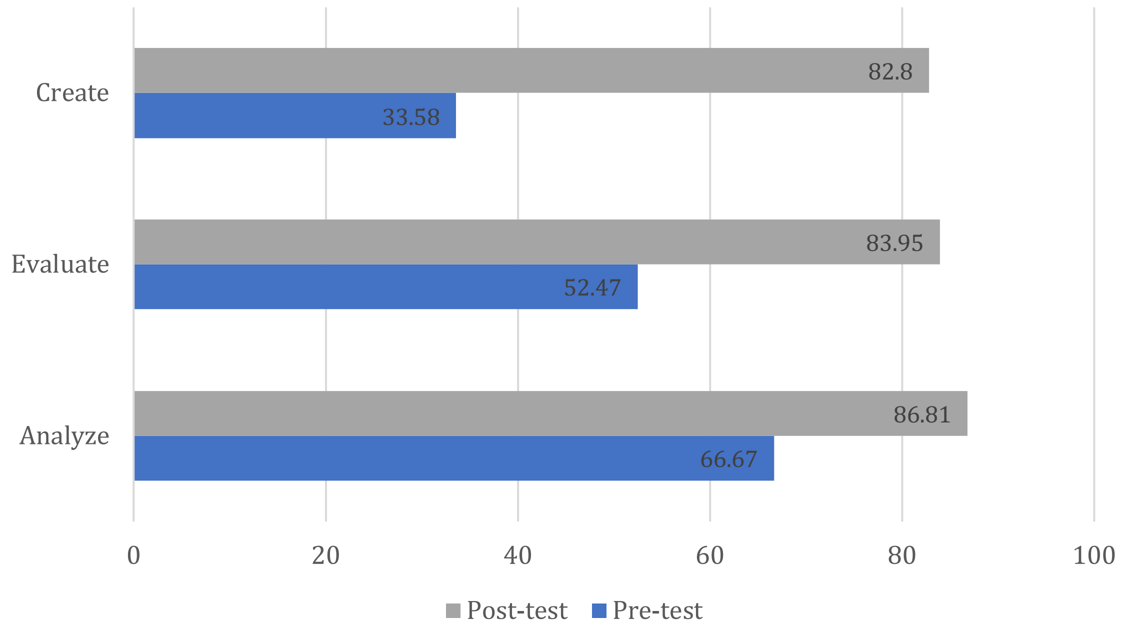

Figure 2. Comparison of HOTS Indicator Achievement Before and After the Intervention

Figure 2 illustrates the improvement in students' HOTS after participating in Project-Based Learning (PjBL). Prior to the intervention, student achievement in HOTS was 66.7% for analyzing, 52.47% for evaluating, and 33.58% for creating. Following the implementation of PjBL, these indicators increased to 86.81% for analyzing, 83.95% for evaluating, and 82.8% for creating. The most substantial improvement was observed in the creating skill (49.22%), followed by evaluating (31.48%) and analyzing (20.14%). These results indicate that the exploration of Jambi's local wisdom through Project-Based Learning was effective in enhancing students' higher-order thinking skills, particularly in analysis (C4), evaluation (C5), and creation (C6). This finding is consistent with previous studies suggesting that project-based learning fosters the development of 21st-century skills such as analytical, critical, and creative thinking (Bell, 2010; Khafah et al., 2023; Rehman et al., 2024; Riyanti, 2024).

The syntax of Project-Based Learning (PjBL) systematically guides students through a progression from analytical to creative thinking. In the initial stage, students formulate essential questions related to socio-cultural phenomena embedded in local wisdom. This not only fosters curiosity but also stimulates analytical thinking in identifying real-world issues related to biological concepts, such as human–environment interactions, biodiversity, and traditional conservation practices. During the project planning phase, students determine the topic of exploration, select informants, design data collection methods, and develop research instruments. These activities sharpen logical and critical decision-making skills. The project implementation stage involves fieldwork that encourages the integration of theory and practice through empirical data collection, analysis, and interpretation, thereby strengthening evaluative and reflective thinking. Subsequently, in the presentation stage, students communicate their research findings through a 3–7-minute documentary video. The video production process, including storyboard development, filming, and scientific narration, integrates biological knowledge, local wisdom, communication skills, and visual aesthetics into an original output that cultivate creative thinking. The final stage, focused on evaluating the learning experience, promotes critical reflection on both the learning process and its outcomes. This fosters metacognitive awareness and reinforces the integration of knowledge, skills, and values within a contextual learning environment.

These findings align with previous research demonstrating that project-based learning enhances students' higher order thinking skills by fostering active engagement, collaboration, complex problem-solving, and critical reflection (Bell, 2010; Husin et al., 2025; Issa & Khataibeh, 2021; Karan & Brown, 2022; Nugroho et al., 2025; Saputri & Maura, 2024). Additionally, projects rooted in local contexts, such as indigenous wisdom, have been found to strengthen the relevance of learning and motivate students to engage in deeper and more creative thinking (Cahyaningsih et al., 2025; Maryanti et al., 2023; Rahman et al., 2023; Wati et al., 2023; Zaki et al., 2024). The evaluation of learning experiences within PjBL further enables students to critically reflect on both the learning process and outcomes, reinforcing the continuous cycle of critical and creative thinking (Rohman et al., 2024; Sumarni & Kadarwati, 2020). Thus, the PjBL syntax holistically provides students with structured opportunities to authentically develop HOTS through meaningful and contextual learning engagement.

The highest improvement in HOTS indicators was observed in the creating aspect (49.22%), compared to the analyzing and evaluating. This finding closely correlates with the characteristics of PjBL syntax, which explicitly guides students to produce a final product in the form of a documentary video. The production process, from planning, filming, and editing to narration, encourages students to synthesize their field exploration findings with visual ideas, scientific narratives, and creative presentation, which are the core elements of the creating skill. The project presentation and evaluation stages further provide students with opportunities to express their understanding in original ways, thereby fostering the development of creative and productive thinking. Previous studies have also highlighted that engagement in authentic product creation within PjBL significantly enhances higher-order thinking skills, particularly in creativity, as students are encouraged to construct innovative and contextually relevant solutions (Asbjornsen, 2015; Billah et al., 2019; Vonny et al., 2023; Yu, 2024).

In addition to the syntax of PjBL that inherently support the development of higher-order thinking skills (HOTS), mini-research activities involving participatory observation of Jambi's local wisdom practices also serve as an essential foundation for students' higher-order cognitive development. When exploring traditional conservation systems or community norms in natural resource management, students are required to analyze indigenous knowledge and relate it with biological concepts, thereby establishing meaningful linkages between empirical findings and scientific theory. Through this process, students also identify real-world issues concerning the sustainability of local wisdom in certain areas, which encourages them to engage in evaluative thinking, such as examining cultural value shifts or the declining use of local resources. They weigh the relevance of traditional practices against contemporary challenges, critically assess their strengths and limitations, and evaluate potential socio-ecological impacts if such practices are abandoned. At the same time, this nurtures students' creative thinking skills to propose context-based solutions (problem-solving creativity), for example by designing educational programs on cultural preservation for schools or developing simple products derived from local resources that remain aligned with cultural values. Thus, direct engagement with local wisdom not only contextualizes learning but also authentically enhances students' analytical, evaluative, and creative abilities.

The exploration of Jambi's local wisdom through the project-based learning model represents an integration of indigenous knowledge into biology education. This approach not only enriches students' perspectives but also serves as a medium to cultivate ecological awareness, cultural values, and 21st-century skills. In this study, the exploration of Jambi's local wisdom through project-based learning provides a contextual and relevant learning experience that enhances the meaningfulness of the educational process. Local wisdom, including the use of medicinal plants, traditional conservation practices, and community interactions with the natural environment, contains authentic biological elements. When examined through scientific approaches, these aspects strengthen students' understanding of key concepts such as ecology, biodiversity, and ethnobotany. Furthermore, integrating local wisdom into learning encourages students to perceive science as an inseparable part of culture and everyday life rather than as abstract, isolated knowledge. This perspective aligns with the principles of culturally responsive pedagogy, which emphasizes the importance of linking educational content to students' local identities and contexts to enhance engagement and knowledge retention (Allen et al., 2017; Chitpin & Karoui, 2021; Gay, 2018). Thus, integrating local wisdom into biology education not only supports academic competence but also fosters a sense of responsibility for environmental conservation and cultural heritage. Both aspects are fundamental components of Education for Sustainable Development (ESD).

These findings have significant implications for higher education, particularly in designing transformative curricula. First, the implementation of project-based learning integrated with local wisdom offers an effective learning model, not only for developing higher-order thinking skills but also for fostering socio-cultural awareness and sustainability literacy. This approach aligns with the learning outcomes framework of outcome-based education, which emphasizes critical thinking, creativity, communication, and ethical reasoning. Second, the final product in the form of a documentary film demonstrates that PjBL can encourage students to create contextually, cultivate a sense of ownership over their learning process, and produce meaningful and socially relevant work. Third, these research findings reinforce the potential for broader applications of PjBL in other courses that focus on local contexts and interdisciplinary integration. Thus, the integration of PjBL based on local wisdom makes a tangible contribution to shaping contextual, transformative, and 21st-century relevant learning.

Although the implementation of PjBL in exploring Jambi's local wisdom has proven effective in enhancing students' higher-order thinking skills, its execution is not without practical challenges. Time constraints within a single semester present a major obstacle, especially as students must balance other academic demands with a project process that requires in-depth stages such as planning, field observation, and product development. Some groups struggled to formulate structured work steps, while others encountered technical difficulties in engaging with local communities, such as limited access to information or a lack of response from informants. Moreover, differences in student motivation and collaboration skills also influenced the dynamics of project implementation, particularly when facing technical challenges in the field, such as accessing informants, documentation, and validating local information. These challenges highlight the importance of intensive mentoring, strengthening collaborative skills, and adaptive instructional planning to ensure the effective implementation of the PjBL Model.

On the other hand, this study employed a quasi-experimental design without a control group, which limits the ability to draw causal conclusions. The small sample size and the focus on a single course also constrain the generalizability of the findings. Therefore, future research is recommended to employ an experimental design with a control group, a larger sample size, and more diverse learning topics to enhance the validity of the results, particularly regarding the effectiveness of PjBL integrated with local wisdom in improving higher-order thinking skills (HOTS). The assessment of HOTS in this study was limited to three core indicators: analyzing and evaluating, assessed through multiple choice test, and creating, assessed through an analytic rubrick, which do not fully capture the processual nature of students' thinking. Thus, further studies should integrate a mixed-methods approach and develop more comprehensive assessment tools that include aspects such as complex problem solving and evidence-based argumentation. This approach is essential to provide a more holistic understanding of the impact of project-based learning on students' thinking skill development.

CONCLUSION

This study demonstrates that the exploration of Jambi's local wisdom through the Project-Based Learning (PjBL) model is effective in enhancing students' Higher-Order Thinking Skills (HOTS), particularly in the aspects of analyzing, evaluating, and creating. The greatest improvement was observed in the ability to create, reflecting the effectiveness of PjBL syntax in encouraging students to produce authentic and contextual products. Project-based learning integrated with local wisdom not only enriches students' biological understanding but also strengthens ecological awareness, cultural values, and sustainability literacy as part of Education for Sustainable Development (ESD). Despite challenges in implementation, such as time constraints, technical obstacles in the field, and variations in students' collaboration skills during fieldwork, this approach remains relevant in supporting contextual and transformative 21st-century learning. Future research is recommended to employ an experimental design with a control group and a more comprehensive assessment approach to obtain a more holistic understanding of HOTS development through PjBL.

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