Psychology, Evaluation, and Technology in Educational Research
8 (1), 2025, 23-34

Available Online: http://petier.org/index.php/PETIER

Etnoscience-based PBL using Subak Bali to shape elementary students' contextual science understanding

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Received: 2 December 2025; Revised: 22 December 2025; Accepted: 23 December 2025

Abstract: This study explores the implementation and challenges of the Etnoscience-Based Problem Based Learning (PBL) model using the Subak Bali Context in shaping science understanding (Force Material) in fourth-grade students at elementary school. Subak is analyzed as an etnoscience-rich irrigation system, providing an authentic context for Deep Learning according to the Merdeka Curriculum. This qualitative study uses a case study design. Data was collected through observation, interviews, and document analysis, including motivation questionnaire response patterns based on Uno's indicators and C4-C5 tests. Strict credibility procedures especially Source Triangulation and Member Checking were used for validation. The results show Etnoscience PBL is effective as a Deep Learning catalyst, evidenced by the C4-C5 narrative quality integrating the concept of Force. The implementation also fosters intrinsic motivation by fulfilling the students' Sense of Belonging. The main challenges found were cognitive focus management and cultural value sensitivity (Member Checking). Mitigation solutions include the Subak Miniature Model (low-cost) and C5 project revision for sustained motivation and HOTS.

Keywords: Problem Based Learning, Etnoscience, Subak Bali, Learning Motivation, Contextual Understanding

How to Cite: Yasa, I. W. D., Jampel, I. N. & Candiasa, I. N. (2025). Etnoscience-based PBL using Subak Bali to shape elementary students' contextual science understanding. *Psychology, Evaluation, and Technology in Educational Research*, *8*(1), 23–34. https://doi.org/10.33292/petier.v8i1.308

INTRODUCTION

Primary education under the implementation of the Merdeka Curriculum demands a fundamental paradigm shift, moving decisively away from simple content memorization toward the cultivation of Higher-Order Thinking Skills (HOTS). This curricular imperative requires students to actively engage in complex cognitive processes, specifically mastering analysis (C4) and evaluation (C5) skills (Aini et al., 2021). The necessity for these high-level skills is particularly pronounced in science learning (Integrated Science) subjects, where true scientific literacy must be anchored in critical reasoning and the ability to connect concepts to the surrounding environment (Amin et al., 2020). Therefore, a major challenge for educators today is finding pedagogical models that can effectively and sustainably trigger this necessary cognitive leap. Identifying and implementing innovative solutions to address the persistent gap between curricular demands and actual student learning outcomes remains an urgent educational priority nationwide (Harefa et al., 2023).

10.33292/petier.v8i.308

Despite these progressive mandates, empirical realities in many elementary schools, including those in the local area, often show that student achievement remains stagnant, largely concentrating at lower cognitive levels (C1-C3). This phenomenon is frequently exacerbated by the continued prevalence of conventional or teacher-centered instructional approaches. Consequently, fundamental science concepts, such as the material on Force, remain abstract and disjointed from students' personal experiences. This severe dislocation between the curriculum and the students' contextual reality directly contributes to a notable decline in their intrinsic learning motivation (Anggreni et al., 2019). Ultimately, low motivation undermines students' willingness to exert the cognitive effort required to break through the analytical and evaluative thresholds (C4-C5) that are the primary objectives of effective science instruction (Darmawati & Mustadi, 2023).

To effectively address this educational stagnation, there is an urgent need to strategically utilize unique and richly endowed cultural and environmental assets. The Subak irrigation system of Bali stands as a magnificent cultural landscape recognized as a UNESCO World Heritage site, embodying an extraordinary blend of hydrological technology, ecology, and the *Tri Hita Karana* philosophy (Saputra et al., 2024). Consequently, Subak should not be viewed merely as a backdrop or tourist attraction but must be integrated as a Living Science Laboratory within the formal educational curriculum (Haris et al., 2019). This integration is vital for the system's cultural preservation, for nurturing a sense of stewardship among youth, and for demonstrating how principles of physics (Force) operate harmoniously within a centuries-old, sustainable system. Leveraging Subak in education thus fulfills an urgent dual need for cultural continuity and enhanced contextual scientific understanding, particularly for students such as those at elementary school Cluster I Bebandem, Karangasem, Bali, Indonesia.

To effectively bridge the gap between abstract concepts and the tangible Subak context, this research adopts the Problem Based Learning (PBL) model as its core pedagogical structure. PBL is globally acknowledged for its robust effectiveness in cultivating critical thinking, problem-solving skills, and collaborative abilities, making it the ideal framework for stimulating HOTS (Sriartha & Kertih, 2020). This model inherently challenges students to engage with authentic and complex problems, which is a key requirement for *Deep Learning* under the Merdeka Curriculum. By framing the core concepts of Force within the real-world operational issues of water management in Subak, PBL transforms students from passive recipients into active scientific investigators.

The established PBL framework is purposefully augmented by the Etnoscience approach, which officially validates and integrates the local, traditional knowledge of Subak as a primary source for scientific inquiry. Etnoscience serves as a vital conceptual mediator, ensuring that the study of Force is directly linked to cultural understanding, such as observing Pressure Force on the *tembuku* (water gate) or Gravitational Force on the terracing (Sanova & Malik, 2023). While the synergistic theoretical potential of PBL and Etnoscience is established, a significant methodological research gap exists regarding the specific processes within the Subak context. Based on the identified urgency and the extant research gaps, this study aims to conduct an implementation process and the inherent challenges of the Etnoscience-Based PBL Model in the Subak context. Ultimately, the findings will yield strategic recommendations for both educators and curriculum developers, enabling them to integrate cultural heritage responsibly and effectively to achieve the high-level *Deep Learning* competencies mandated by the Merdeka Curriculum.

METHODS

This study employed a Qualitative Approach utilizing a Case Study Design to explore the complex, context-specific phenomenon of Etnoscience-Based PBL implementation. The qualitative design was selected to allow for an in-depth, holistic investigation into the *process*, *meaning*, and *challenges* faced by participants, which statistical analyses cannot fully capture. The research was conducted at elementary school at Bali, Indonesia. A primary school located within the cultural proximity of the Subak irrigation system in Karangasem, Bali. The key participants were purposively selected based on their direct involvement in the Etnoscience intervention. These included the Grade IV science teacher (as the primary implementer), the Principal (for institutional context), and a subset of Grade IV Students (as the core informants regarding learning experience and motivation). The duration of the fieldwork was specifically set to cover the entire learning cycle of the Force material, ensuring comprehensive data saturation.

Data collection utilized a Triangulation of Sources technique to enhance the validity and richness of the empirical findings. The three primary data streams were: 1) Participant Observation, where the researcher engaged in Prolonged Engagement during classroom sessions and field visits to the Subak, meticulously recording thick descriptions in field notes concerning student behavior and teacher dynamics; 2) In-depth Interviews, conducted with the teacher and students, focusing on their perceptions of the model's Implementation and the contextual Challenges encountered; and 3) Document Analysis, which included instructional plans and quasi-quantitative instruments (Dantes, 2017). Crucially, the motivation questionnaire (based on Uno's indicators) and the C4-C5 learning outcomes test were treated as qualitative data artifacts, analyzed not for numerical scores, but for the quality of the narrative responses and the discernible patterns of student motivation and cognitive output. This approach ensured all available data contributed to the overall qualitative narrative.

The qualitative data was analyzed using the interactive which involves the cyclical stages of Data Condensation (selecting and focusing the data), Data Display (organizing the information into matrices and charts), and Conclusion Drawing/Verification (Jampel & Puspita, 2017). To establish the study's scientific credibility (Trustworthiness), three specific procedures were applied: First, Prolonged Engagement ensured rapport building and prevented preliminary bias by observing the full science learning cycle. Second, Source Triangulation was systematically used to compare themes across all three sources (teacher vs. student vs. observation notes), explicitly seeking both consistency and discrepancy. Third, Member Checking was performed after initial analysis, where the researcher presented preliminary findings and interpretations back to the key informant (the teacher) for confirmation or correction (e.g., the correction from *logistics* to *cultural-affective values*), ensuring the final results accurately represented the participants' experiences.

RESULTS AND DISCUSSION

Result

Implementation Findings: Concept Penetration through Prolonged Engagement

This sub-section presents the empirical findings from the in-depth exploration of the Etnoscience-Based PBL Model implementation within the Subak Bali context. The core data was collected through Prolonged Engagement, spanning the entire learning cycle of the Force material (totaling eight meetings, including two field visits to the Subak). This intensity of presence allowed the researcher to observe the natural *transformation* in students' understanding, the teacher's dynamics, and the deep integration of the Force concepts—dynamics that are rarely captured through short-term observations. Key findings encompass the shift in language usage, the authentic emergence of HOTS, and the effective use of artifacts as evidence of contextual learning.

Although the motivation questionnaire utilized a Likert scale, in this qualitative study, the instrument was treated as a qualitative data artifact documenting the students' perceptions. The response pattern analysis revealed a strong qualitative indication that the Etnoscience Subak Model successfully engaged students' intrinsic motivation. A discernible clustering of Strongly Agree (SA) and Agree (A) responses was found on items explicitly linking motivation to material relevance and contextual problem-solving experience. For instance, items asking whether *"I feel more enthusiastic science learning when the material can be found in the Subak environment"* and *"I am motivated to seek solutions for water distribution problems in Subak"* showed the highest positive scores. This pattern empirically supports the observation that the field experience successfully cultivated curiosity and problem-solving tenacity, which are hallmarks of effective PBL.

The learning outcomes test, specifically designed to target the C4 (Analysis) and C5 (Evaluation) cognitive dimensions, was also analyzed as a cognitive output document. The analysis focused not on numerical grading, but on the quality of the narrative construction in students' written answers, particularly those requiring contextual explanation. The findings confirmed that students exhibited an exceptional ability to construct C4 and C5 explanations seamlessly integrated with the Subak context. For example, when asked to analyze (C4) the impact of changing water discharge on *Pressure Force*, students consistently utilized Subak terminology to explain the physical phenomenon. This analysis provides robust empirical evidence that the *deep learning* fostered by Etnoscience was successfully translated into written form, demonstrating the solid formation of Contextual Science Understanding.

Table 1. Observed transformation in cognitive and behavioral engagement

Observation Dimension	**Beginning of Cycle (Pre-Subak)**	**End of Cycle (Post-Subak)**
Language Integration	Formal scientific terms (Force, Gravity, Pressure) separate from Subak terms (ulun, teben).	Blending of terminology occurred: Gravity Force was often described as "The Force pulling the water from ulun to teben in the Subak system."
Cognitive Engagement (HOTS)	Tended toward receiving information and describing (C1-C3).	Active Analysis (C4): Students spontaneously questioned the relationship between the slope of the rice paddies and water velocity (Force variables).
Teacher's Role	Predominantly directed activities and provided information.	Shifted to facilitator and exploration partner, provoking open-ended questions: "Which Force principle is the farmer using when operating the traditional hoe?"

The empirical data derived from prolonged observation and the qualitative analysis of documents confirmed that the Etnoscience Subak PBL model successfully transformed the Subak into a genuine "Science Laboratory." Contextual Understanding formed and internalization of Force concepts were deeply rooted through the students' local language. The most compelling evidence lies in the increased HOTS activity (C4) that emerged spontaneously in the field and was reflected in the quality of the C4-C5 test narratives. The transition of the teacher's role from *information provider* to *cognitive challenger* further validates that the model is effective in encouraging self-directed student engagement, aligning perfectly with the core principles of PBL.

Validation Findings: Verification through Source Triangulation

This section presents the verification results for the main findings regarding model effectiveness and implementation challenges through the rigorous procedure of Source Triangulation. This systematic process involved comparing the same qualitative data obtained from three distinct empirical streams: Teacher Interviews, Student Interviews, and Observation Notes. The primary objective was to confirm the internal consistency of the findings and, crucially, to identify discrepancies or conflicting data points. Identifying these discrepancies was vital as it prompted deeper investigation to generate practical and relevant solutions, which forms the basis of the empirical validity in this study.

Table 2. Comparison matrix of key findings and identified discrepancy

Key Finding	Teacher Perspective	Student Perspective	Observation/Project Artifacts
Understanding of Force	"Force concepts are internalized and easily exemplified using the Subak irrigation system."	"Gravity Force is simple now because we see the water flowing down ourselves."	Project document analysis shows an average C4 accuracy regarding Tembuku (water gate) mechanisms reaching 85%.
Implementation Challenge	"Time management is severely impacted because of the Subak location and the long duration of the PBL cycle."	"Sometimes in the rice fields, we forget to learn. We prefer playing in the water, so it's hard to focus on the project."	Observed that student focus and transition time significantly decreased after the first 45 minutes in the field.
Initial Discrepancy	Teacher claimed student motivation was always high.	Students admitted feeling boredom/fatigue if the field trip was too frequent without varying the cognitive tasks.	Observed high physical engagement but corresponding cognitive engagement did not always match the physical activity.
Key Finding	Teacher Perspective	Student Perspective	Observation/Project Artifacts

Source Triangulation successfully strengthened the primary findings regarding the model's success in enhancing Contextual Understanding of Force and confirmed the challenges related to Time and Focus Management. Most significantly, an empirical discrepancy was identified concerning student motivation. The teacher (as the implementer) tended to interpret physical engagement (enthusiasm, water interaction) as inherently high learning motivation. Conversely, the consistent data from student interviews and field observation notes indicated that cognitive involvement risked experiencing saturation when the duration at the Subak site was excessive. This discrepancy is crucial because it suggests that the effectiveness of the Etnoscience PBL Model could decline if the teacher fails to manage the intensity and variation of cognitive tasks. Thus, the real challenge is sustaining the students' cognitive focus amidst a stimulating natural environment.

As a direct and practical response to the identified empirical discrepancy, this research formulated a Follow-up Plan and generated specific Low-Cost and Efficient Sustainable Learning Innovations, all of which are grounded in the triangulation data:

Short-Term Follow-up Plan

Duration and Focus Modification with the Field Flipping Technique. The solution is to structurally shorten the Subak visit duration (e.g., 60 minutes dedicated purely to cognitive investigation) and allocate the remaining PBL time for data analysis and concept synthesis back in the classroom. This strategy directly addresses the consistent findings on time management and student saturation, effectively flipping the primary analysis phase back to the school environment, where focus is more easily managed (Kardoyo et al., 2020).

Sustainable Learning Innovation (Low-Cost)

Development of Miniature Subak Model. To mitigate the issues of logistical costs, travel time, and repetitive field-induced saturation, the innovation involves creating a Miniature Subak Model (Diorama) using simple, low-cost recycled materials for the classroom or schoolyard (Basit et al., 2023). This model serves as a permanent simulation laboratory. This innovation allows students to efficiently and repeatedly test hypotheses related to Gravity Force (slope variation), Pressure Force (gate adjustments), and Friction Force (different materials). By enabling repeated, in-school experimentation, this model is the most practical, cost-effective, and sustainable solution for teachers to facilitate C4 and C5 learning in the context of Etnoscience.

Final Validation Findings: Correcting Interpretation through Member Checking

The Member Checking procedure represents the apex of the validation process, ensuring that the researcher's final interpretations were accurately verified and approved by the key participant (the Grade IV Teacher). This step was critical for eliminating potential researcher bias and correcting initial interpretations that were incomplete or skewed by focusing too heavily on technical observations. In this stage, the researcher presented the draft final findings, specifically those pertaining to challenges and model successes, to the teacher for confirmation or empirical correction, focusing on indicators related to motivation and C4-C5 performance.

Table 3. Empirical Correction and Mitigation Strategy

Variable Indicator	Initial Researcher Interpretation (Skewed/Biased)	Critical Feedback from Key Participant (Teacher)	Final Finding & Mitigation Strategy
Motivation: Persistence & Relevance	The main challenge is Logistics (time and transportation), which reduces persistence and causes quick fatigue.	"Logistics is difficult, but the most essential challenge is Cultural/Value Sensitivity. We must instill the consciousness that Subak is sacred so students' motivation becomes intrinsic and enduring."	Final Finding: The true challenge is Cultural-Affective. Mitigation Strategy: Implement an "Etnoscience Code of Ethics" in the lesson plan to reinforce intrinsic motivation and cultural respect.
HOTS: C4 (Analysis) &	The model succeeded in improving C4 on the technical mechanisms	"Technical C4 success will crumble if students don't feel Subak is theirs (Sense	Final Finding: C4 success must be linked to Cultural Ownership. Mitigation

Variable Indicator	Initial Researcher Interpretation (Skewed/Biased)	Critical Feedback from Key Participant (Teacher)	Final Finding & Mitigation Strategy
C5 (Evaluation)	of Subak (Pressure Force, Friction).	of Belonging). We need to push C5 on sustainability issues."	Strategy: Revise the PBL module to focus the project theme on "How to Save Subak?" (a C5 problem), forcing students to evaluate and create solutions.

The Member Checking process yielded profound and essential corrections, successfully dismantling the researcher's initial skewed interpretation that prioritized technical aspects (logistics) over sociocultural and affective values.

Correction on Skewed Motivation Indicators (Affective)

The researcher's initial conclusion that the problem lay in Logistics (affecting *persistence*) was contradicted by the teacher's empirical experience. The teacher corrected the finding to Cultural Challenge, stating that logistical fatigue was less severe than the risk of undermining the Etnoscience value if Subak was treated merely as a playground. This correction generated the Affective Mitigation Strategy: All Subak activities must commence with cultural value immersion to cement intrinsic motivation driven by cultural responsibility, rather than mere interest in the activity itself (Jampel et al., 2018).

Correction on Skewed Learning Outcomes Indicators (Cognitive C4-C5)

The researcher's initial satisfaction with the observed increase in Analysis (C4) of Subak mechanisms was corrected by the teacher's demand for a leap to Evaluation (C5). This critical feedback shifted the focus from merely understanding *how* Subak works to *how to preserve* Subak, requiring C5-level thinking on sustainability (Ekayanti et al., 2019). This generated the Cognitive Mitigation Strategy: The PBL project themes must be revised from technical analysis to sociological solutions based on scientific principles (Bağ & Gürsoy, 2021). This guarantees that students are compelled to *evaluate* and *synthesize* (C5), thereby confirming the highest level of competency attainment in the context of the Merdeka Curriculum.

Discussion

Functional Proof of the Model: Subak as Context and Problem Based Learning

The discussion begins by firmly substantiating the findings from the Prolonged Engagement (Results Sub-section A) which empirically established that Subak Bali functions effectively as a Living Science Laboratory. This conclusion moves the understanding of Subak beyond a mere cultural heritage site to a robust, dynamic learning environment. The implementation demonstrated that the rich, authentic setting of the irrigation system spontaneously stimulates curiosity and fosters continuous inquiry, fundamentally altering the traditional classroom dynamics and setting the stage for authentic scientific engagement (Haris et al., 2019). This immediate physical and cultural immersion is the crucial first step that validates the entire Etnoscience-PBL framework.

Empirical evidence, such as the finding that the concept of Force was seamlessly internalized by students using local terminology (*ulun* for upriver and *teben* for downriver), strongly confirms the crucial mediating role of Etnoscience. The Subak context successfully transformed the abstract and often hypothetical problems typically found in standard PBL modules into authentic, meaningful problems directly relevant to the students' community and identity (Ramdani et al., 2021). This transformation adheres strictly to the core principle of PBL theory, which mandates that learning must be driven by real-world problem-solving to be effective. Through Etnoscience, the *deep learning* process is initiated by creating a cognitive bridge, allowing students to access and process modern scientific principles through familiar cultural schemas (Iriani & Kurniasih, 2019).

The utilization of Subak effectively addresses the persistent gap between the demands of the modern curriculum (requiring mastery of physics concepts like Force) and the deep reservoir of local Balinese wisdom. By grounding the study of Force principles in the operational reality of the Subak system, the research supports the core arguments of Etnoscience experts, who advocate for the integration of indigenous knowledge systems into education. This approach ensures that scientific learning does not alienate students from their culture but rather utilizes their heritage as a powerful foundation for scientific understanding (Dewi et al., 2018). Furthermore, it validates the use of cultural assets as legitimate, high-quality educational resources, reinforcing the value of cultural preservation alongside intellectual development, which aligns perfectly with the holistic goals of the Merdeka Curriculum (Fadilla et al., 2021).

Table 4. Theoretical justification for Subak as a context for force material

Science (Force) Concept	**Scientific Principle in Subak Context**	**Etnoscience Terminology as Mediator**	**Theoretical Justification**
Gravitational Force	Water consistently flows from a higher point (Subak head/dam) to lower-terraced paddies, illustrating the pull of gravity and its effect on irrigation.	*Ulun (upstream) and Teben (downstream)*	Grounding abstract force vectors in spatial, culturally defined directionality, making gravity an observable, predictable phenomenon.
Pressure Force	The mechanism of the Tembuku (water division gate) and water flowing through narrow, regulated channels, demonstrating how cross-sectional area affects water velocity and pressure distribution.	*Tembuku and the concept of Nyukcuk (precise water allocation)*	Linking the physical principle of pressure regulation to the cultural principle of equitable water sharing, forcing C4 analysis on design and function.

Contextual Understanding and the Reinforcement of HOTS (C4-C5)

The empirical finding that students possess the ability to construct C4 and C5 explanations seamlessly integrated with the Subak system proves that contextual instruction significantly supports Deep Learning. This achievement aligns directly with the philosophical underpinnings of the Merdeka Curriculum, which prioritizes profound understanding over superficial retention.

Vygotsky's Sociocultural Theory

This phenomenon is best understood through Vygotsky's Social Constructivism, where knowledge is not passively absorbed but actively constructed through interaction with the environment (Subak) and culture. The C4-C5 proven understanding suggests that the Subak intervention acted as a cognitive catalyst, enabling students to operate within their Zone of Proximal Development (ZPD) (Zajda, 2023).

Cognitive Structure Transformation

The experience of observing how Force principles (gravity, pressure) determine the efficiency of the Subak successfully alters the students' cognitive structure. The ability of students to consistently use local terms to explain complex physics implies that they have internalized and contextualized the scientific rules, moving their cognitive engagement from mere application (C3) to authentic scientific analysis (C4) and evaluation (C5) of system effectiveness and sustainability (Kasanah & Pratama, 2024).

The analysis of the motivation data revealed a strong correlation: high motivation clustered around items related to contextual problem-solving. This finding supports the argument that increased relevance, established through Etnoscience, directly drives intrinsic motivation, which is the necessary precursor for sustained cognitive effort.

HOTS as Energy Output

According to cognitive theory, achieving HOTS (C4-C5) requires significant cognitive energy output. This energy is sustained not by external rewards (extrinsic motivation) but by a deep-seated desire to master the content (intrinsic motivation) (Widiana & Jampel, 2016).

Etnoscience and Sense of Belonging

The findings from the *Member Checking* procedure, which highlighted the critical importance of the students' Sense of belonging toward Subak, provide the theoretical link. When students perceive the material as relevant to *their* heritage (Etnoscience), it fulfills their psychological need for Relatedness (Self-Determination Theory). This internal drive—the feeling of responsibility to analyze and protect their cultural asset—is what compels students to dedicate the sustained cognitive effort required to perform at the analytical (C4) and evaluative (C5) levels (Meeuwisse et al., 2010). The motivation, therefore, is rooted in cultural stewardship.

Contextual Force Implication on Learning Motivation Outcomes

The empirical implementation of the Etnoscience Subak PBL Model successfully fulfilled the three basic psychological needs proposed by Self-Determination Theory (SDT), which is essential for fostering high-quality, intrinsic motivation (Table 5).

Table 5. Implications of Subak etnoscience on deep learning and student motivation

SDT Basic Psychological Need	Empirical Fulfillment in Subak Context	Theoretical Outcome
Competence	Students gained confidence and felt capable of understanding Force principles because they could repeatedly test and verify the concepts directly within the functional Subak system.	Increased Self-Efficacy regarding science concepts.
Autonomy	The PBL cycle allowed students control over their inquiry process, requiring them to independently solve real-world problems related to water distribution and Pressure Force in Subak.	Enhanced Self-Initiative and ownership over the learning process.

Relatedness	The integration of Subak fulfilled the student's need to feel deeply connected to their local culture, community, and heritage, validating their personal identity within the learning process.	Stronger Sense of Belonging and cultural validation.

Motivation Shift Towards Cultural Value-Based Outcomes

The most significant affective finding of this study is the qualitative shift observed in student motivation, which moved away from a reliance on an extrinsic reward system toward one fundamentally based on internalized cultural values. This profound shift was verified through the Member Checking procedure, where the teacher's critical feedback confirmed that the genuine challenge was not rooted in the visible logistical difficulty of the field trip but in the more subtle issue of cultural value sensitivity. This suggests that learning motivation was sustained not merely by the temporary enjoyment of playing in the water, but by a deep-seated sense of responsibility toward the UNESCO heritage site (Surata & Vipriyanti, 2018). This finding empirically proves that for Etnoscience to be truly effective, the pedagogical design must prioritize affective outcomes that align with cultural preservation.

The successful cultivation of value-based motivation highlights the model's profound impact on character education, aligning with the holistic goals of the Merdeka Curriculum. By grounding the study of Force in the functionality of the Subak, the Etnoscience model successfully used scientific education as a vehicle for cultivating responsible cultural stewardship. This outcome, driven by the internalization of cultural values, represents the highest affective goal achievable in character development. The results thus demonstrate that the Etnoscience-Based PBL model's contribution extends far beyond mere cognitive improvement, offering a sustainable mechanism for fostering deeply responsible and scientifically literate citizens, surpassing the limited impact of traditional, extrinsic reward-based motivation.

CONCLUSION

The findings of this rigorous qualitative study confirm that the Etnoscience-Based Problem Based Learning (PBL) Model effectively serves as a catalyst for Deep Learning and meets the high-level HOTS (C4-C5) objectives of the Merdeka Curriculum, thereby fully achieving the research goals. Empirical evidence, derived from Source Triangulation, demonstrated the model's success through the sustained C4-C5 narrative quality in learning outcomes and a significant cultivation of intrinsic motivation, validating the students' Sense of Belonging towards the Subak system. A key theoretical contribution emerged when Member Checking corrected the main implementation obstacle, proving that the true challenge was not logistical, but a crucial issue of cultural-affective sensitivity, which highlights the necessity of anchoring motivation in internalized values (Self-Determination Theory). Consequently, the final conclusion affirms the model's validity but necessitates specific action: future implementation must incorporate the Miniature Subak Model as a low-cost innovation to manage cognitive focus and systematically revise PBL themes to address C5 sustainability issues, ensuring the model continues to foster responsible cultural stewardship alongside scientific literacy.

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