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Integration of Traditional Ecological Knowledge in Problem-Solving Model: Its Impact on Students' Learning Outcomes and Environmental Awareness

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ABSTRACT
Students' low academic achievement and limited environmental awareness suggest that biology instruction has not yet fully supported the development of both conceptual understanding and environmental responsibility. In many cases, learning also remains disconnected from students' local contexts, particularly from Traditional Ecological Knowledge(TEK), which can make scientific concepts feel less meaningful and relevant to their everyday lives. Addressing this gap requires learning approaches that are both contextual and engaging. Therefore, this study aims to examine the impact of integrating TEK into the Problem Solving model on students' learning outcomes and environmental awareness. This study employed a quasi-experimental method with a post-test only control group design. The sample consisted of two groups of 10th-grade students at SMA Negeri 4 Payakumbuh, namely an experimental class and a control class. The instruments used included a learning outcome test and an environmental awareness questionnaire, both of which had been validated. Data were analyzed using independent sample t-tests and descriptive analysis. The results showed that students in the experimental class achieved higher average learning outcomes (83.69) compared to those in the control class (78.57), with a statistically significant difference at the 0.05 level (t-calculated = 2.45 > t-table = 1.67). In terms of environmental awareness, students in the experimental class also demonstrated higher scores, particularly in the knowledge aspect (81.80 vs. 73.37) and critical awareness (73.85 vs. 67.24). However, improvements in the attitude and behavior aspects were relatively modest.
These findings suggest that integrating TEK into the Problem Solving model can effectively enhance students' cognitive outcomes and their critical awareness of environmental issues. Nevertheless, fostering changes in environmental attitudes and behaviors may require more sustained and long-term educational interventions.

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INTRODUCTION

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Education plays a strategic role in shaping a generation that not only masters scientific concepts but is also capable of critical thinking, problem-solving, and caring for the environment. In the context of biology learning in upper secondary schools, these objectives require a learning process that can link scientific concepts to the realities of students' lives, thereby making learning meaningful and relevant (Kamila & Waluya, 2023). However, in practice, biology teaching often fails to fully develop these skills to their full potential.

Various innovative learning models such as Problem Solving, Creative Problem Solving, and Reciprocal Teaching have been developed to enhance student engagement and higher-order thinking skills. In line with constructivist theory, learning is more effective when students construct their knowledge through meaningful and contextual experiences, including through integration with local culture and knowledge (Susanti et al., 2024). In this context, Traditional Ecological Knowledge (TEK) emerges as a promising approach, as it embodies local wisdom in environmental management that is relevant to students' lives.

However, conditions on the ground reveal a gap between expectations and learning practices. Findings derived from classroom observations and interviews conducted at Payakumbuh State Senior High School No. 4 reveal that biology instruction remains predominantly teacher-centred, relying heavily on lectures and presentations with minimal active student participation. This instructional approach has contributed to suboptimal student learning outcomes, which have not yet met the Learning Objective Achievement Criteria (KKTP), and is associated with limited development of students' critical thinking and problem-solving skills. Moreover, the teaching practices have not adequately incorporated local contextual elements, resulting in students' insufficient understanding of the relevance of biological concepts to their immediate environment. These findings are in line with prior studies suggesting that teacher-centred pedagogies tend to diminish student motivation and engagement (Collins et al., 2021; Zendrato & Andriani, 2023).

In contrast, contemporary educational challenges extend beyond mere conceptual understanding to include the development of students' environmental awareness as a key component in supporting sustainable development. Environmental awareness involves the integration of knowledge, attitudes, and behaviours in addressing increasingly complex environmental issues. Nevertheless, existing research shows that students' levels of environmental awareness are generally still in the low to moderate range ((Saylor et al., 2017; Zulyetti et al., 2024). This condition is largely attributed to instructional practices that emphasize cognitive achievement while lacking contextual and meaningful learning experiences. As a result, students often grasp environmental concepts at a theoretical level but struggle to apply them in real-life situations. This suggests that biology instruction should be systematically designed not only to enhance academic achievement but also to foster students' environmental awareness holistically.

The Problem Solving model is widely regarded as a relevant instructional approach for addressing these challenges, as it facilitates the development of students' critical thinking and problem-solving skills. Although this model has been demonstrated to be effective in improving learning outcomes, its implementation has rarely been linked to the enhancement of students' environmental awareness and has not been systematically integrated with Traditional Ecological Knowledge (TEK). In fact, TEK holds considerable potential for fostering ecological values and strengthening students' environmental literacy (Saylor et al., 2017; Zulyetti, 2024). Therefore, there is a clear need for studies that integrate instructional models, local wisdom, and the development of environmental awareness within a coherent and comprehensive learning framework.

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Building on the foregoing arguments, there is a compelling need to design instructional approaches that extend beyond the enhancement of academic achievement to deliberately cultivate students' environmental awareness through contextualized and meaningful learning experiences. In response to this need, the present study aims to critically examine the effects of integrating Traditional Ecological Knowledge (TEK) into the Problem Solving model on both students' learning outcomes and their environmental awareness. This study is significant not only because it evaluates gains in academic performance, but also because it provides deeper insight into how pedagogical approaches grounded in local wisdom can meaningfully and sustainably shape students' environmental awareness.

METHOD

This study employed a quasi-experimental design with a post-test only control group design, in which the experimental class of 36 students was treated with a Problem Solving model integrated with Traditional Ecological Knowledge (TEK), whilst the control class, also comprising 36 students, was taught using a conventional model supported by PowerPoint (PPT) presentations. The effect of the treatment was analysed by comparing the final results between the two groups. The research instruments consist of two types, namely: (1) an objective test to measure students' biology learning outcomes, and a questionnaire designed to measure several key dimensions of environmental awareness, adapted from Adriyanto et al., 2021; Arı & Yılmaz, 2017, namely: (1) knowledge (environmental knowledge) regarding environmental issues, (2) attitudes (environmental attitudes) towards environmental protection and conservation efforts, (3) behaviour (environmental behaviour) reflecting concrete actions in daily life, and (4) critical awareness (critical environmental awareness) in understanding and responding to environmental issues reflectively. Data collection was carried out by administering a post-test to measure learning outcomes and distributing a questionnaire to measure students' environmental awareness after the intervention. The research data were analyzed through prerequisite tests, including tests of normality and homogeneity, followed by hypothesis testing using an independent samples *t*-test at a significance level of 0.05 to determine differences in learning outcomes between the experimental and control groups. Meanwhile, data on environmental awareness were analyzed descriptively by comparing the mean scores of each aspect across the two groups.

RESULTS AND DISCUSSION

The impact of implementing the Problem Solving model integrated with Traditional Ecological Knowledge (TEK) was examined through analyses focused on students' learning outcomes as indicators of their conceptual understanding in biology, as well as through the analysis of environmental awareness questionnaire data completed by the students. Learning outcomes serve as a key indicator in assessing the extent to which the instructional process enhances students' cognitive mastery of concepts. Accordingly, a series of statistical analyses, including prerequisite tests and hypothesis testing, were conducted to compare the learning outcomes between the experimental and control groups.

Impact on Students' Learning Outcomes

Prior to hypothesis testing, prerequisite analyses were conducted, namely tests of normality and homogeneity on the students' learning outcome data. The results of the normality test for both groups are presented in Table 1.

Table 1. Results of Normality Test for Learning Outcome Data

Group	N	α	L_0	L_t	Interpretation
Experimental	31	0.05	0.01929	0.16	Normal
Control	30	0,05	0,02237	0,16	Normal

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Based on Table 1, it can be seen that $L_0 < L_t$ for both groups; therefore, it can be concluded that the students' learning outcomes in the experimental and control classes are normally distributed. Furthermore, the results of the test for homogeneity of variance between the two groups are presented in Table 2.

Table 2. Results of Homogeneity Test for Learning Outcome Data

Group	N	Variance	F_calculated	F_table	Interpretation
Experimental	31	7.31	1.58	1.84	Homogeneous
Control	30	9.27			Homogeneous

The analysis indicates that F_calculated < F_table (1.58 < 1.84), suggesting that the variances of the two groups are homogeneous. Since the data are both normally distributed and homogeneous, hypothesis testing was conducted using an independent samples *t*-test. The results show that the value of t_calculated = 2.45 with degrees of freedom (df) = 59, while t_table at a significance level of 0.05 is 1.67. Thus, t_calculated > t_table (2.45 > 1.67), leading to the rejection of H_0 and acceptance of H_1. The mean learning outcome score of students in the experimental group was 83.69, which is higher than that of the control group at 78.57. These findings indicate that the implementation of the Problem Solving model integrated with Traditional Ecological Knowledge (TEK) has a statistically significant effect on improving students' learning outcomes.

Impact on Students' Environmental Awareness

The analysis of students' environmental awareness in this study was conducted to determine the extent to which the implemented learning not only impacts cognitive aspects but also the affective and behavioural dimensions related to environmental concern. Environmental awareness was measured using a questionnaire completed by students after participating in the learning process. The main aspects of environmental awareness measured were knowledge, attitudes, behaviour, and critical awareness. This analysis aimed to identify differences in environmental awareness profiles between the experimental and control classes following the implementation of the learning programme. The results of the comparison of average environmental awareness scores for both groups are presented in Table 3.

Tabel 3. Comparison of Students' Environmental Awareness Mean Scores in the Experimental and Control Groups

Aspect	Experimental	Control	Difference
Knowledge	81.80	73.37	8.43
Attitudes	73.35	71.98	1.37
Behavior	72.05	71.34	0.71
Critical	73.85	67.24	6.61

Table 3 indicates that the experimental group consistently outperformed the control group across all dimensions of environmental awareness. The largest disparities were observed in the knowledge (Δ = 8.43) and critical awareness (Δ = 6.61) aspects, suggesting that the integration of Traditional Ecological Knowledge (TEK) within the learning process is particularly effective in strengthening students' conceptual understanding and reflective

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engagement with environmental issues. In contrast, the differences in the attitudes and behavior aspects were comparatively modest.

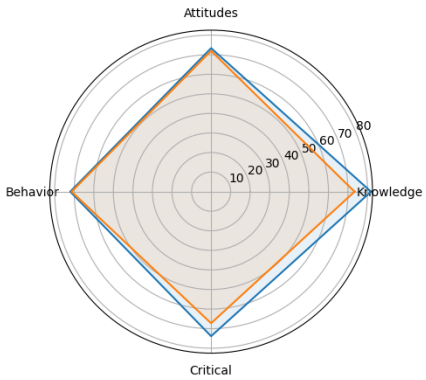

Figure 1. Profile of students' environmental awareness in the experimental class (blue line) and control class (orange line)

These findings are further illustrated in Figure 1, which visually demonstrates that the experimental group attained higher scores across all environmental awareness dimensions than the control group. The most pronounced gaps appear in the knowledge and critical awareness aspects, whereas the differences in attitudes and behavior remain relatively limited. The radar chart illustrates that the experimental group achieved higher scores across all dimensions of environmental awareness compared to the control group. The most pronounced differences are evident in the knowledge and critical awareness aspects.

The findings of this study demonstrate that the application of a Problem-Solving model integrated with Traditional Ecological Knowledge (TEK) exerts a significant effect on students' biology learning outcomes. The experimental group achieved a higher mean score (83.69) compared to the control group (78.57), suggesting that contextualized problem-solving instruction, connected to students' real-life environments, is more effective in promoting deeper conceptual understanding. These results are consistent with prior studies indicating that problem-solving approaches enhance students' cognitive performance (Liska et al., 2021)

The application of the Problem Solving model has been shown to promote higher levels of cognitive engagement through activities such as problem identification, analysis, and decision-making. This stands in contrast to conventional instructional approaches, which tend to be more passive, with students primarily receiving information from the teacher (Zendrato & Andriani, 2023), a condition that has been associated with decreased motivation and lower learning outcomes (Susanti et al., 2024). Learning activities implemented in the experimental group were effective in enhancing students' cognitive engagement, which, as highlighted by (Hattie, 2008) is a key factor influencing improvements in learning outcomes. This finding is further supported by research of Sarkity et al., (2025), which emphasizes that problem-based learning promotes active student involvement through engagement with real-world problems, collaboration, and meaningful learning processes . Such characteristics make problem-oriented learning approaches particularly relevant for developing 21st-century skills.

Accordingly, the integration of a problem-based approach with local contextual elements through TEK creates a more active and meaningful learning environment. The incorporation of TEK functions as a contextual bridge that connects scientific concepts with students' lived experiences, thereby facilitating the process of knowledge construction (Sumarwati & Anindyarini, 2017). Within this framework, context-based learning experiences

enable students to understand ecosystem concepts not merely at an abstract level, but also through real-world practices familiar in their daily lives. Furthermore, the inclusion of indigenous knowledge within formal education, as recommended by (Zulyetti et al., 2025), equips students with pro-environmental attitudes, indicating that this approach contributes not only to improved learning outcomes but also to the development of ecological awareness.

In addition to enhancing academic achievement, the findings of this study also demonstrate that the integration of TEK within the Problem Solving model, implemented using the syntax proposed by (Gerson Ratumanan & Ayal, 2021), has a positive impact on students' environmental awareness, particularly in the domains of knowledge and critical awareness. This suggests that the learning process not only strengthens conceptual understanding but also enhances students' capacity to reflect on and critically evaluate environmental issues in a more comprehensive manner. TEK also integrated in biology material. Moreover, prior research (Saleh & Arya, 2025) demonstrates that the use of diverse instructional materials significantly enhances students' learning outcomes.

Based on the radar chart presented in Figure 1, the environmental awareness profile of students in the experimental group forms a consistently larger area compared to that of the control group across all assessed dimensions. This pattern indicates that students who engaged in learning integrated with Traditional Ecological Knowledge (TEK) demonstrate a higher overall level of environmental awareness. The most pronounced differences are observed in the knowledge and critical awareness dimensions, where the experimental group's curve extends substantially beyond that of the control group, reflecting notable gains in both conceptual understanding and the ability to critically analyse and respond to environmental issues. The improvement in the knowledge dimension suggests that the integration of TEK effectively enriches students' understanding of environmental concepts through a contextualized approach. As a knowledge system developed through long-term interactions between humans and their environment, TEK offers a more holistic perspective in interpreting ecological phenomena (Sinthumule, 2023). This perspective is consistent with the view of (Berkes, 2018; Berkes et al., 1995) who emphasizes the important role of TEK in fostering ecological awareness due to its contextual grounding and its basis in community-based experiences.

Overall, the radar chart indicates that the impact of learning is more pronounced in the cognitive and critical awareness domains than in the affective and behavioural domains. This finding is consistent with the research by Hungerford and Volk (1990), which states that changes in environmental behaviour do not occur instantly, but rather require repeated experience, emotional engagement, and social support. In this regard, classroom instruction primarily establishes a cognitive foundation, while meaningful behavioral change necessitates sustained and long-term efforts. The integration of Traditional Ecological Knowledge (TEK) within the Problem Solving model can therefore be considered an effective initial step in strengthening students' environmental awareness, particularly in the cognitive and critical dimensions. However, fostering more observable changes in attitudes and behavior requires the implementation of sustained instructional strategies, such as project-based learning, field-based activities, and active student participation in environmental initiatives.

Despite these contributions, this study is not without limitations. These include the relatively limited instructional time and the fact that the integration of TEK has not been fully contextualized to the students' immediate local environment. Accordingly, future research should focus on developing more sustainable and contextually grounded learning designs, as

well as incorporating experiential learning activities to more effectively promote changes in students' environmental attitudes and behaviors.

CONCLUSION

Based on the findings, it can be concluded that the implementation of the Problem Solving model integrated with Traditional Ecological Knowledge (TEK) has a significant effect on students' biology learning outcomes. This is evidenced by the higher mean scores achieved by the experimental group compared to the control group, as well as the statistical test results indicating a significant difference between the two groups. Therefore, this instructional approach has proven effective in enhancing students' cognitive understanding of biological concepts.

In addition, the integration of TEK within the Problem Solving model also exerts a positive influence on students' environmental awareness. The most substantial improvements were observed in the knowledge and critical awareness dimensions, indicating that the learning process successfully strengthens both students' conceptual understanding and their reflective capacity in addressing environmental issues. However, the relatively smaller gains in the attitudes and behavior dimensions suggest that changes in affective and behavioral aspects require a more sustained and long-term process.

REFERENCES

Adriyanto, Y. N., Martono, D. N., Soesilo, T. E. B., & Nadiroh. (2021). Environmental awareness at senior high school in Jakarta. *IOP Conference Series: Earth and Environmental Science*, *716*(1). https://doi.org/10.1088/1755-1315/716/1/012046

Arı, E., & Yılmaz, V. (2017). Effects of environmental illiteracy and environmental awareness among middle school students on environmental behavior. *Environment, Development and Sustainability*, *19*(5), 1779–1793. https://doi.org/10.1007/s10668-016-9826-3

Berkes, F. (2018). *Sacred Ecology Fourth Edition*.

Berkes, F., Folke, C., & Gadgil, M. (1995). *Traditional Ecological Knowledge, Biodiversity, Resilience and Sustainability*. Kluwer Academic Publisher

Collins, S. P., Storrow, A., Liu, D., Jenkins, C. A., Miller, K. F., Kampe, C., & Butler, J. (2021). Penerapan Metode Studi Kasus Dalam Penelitian Kualitatif. 5(2), 167–186.

Gerson Ratumanan, T., & Ayal, C. S. (2021). *Introduction to Problem Solving Based Learning Model*.

Hattie, J. (2008). *Visible Learning A Synthesis of Over 800 Meta-Analyses Relating to Achievement*. 1–392.

Hungerford, H. R., & Volk, T. L. (1990). Changing learner behavior through environmental education. *The Journal of Environmental Education*, 21(3), 8–21. https://doi.org/10.1080/00958964.1990.10753743

Kamila, S. H., & Waluya, S. B. (2023). Systematic Literature Review: Model Pembelajaran Dalam Meningkatkan Kemampuan Berpikir Kritis Pada Pembelajaran Matematika. Prosiding Seminar Nasional OPPSI 2023, 2, 8 21.

Liska, Ruhyanto, A., & Yanti, R. A. E. (2021). Penerapan Model Pembelajaran Problem Solving Untuk Meningkatkan Kemampuan Berpikir Kritis Siswa. In *Jurnal Keguruan dan Ilmu Pendidikan)* (Vol. 2, Number 3).

Saleh, A. R., & Arya. (2025). Meta-Analisis Pengaruh Bahan Ajar Terhadap Hasil Belajar Biologi Siswa SMP dan SMA Di Indonesia. In *Biology And Education Journal* (Vol. 5, Number 2). https://doi.org/10.25299/baej.2025.21694

Sarkity, D., Pratama, Y., Pemberdi Intasir, M., Studi Pendidikan Biologi, P., Maritim Raja Ali Haji, U., & Riau, K. (2025). Evaluasi Kesesuaian Penerapan Problem-Based Learning dalam Perkuliahan Microteaching: Studi pada Calon Guru Biologi. In *Biology And Education Journal* (Vol. 5). https://doi.org/10.25299/baej.2025.22243

Saylor, C. R., Alsharif, K. A., & Torres, H. (2017). The importance of traditional ecological knowledge in agroecological systems in peru. *International Journal of Biodiversity Science,*

Ecosystem Services and Management, *13*(1), 150–161. https://doi.org/10.1080/21513732.2017.1285814

Sinthumule, N. I. (2023). Traditional ecological knowledge and its role in biodiversity conservation: a systematic review. In *Frontiers in Environmental Science* (Vol. 11). Frontiers Media SA. https://doi.org/10.3389/fenvs.2023.1164900

Sumarwati, & Anindyarini, A. (2017). Proceeding of 2nd International Conference of Arts Language And Culture THE IMPORTANCE OF TRADITIONAL ECOLOGICAL KNOWLEDGE TAUGHT IN RURAL PRIMARY SCHOOL. *Proceeding of 2nd International Conference of Arts Language And Culture*.

Susanti, S., Aminah, F., Assa'idah, I. M., Aulia, M. W., & Angelika, T. (2024). Dampak Negatif Metode Pengajaran Monoton Terhadap Motivasi Belajar Siswa. PEDAGOGIKJurnal Pendidikan Dan Riset, 2(2), https://journal.ummat.ac.id/index.php/fkip/article/view/10044/pdf 86–93.

Zendrato, E., & Andriani Zega, N. (2023). 18382-Article Text-60466-1-10 20230921. Penerapan Model Pembelajaran Problem Solving Untuk Meningkatkan Hasil Belajar Biologi Peserta Didik Kelas Xi Sma Negeri 1 Lahewa, 6 Nomor 3,(3), 521–527.

Zulyetti, D., Festiyed, & Lufri. (2024). Empowering Traditional Ecological Knowledge throught Project Based Learning Models to Enhancing Students'Environmental Literacy. *EASE Letters*, *3*(2).

Zulyetti, D., Wiyaguna, D., Lufri, L., Andromeda, A., & Mufit, F. (2025). Comparative analysis of environmental awareness among students in senior high schools, vocational schools, and islamic schools: Implications for enhancing naturalistic intelligence. *DWIJA CENDEKIA: Jurnal Riset Pedagogik*, *9*(1), 87. https://doi.org/10.20961/jdc.v9i1.97546