Id: 1663413

Participatory Educational Research (PER)
Vol.12(6), pp. 108-122, November2025
Available online at http://www.perjournal.com
ISSN: 2148-6123
http://dx.doi.org/10.17275/per.25.81.12.6

# Strengthening Conservation Literacy through Integrating Local Wisdom into Problem-Based Learning in Secondary School Students

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**Article history**

**Received:**
23.03.2025

**Received in revised form:**
09.06.2025

**Accepted:**
28.08.2025

**Key words:**
conservation literacy; high school; local wisdom; problem-based learning

The purpose of this study was to explore the impact of problem-based learning (PBL) integrated with local wisdom on conservation literacy among high school students. This study used a quasi-experimental method, which compared students in the intervention and control group using pre- and post-assessments with the Conservation Literacy Assessment instrument for ten weeks.A total of 96 students from an Indonesian senior high school participated in this study.The intervention group engaged in PBL integrated with local wisdom, which consisted of three phases: (1) problem identification and local wisdom integration, (2) collaborative investigation and local wisdom exploration, (3) critical presentation and local value reflection. In contrast, the control group received the traditional teaching method. The results showed that the intervention group had significantly higher conservation knowledge and attitude, whereas the control group had moderately higher knowledge but no change in attitude. These findings suggested that integrating local wisdom in PBL bridges the preservation of cultural heritage and can also strengthen conservation knowledge and attitude. Therefore, this study recommended to educators that PBL should be integrated with local wisdom to foster conservation literacy among secondary school students and highlighted the urgency of future research to identify local wisdom values to be integrated into the curriculum to support student learning.

## Introduction

Helping students develop conservation literacy has become a global agenda to support using and managing natural resources more sustainably (Børresen et al., 2023; IPBES et al., 2019). Fostering conservation literacy is important for students to acquire personal knowledge and influence attitudes, to construct conscious citizens who understand why natural resource utilisation should be implemented carefully (Lyamuya et al., 2016; Olsen et al., 2024). In

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recent years, numerous countries have attempted to strengthen conservation education through integrating it into school curricula, with the aim of promoting conservation awareness, attitudes, and behaviours, and fostering sustained conservation intentions among students (IPBES et al., 2019; OECD, 2023). In contrast to this global trend, although Indonesia is known for its abundant natural resources, the population's knowledge and conservation awareness remain limited (Parker & Prabawa-Sear, 2019). One reason for this discrepancy is that the standard national evaluation system for secondary schools in Indonesia is still strictly oriented towards knowledge. This assessment system has not placed attitude and awareness as its main focus. Thus, improving conservation literacy among these students is challenging (Arrafii, 2023).

Conservation literacy has emerged as an essential competency that encompasses understanding the fundamental principles of conservation biology, fostering environmental awareness, and promoting readiness to engage in sustained behaviour (Dealy et al., 2024; Wang & Li, 2025). Conservation knowledge enables students to appreciate the value of biodiversity, maintain ecosystem functions, and preserve ecological health and integrity (Trombulak et al., 2004; Wang & Li, 2025). Meanwhile, attitudes towards conservation reflect students' sense of connection to nature, as well as their long-term commitment to its conservation (Fettahlıoğlu & Aydoğdu, 2020; Mutisya et al., 2013). Knowledge and attitudes towards conservation are recognised as critical factors for strengthening students' ecological awareness and developing a sense of responsibility to conserve natural resources from the present into the future (Ekwesaranna et al., 2025). Conservation literacy is not only necessary for raising students' awareness of the need to prevent the exploitation of natural resources, but alsofor encouraging them to take an active role in preserving natural resources heritage (Günther et al., 2024). Therefore, the development of conservation literacy should be part of the secondary school curriculum (Børresen et al., 2023).

Conservation literacy education is considered an important predictor of preventing the threat of natural resource exploitation. It makes a significant contribution to future generations, as it not only provides them with essential knowledge, but also fosters their capacity to make informed decisions, adopt responsible behaviours, and cultivate a sustained commitment to the preservation of natural resources (Børresen et al., 2023; Karris et al., 2020; Martinis et al., 2018). Although the importance of reinforcing affective aspects in conservation literacy has been recognised, the implementation of learning that cultivates conservation values and attitudes is still limited, mostly due to the education systems that are more focused on cognitive achievement (Parker & Prabawa-Sear, 2019). This condition has an impact on the limited internalisation of conservation values among students. On the other hand, a comprehensively developed conservation literacy curriculum can broaden students' perspectives and equip them with the ability to make well-informed, responsible decisions that prioritise environmental sustainability (Ekwesaranna et al., 2025). Consequently, conservation literacy needs to be developed through contextual learning that is aligned with local ecological realities, ensuring that conservation values are more deeply embedded in students' attitudes and behaviours.

To support the development of conservation literacy, previous studies have have employed various strategies and approaches, including project-based learning (Cheung & Chow, 2011; Niemiller et al., 2021), place-based learning (Haywood et al., 2016), problem-based learning (Copsey et al., 2024; Fettahlıoğlu & Aydoğdu, 2020), which are explicitly designed to address contextualised issues, as well as environmental issues. Although numerous approaches have been explored, this study adopts problem-based learning (PBL) as it is regarded as an

effective pedagogical approach that promotes active learning through student engagement in real-life scenarios (Barrows, 1986). Moreover, PBL provides a structured framework that encourages active student participation through three main stages: (1) identifying and formulating a problem, (2) gathering and analysing information to design a solution, and (3) evaluating and reflecting on the proposed solution (Wijnia et al., 2024).

While numerous studies have highlighted the benefits of PBL in environmental education, empirical evidence that measures the effect of PBL on changes in conservation attitudes remains limited. Vasconcelos (2012) demonstrated that the implementation of PBL can enhance students' conceptual understanding and collaborative skills within the context of environmental education. In contrast, Fettahlıoğlu and Aydoğdu (2020) reported a significant increase in environmentally responsible behaviour among pre-service teachers following an intervention based on PBL integrated with scientific argumentation. Similar outcomes were also demonstrated by Copsey et al. (2024) through the implementation of the Eco-Schools approach based on PBL at the secondary school. This study highlighted how the active involvement of students, teachers, and communities in contextualised climate action projects contributed to enhancing the relevance of education and strengthening collective participation in sustainability issues. Thus, the findings of Fettahlıoğlu and Aydoğdu (2020) and Copsey et al. (2024) further suggest that the effectiveness of PBL in the context of environmental education can be improved through the integration of contextualised and socio-culturally relevant elements.

Extending this pedagogical perspective, many studies in recent years have emphasised the importance of contextualising PBL through the integration of local wisdom as a means of strengthening student engagement and deepening their understanding of culturally relevant sustainability issues (Zidny et al., 2020). Local wisdom, as well as traditional ecological knowledge and the values of indigenous communities, not only provides an authentic context for conservation learning, but also offers a valuable link between modern science and local practices (Smith et al., 2020). This integration has the potential to enrich the learning experience by fostering critical awareness of the relationship between people and the environment, and cultivating conservation values rooted in local cultural traditions (Chang & Kuo, 2021). Nevertheless, empirical evidence on the effectiveness of the PBL approach integrated with local wisdom in enhancing secondary students' conservation literacy remains limited. Therefore, the effect of integrating local wisdom into PBL on students' conservation literacy in biology classes was investigated in this study.

## Literature review

### *Conservation literacy*

Conservation literacy is defined as a sufficient understanding of the basic principles of conservation biology, which includes key concepts and values to conserve them (Trombulak et al., 2004). From this perspective, conservation literacy encompasses two main components: knowledge of basic conservation principles (Trombulak et al., 2004) and attitudes towards conservation (Dealy et al., 2024). Specifically, sufficient knowledge of basic conservation principles such as biodiversity, ecological integrity and ecological health provides an important foundation for individuals to commit to a conservation ethic (Lyamuya et al., 2016; Shingote, 2013; Trombulak et al., 2004). Furthermore, conservation attitudes enable individuals to connect with nature, which triggers them to engage in environmental protection efforts (Woosnam et al., 2019; Zylstra et al., 2014). Thus, if the current goal of science education is to improve views and attitudes towards natural resources, it is important to

strengthen conservation literacy, especially for secondary school students (Børresen et al., 2023; Zheng et al., 2017).

Higher education students are more likely to dedicate significant time to learning, which is an appropriate phase for developing conservation literacy (Neff et al., 2017). Conservation literacy education is highly needed for secondary school students, especially for those who live around protected areas (Djosetro & Behagel, 2024). Through conservation literacy education, students can develop positive attitudes towards the environment through an increased understanding of the importance of protecting the local environment (Broom, 2017). Students who have deep knowledge of the basic principles of conservation will not only have the awareness to protect the environment but will also be able to be thoughtful in sustainably utilising natural resources (Ardoin et al., 2020). Additionally, teaching conservation literacy highlights the importance of encouraging values that connect individuals with nature to commit to preserving biological heritage in the future (Woosnam et al., 2019). Beyond this, students can positively transfer their knowledge into society, thereby contributing to safeguarding the natural resources around them (Günther et al., 2024). Without adequate preparation in educating students in conservation literacy, there is concern that this could lead to the irresponsible management and use of natural resources (Neff et al., 2017). Therefore, instructional approaches that encourages students to actively participate in solving conservation issues is required to foster the development of students' conservation literacy.

### *Problem-based learning*

Problem-based learning (PBL), which is grounded in socio-constructivism theory, has been interpreted in various ways by the science education community. According to Barrows (1986), PBL is defined as a learning approach that enables students to understand and use skills to find a solution to a problem. According to Albanese and Mitchell (1993), PBL is a natural process that promotes group discussion among students, which is helpful for coming up with answers. In this process, the teacher serves as a facilitator rather than a traditional instructor These definitions describe three main characteristics of PBL. First, PBL is a student-centred learning approach where students work in groups to discuss problems and recognise different points of view (Hung, 2019). Second, there is a shift in the role of the teacher from instructor to facilitator, which allows students to think more creatively and critically when solving problems (Wijnia et al., 2024). Third, PBL uses authentic problems related to real-life conditions, which can be phenomena, cases, or stories that can help them gain new knowledge through direct experience (Loyens et al., 2023).

PBL has been widely recognised as successful in supporting biology learning, such as in health literacy (Suwono et al., 2023), clinical embryology (Carroll et al., 2024), and biochemistry (Tarhan & Ayyıldız, 2015). However, research demonstrating the effectiveness of PBL in supporting conservation literacy is still scarce. Yet, conservation literacy has been increasingly recognised as a core component of sustainable environmental education, which aims to build awareness to conserve nature and sustainable use of natural resources (Yadav et al., 2022). Furthermore, conservation literacy education has been designed to increase students' sensitivity to nature, influence values, and develop responsible behaviour in environmental conservation (Wuebold et al., 2022). However, the actual implementation of conservation literacy education in classrooms still encounters challenges, such as the struggle to adapt concrete learning strategies and the lack of approaches that link local wisdom (Zidny et al., 2020). Without a systematic effort to design PBL based on local contexts, the goal of

conservation literacy education, which is to raise a generation committed to conservation, will be difficult to achieve.

### *Integrating local wisdom into problem-based learning*

Problem-based learning (PBL), as a constructivist approach, has been reported to effectively support students' thinking skills in science education (Carroll et al., 2024; Suwono et al., 2023; Tarhan & Ayyıldız, 2015). However, although the implementation of PBL in science education has been widely investigated, there are still gaps in understanding the challenges of applying it to conservation literacy. There is limited research that addresses how to overcome practical difficulties, such as the lack of contextualised materials and student engagement in teaching conservation literacy through PBL. Furthermore, there has been a recent call to enrich the PBL design by integrating local wisdom, which brings authenticity to conservation issues and empowers students as agents of change who understand cultural values in environmental conservation (Sakti et al., 2024). This approach aligns with the principle of culturally relevant pedagogy, where learning should be appropriate to learners' cultural identity to build emotional attachment and ecological responsibility (Hugh-Pennie et al., 2022).

The current study has adopted the PBL framework proposed by Wijnia et al. (2024), which comprises three main components: problem identification, research process, and solution synthesis and evaluation. Furthermore, this study further enriches the framework by integrating the principle of local wisdom into the three stages of problem-based learning activities. At the first stage of problem identification and local wisdom, students not only recognise issues such as biodiversity loss but also identify contextual problems in their surrounding areas and recognise relevant traditional values. This is followed by the collaborative investigation and local wisdom exploration stage, in which students incorporate literature studies, interviews with traditional leaders, and field observations to collect data based on evidence that integrates scientific knowledge with local wisdom. Finally, in the critical presentation and reflection of local values stage, students present solutions in a mini-symposium that includes contextual analyses of social and ecological conditions, proposed hybrid solutions, and critical reflections on the impact of solutions on cultural and ecosystem sustainability. In this way, the integration framework of local wisdom with PBL is not merely a pedagogical tool but also a way to preserve local wisdom while holistically strengthening students' conservation literacy.

### *Research Objectives*

Conservation literacy is critically important for promoting sustainable natural resource management. However, conservation literacy is often not a primary focus in Indonesian secondary schools, as conventional teaching methods tend to emphasise factual knowledge rather than foster students' attitudes related to environmental conservation. As a result, students frequently lack meaningful connections between scientific knowledge and local cultural wisdom. Although problem-based learning (PBL) has been recognised as effective in enhancing student engagement and understanding within environmental education, its potential to strengthen conservation literacy among secondary school students through the integration of local wisdom remains limited. To address this gap, the present study aims to examine whether PBL integrated with local wisdom significantly improves the conservation knowledge and attitudes of secondary school students compared to conventional learning.

## Methods

### *Research design and procedure*

This study used a quasi-experimental design to evaluate the effectiveness of integrating local wisdom into problem-based learning in improving conservation literacy. The within-group variables consisted of time, including initial and final assessments. Meanwhile, the between-group variable is the condition, which consisted of an intervention group (PBL integrated with local wisdom) and a control group (traditional teaching method). In both groups, the pre-assessment was performed one week before the intervention, and the post-assessment was performed one week after the intervention. During the intervention, the researcher conducted observations and recorded the results of field observations. Biology teachers who had been trained assisted the researcher in implementing both assessments. After all data were collected, the data were comprehensively analysed and interpreted.

### *Research participants*

The research location was selected from one of the high schools in Manokwari City, Papua, Indonesia, using the convenience sampling method. The school was chosen because it is located near an important biodiversity hotspot. The study involved 96 Grade X students divided into four classes, with 48 students (29 males, 19 females; aged 15–16) in the intervention group and 48 students (30 males, 18 females; aged 15–16) in the control group. Before the study, teachers who showed high enthusiasm and commitment were selected for intensive training on the two interventions. In addition, all of the students and teachers involved in this study provided informed consent for their participation. The school principal also granted ethical approval to ensure the responsibility and feasibility of conducting this study.

### *The design of teaching intervention*

The problem-based learning intervention integrated with local wisdom was implemented in biology subjects for 10 weeks (45 minutes each). The intervention schedule was adjusted to the standard curriculum and implemented in parallel with the control group to ensure equitable learning time. The learning design is based on the biodiversity content of Papua and refers to the theoretical framework of problem-based learning enriched with local wisdom principles. Furthermore, the structured intervention process consisted of three main interrelated phases:

*Phase 1. Problem identification and integration of local wisdom (2 Sessions)*

Students were divided into heterogeneous small groups (4 people) to analyse real environmental cases of Papua associated with local wisdom. These cases were presented to reflect the current dynamics of the biodiversity of Papua, with the main theme: ‘From Past Abundance to Future Uncertainty on Papua’s Biodiversity’. Furthermore, each group focused on specific issues, such as (1) the destruction of coral reefs, (2) the degradation of mangrove forests into settlements, (3) the conversion of coastal areas into illegal garbage dumps, (4) the threat of invasive plant invasions in forests; (5) the expansion of oil palm plantations. After reading and discussing the text, each group was requested to formulate key questions and plan steps to obtain further information. This stage is designed to introduce students to environmental conservation issues around them.

*Phase 2. Collaborative investigation and local wisdom exploration (5 sessions and 1 field trip)*

In this phase, students incorporated literature research, interviews with Indigenous leaders and field observations to develop solutions based on evidence and local context. Students in groups explored various sources of information, including textbooks, the internet and local policy documents, to understand the ecological dimensions of the problem. Afterwards, each group interviewed traditional leaders invited to the class to explore the values of local wisdom that can be applied in problem-solving. In addition, each group also made direct observations of the case study location to obtain authentic data. The teacher guided the students during the observation to ascertain key aspects that supported the analysis. After collecting the data, each group showed the results of the exploration of local wisdom values: (1) the value of *Sea Sasi* in restoring coral reefs (*Sea Sasi* is a culture of the Maya Tribe in Raja Ampat, Papua that regulates a temporary ban on the utilisation of marine resources to restore coral reefs to increase fish stocks); (2) the role of *Igya Ser Hanjob* in maintaining coastal ecosystems (*Igya Ser Hanjob* is a culture of the Marind Tribe, Merauke, Papua that regulates the preservation of mangroves and coastal zones to improve water quality and prevent coastal abrasion); (3) the role of *Wambrakwu* in restoring natural harmony (*Wambrakwu* is a culture of the Mee Tribe, Papua Mountains that has a philosophy of living in harmony with nature with the principle of not taking too much to support forest restoration based on the carrying capacity of the ecosystem); (4) the value of *Sacred Forest* to preserve invasive plants (*Sacred Forest* is a forest area protected by the taboo ritual of the Moi Tribe, Sorong, Papua, which serves to maintain endemic plant diversity and control invasive species); (5) revitalisation of local wisdom to stop the loss of oil palm plantations (*Local Wisdom Revitalisation* is a cross-tribal Papua's culture that integrates customary rules in palm oil governance through sustainable zoning to suppress forest conversion). Next, each group integrated scientific findings and local wisdom perspectives into a draft solution. This stage aimed to broaden students' understanding of the relationship between local wisdom and biodiversity conservation.

*Phase 3. Critical presentation and local value reflection (2 Sessions)*

Each group presented their proposed solutions in a mini-symposium format with several components, which included contextual analysis, hybrid solutions, and ethical reflection. In the contextual analysis, each group explained the cause-and-effect relationship of environmental degradation and the opportunity to revitalise local wisdom. Then, in the hybrid solution activity, each group proposed innovative strategies that combine modern ecological principles and traditional practices, such as integrating coral reef restoration technology with the *Sasi Laut* culture. Finally, in the ethical reflection activity, each group outlined the challenges of implementing these solutions, including economic, social and cultural conflicts, and reflected on moral values to consider in conservation efforts. This stage was designed to strengthen students' understanding of biodiversity conservation, develop problem-solving competencies, and foster awareness of the importance of local wisdom in environmental education.

In the control class, teaching biodiversity was conducted using traditional teaching methods with a teacher-centred approach. The teacher took the main role in controlling the learning process, starting from explaining the material based on the topic, giving assignments through worksheets, and discussing the answers with students. The questions in the worksheets were designed to test students' understanding of biodiversity concepts, such as definitions and levels of biodiversity, benefits of biodiversity, and biodiversity challenges. This method

emphasised mastery of concepts through teacher explanation and structured exercises without involving exploration of local wisdom or problem-based approaches.

### *Research Instrument*

Students' conservation literacy was evaluated using the Conservation Literacy Assessment developed based on the framework of Trombulak et al. (2004) and Dealy et al. (2024), which included two dimensions: conservation knowledge and conservation attitude. Conservation knowledge was measured using 12 multiple-choice items to assess three key principles: diversity, ecological health, and ecological integrity (Trombulak et al., 2004). The conservation knowledge instrument showed validity, with Pearson's r values ranging from 0.37-0.77 and acceptable reliability, with Cronbach's alpha of 0.78. Here is an example of a conservation knowledge question.

The researchers compared biodiversity in three locations that have the following characteristics.

(1) The protected forest has dense canopies, epiphytes, and endemic animals.
(2) The monoculture farmland is planted with a single crop and uses pesticides.
(3) The urban park features ornamental plants and shade trees but faces pollution.

Biodiversity data is summarised in the following table.

| Locations | Plant Species | Bird Species | Mammal Species |
|---|---|---|---|
| Protected Forest | 120 | 45 | 10 |
| Monoculture Farmland | 1 | 5 | 2 |
| Urban Park | 20 | 10 | 7 |

According to the data, which is the most dominant factor in influencing the differences in biodiversity in the three locations?
A. The level of air pollution in each location.
B. Diversity of habitat structure and lack of human disturbance.
C. Presence of apex predators in the food chain.
D. Different rainfall frequencies in each region.
(Correct answer: B)

Meanwhile, conservation attitude was measured using a 10-item 1-5 Likert scale (1 = strongly disagree to 5 = strongly agree) designed to evaluate two indicators of connectedness with nature and commitment to nature (Dealy et al., 2024). The following are sample questions on the dimensions of connectedness to nature (I trust nature needs our help to heal itself) and commitment to nature (I believe teamwork and collaboration are important to solve future problems). The conservation attitude instruments showed validity, with Pearson's r values ranging from 0.44-0.64 and acceptable reliability, with Cronbach's alpha of 0.71. These results confirmed that both instruments met the valid and reliable criteria for measuring conservation literacy.

### *Data analysis*

Data on conservation literacy consisted of conservation knowledge and attitude as dependent variables obtained through pre-test and post-test measurements. These two variables were analysed independently to assess their respective trends. The statistical approach was conducted in stages to answer the research questions comprehensively, with the following steps. Firstly, mixed ANOVA was used to examine the effect of the PBL integrated

with local wisdom intervention. Three primary effects were analysed in this study: (1) the time effect (difference between the pre-test and post-test), (2) the group effect (difference between the intervention and control groups), and (3) the interaction between time and group (to determine whether the intervention and control groups' changes in scores over time differed).

After finding significant interaction between time and group on both variables, a paired t-test was conducted as a post-hoc analysis to compare pre-test and post-test scores within the same group (intervention or control). The aim was to identify whether increases and decreases in scores occurred significantly in either group. The pre-test score was then controlled as a covariate to apply an analysis of covariance (ANCOVA). By taking this step, it was made sure that variations in post-test scores between the intervention and control groups represented the intervention's effect rather than variations from the baseline. Before analysis, statistical assumptions were ensured to be met on both variables. The normality of distribution test using Shapiro-Wilk showed that the data were normally distributed ($p > 0.05$), and the homogeneity of variance test using Levene's test met the normal assumption ($p > 0.05$).

## Results

This section presents the analysis of conservation literacy, with conservation knowledge and conservation attitude as dependent variables based on descriptive statistics. Table 1 shows the comparison of pre-post score changes in each group. Descriptive statistics compared the mean and standard deviation of the conservation knowledge and conservation attitude scores for the intervention and control groups in the pre- and post-intervention measurements. These results indicated that the intervention group experienced a greater increase in both variables than the control group. In contrast, the control group showed only a moderate increase in conservation knowledge (M = 6.30) to (M = 6.93) and a decrease in conservation attitude (M = 28.5) to (M = 28.00).

Table 1. Analysis of the comparison of pre-post score changes in each group

| Variables | Group | Pre-Post | M | SD |
|---|---|---|---|---|
| Conservation knowledge | Intervention | Pre | 6.54 | 1.06 |
| | | Post | 7.94 | 1.28 |
| | Control | Pre | 6.30 | 1.30 |
| | | Post | 6.93 | 1.48 |
| Conservation attitude | Intervention | Pre | 29.00 | 3.69 |
| | | Post | 34.15 | 2.53 |
| | Control | Pre | 28.50 | 3.74 |
| | | Post | 28.00 | 3.60 |

Next, mixed ANOVA was applied to each subscale to test the effectiveness of the problem-based learning intervention integrated with local wisdom, including conservation knowledge and attitude. In the conservation knowledge analysis, the time factor showed a significant influence with a large effect, $F(1, 106) = 39.113$, $p < .001$, partial $\eta 2 = .270$, Wilks's $\lambda = .730$. In addition, there was a significant interaction between time and group, although with a small effect, $F(1, 106) = 5.702$, $p = .019$, partial $\eta 2 = .051$, Wilks's $\lambda = .949$. This finding indicated that the intervention had a significantly different impact on improving conservation knowledge between groups, although the interaction effect was relatively limited. To confirm the differences between groups, a paired t-test showed that the intervention group experienced a significant increase in conservation knowledge with a large effect, $t(53) = -5.596$, $p < .001$, $d = -0.76$, while the control group showed only a moderate increase, $t(53) = -3.042$, $p = .004$, $d = -0.41$. More specifically, ANCOVA results revealed significant differences in post-test

conservation knowledge scores after controlling for covariate variables, F (1, 105) = 13.558, p < .001, partial η2 = 0.114. The adjusted R2 = 0.122 indicated that the model explained 12.2% of the variance in the increase in conservation knowledge. Thus, these results confirmed that the intervention significantly improved conservation knowledge, although most of the variance was still influenced by factors outside the study.

In the conservation attitude analysis, mixed ANOVA analysis revealed a significant effect of time with a large effect, $F$ (1, 106) = 43.969, $p$< .001, partial $\eta^2$ = .293, Wilks's λ = .707, as well as an interaction between time and group that also had a large effect, $F$ (1, 106) = 64.923, $p$< .001, partial $\eta^2$ = .380, Wilks's λ = .620. These findings demonstrated that the intervention strengthened conservation attitudes over time and created large differences between groups. Paired t-tests confirmed that the intervention group experienced a large increase in conservation attitude $t$ (53) = -9.376, $p$< .001, d = -1.28, while the control group had decreased, $t$ (53) = 1.147, $p$ = .256, d = 0.16. The ANCOVA results reinforced the findings by explaining 58.9% of the variance in post-test scores (adjusted $R^2$ = 0.589) with a large effect, $F$ (1, 105) = 121.400, $p$< .001, partial $\eta^2$ = .536. In other words, these findings highlighted that the intervention was the dominant predictor of conservation attitude, although external factors accounted for 41.1% of the unexplained variance.

## Discussion

This study implemented problem-based learning (PBL) integrated with local wisdom in the biology curriculum to provide an authentic context for biodiversity topics. Based on the analysis, the intervention group of PBL integrated with local wisdom showed a significant increase in conservation knowledge and attitude. In contrast, the control group only showed a moderate increase in knowledge without any change in attitude. These findings suggested that cultural contextualisation in PBL effectively improves cognitive understanding and fosters values of being more environmentally conscious. The effect of PBL intervention integrated with local wisdom was stronger on conservation attitudes (η2 = 0.536) compared to conservation knowledge (η2 = 0.114). This aligns with the theory of culturally responsive pedagogy, where integrating local wisdom can create emotional attachment and a sense of belonging to the environment (Hugh-Pennie et al., 2022; Taylor & Sobel, 2011). The cultural narrative transforms the abstract concept of conservation into a meaningful personal experience, thus strengthening students' intrinsic motivation to act pro-environmentally. These findings enriched the PBL model by emphasising the role of culture as a mediator of attitudes, an aspect that has not been explored extensively in previous studies (Vasconcelos, 2012).

By examining the control group's findings, we can better understand that students' conservation attitudes decreased despite the increase in conservation knowledge. These findings strengthen the arguments of Gatersleben et al. (2014) and Tamar et al. (2020) that although environmental knowledge is a prerequisite to support pro-environmental behaviour, the knowledge itself is insufficient to foster changes in pro-environmental attitudes or behaviours. These results align with Mukhacheva et al. (2015), who demonstrated that a holistic approach combining in- and out-of-class learning, such as community projects, is more effective in increasing positive attitudes. The uniqueness of the finding of this study is that it involves the integration of local wisdom in natural resource management in the PBL model. This aspect has not been adequately explored in previous research (Vasconcelos, 2012), which focused on the environment of the mining industry. Thus, this study confirmed the importance of participatory approaches and proposed a new perspective on integrating

biodiversity conservation and local cultural preservation. Consequently, conservation education is designed to transfer knowledge and foster environmental identity for students so that they can see themselves as part of an interconnected ecosystem and local culture.

From a theoretical perspective, this research broadens the framework of culturally responsive pedagogy by showing that integrating local wisdom in PBL can be a transformative strategy for conservation education. More practically, this research has several practical recommendations for conservation education. Educators can integrate local wisdom into PBL teaching materials to increase contextuality in supporting student engagement, such as collaborating with indigenous community elders to design specific materials. In addition, educational institutions need to organise workshops with a community-based participatory research approach to equip teachers to identify and utilise local cultural resources in teaching conservation. Furthermore, this research recommended that policymakers support the incorporation of local knowledge into the national curriculum in line with the education for sustainable development framework. This could ensure that conservation education is about global knowledge and starts from the local context.

Although this study provides strong evidence of the effectiveness of the intervention, researchers recognise the limitations of this study. This study only measured outcomes a week after the intervention and did not evaluate long-term retention of knowledge and attitudes. Further research needs to be conducted in a longitudinal study of 6-12 months to measure the sustainability of the intervention's impact. Furthermore, this study was conducted in a specific cultural and geographical context, so the generalisation of the findings may be limited. The study replication in various settings is needed to validate the proposed learning model framework. Finally, although the intervention showed a significant impact, 41.1% of the variance in conservation attitude remains unexplained. Future research should explore additional factors, such as family influence, community involvement, exposure to environmental media, or school policies that may interact with the intervention. Despite the limitations, this study offers an innovative model for culturally relevant conservation education, which can be adapted in high-biodiversity regions. By strengthening environmental identity through local wisdom, education can be a powerful and valuable catalyst to shape a generation that is knowledgeable and committed to sustaining the earth.

## Conclusion, Limitations and Implications for Future Research

Given the lack of empirical studies examining the impact of problem-based learning (PBL) integrated with local wisdom on conservation literacy, this study sheds light on this issue through a cohort intervention conducted over two to three months in a high school near a biodiversity hotspot. The findings provide empirical evidence that integrating PBL with local wisdom can significantly enhance students' conservation literacy, both in knowledge and attitudes, compared to conventional teaching methods. Moreover, although the Indonesian educational context remains strongly orientated towards cognitive achievement, the implementation of a PBL intervention combined with local wisdom is valuable for biology teachers to adopt in order to strengthen students' conservation attitudes. Nevertheless, this study is limited by the relatively short duration of the intervention. Therefore, further research is recommended to examine the impact of similar interventions over an extended period to assess the sustainability of changes in students' attitudes. Based on this study's experience, we recommend embedding local wisdom values within the secondary school curriculum as a strategy to foster collective awareness of natural resource conservation, and emphasise the need for further research to identify context-specific local wisdom that can be

meaningfully integrated to enrich student learning. Furthermore, the implementation of similar programmes could be expanded to other schools, particularly those near biodiversity hotspots, through collaboration between teachers, curriculum developers, indigenous communities, and researchers. All stakeholders should recognise that conservation literacy education is an essential element in building an educational ecosystem that supports environmental sustainability.

## Declarations

***Acknowledgments:***
***Funding:*** *This research is conducted based on a research contract with the Indonesian Ministry of Research, Technology and Higher Education for funding in 2024 through the Fundamental Basic Research Scheme in Higher Education (No: SP-34/UN42.15/PG/2024).*
***Ethics Statements:*** *Ethical approval for this study was provided by the Social Sciences Ethics Committee within the researcher's university*
***Conflict of Interest:*** The author declares no conflict of interest.
***Informed Consent:*** *An informed consent form was obtained from each participant*
***Data availability:*** *The data used in this study are not publicly available due to ethical restrictions but can be individually provided on a reasonable request.*

## References

Albanese, M. A., & Mitchell, S. (1993). Problem-based learning: A review of literature on its outcomes and implementation issues. *Academic Medicine*, *68*(1), 52–81. https://doi.org/10.1097/00001888-199301000-00012

Ardoin, N. M., Bowers, A. W., & Gaillard, E. (2020). Environmental education outcomes for conservation: A systematic review. *Biological Conservation*, *241*, 108224. https://doi.org/10.1016/j.biocon.2019.108224

Arrafii, M. A. (2023). Assessment reform in Indonesia: Contextual barriers and opportunities for implementation. *Asia Pacific Journal of Education*, *43*(1), 79–94. https://doi.org/10.1080/02188791.2021.1898931

Barrows, H. S. (1986). A taxonomy of problem-based learning methods. *Medical Education*, *20*(6), 481–486. https://doi.org/10.1111/j.1365-2923.1986.tb01386.x

Børresen, S. T., Ulimboka, R., Nyahongo, J., Ranke, P. S., Skjaervø, G. R., & Røskaft, E. (2023). The role of education in biodiversity conservation: Can knowledge and understanding alter locals' views and attitudes towards ecosystem services? *Environmental Education Research*, *29*(1), 148–163. https://doi.org/10.1080/13504622.2022.2117796

Broom, C. (2017). Exploring the relations between childhood experiences in nature and young adults' environmental attitudes and behaviours. *Australian Journal of Environmental Education*, *33*(1), 34–47. https://doi.org/10.1017/aee.2017.1

Carroll, M., Tomova, A.-M., & Hunter, H. R. (2024). Exploring the use of problem-based learning in clinical embryology training. *Journal of Biological Education*, *58*(5), 1204–1212. https://doi.org/10.1080/00219266.2023.2182816

Chang, S. E., & Kuo, M.-Y. (2021). A place-based pedagogical action study to enrich rural sustainability: Knowledge ties of National Taiwan University's 10-year partnership with Pinglin. *Sustainability*, *13*(5), 2916. https://doi.org/10.3390/su13052916

Cheung, S. M., & Chow, A. T. (2011). Project-based learning: A student investigation of the turtle trade in Guangzhou, People's Republic of China. *Journal of Biological Education*, *45*(2), 68–76. https://doi.org/10.1080/00219266.2010.546691

Copsey, O., Kubwimana, J. P., Kanyamibwa, S., Nshimiyimana, B., Maniraho, J. F., & Ishimwe, M. E. (2024). Climate action to enable quality education: Exploring the potential of Eco-Schools to reverse the triple education crises in Rwanda. *Global Social Challenges Journal*, *3*, 84–106. https://doi.org/10.1332/27523349y2024d000000016

Dealy, H. R., Jarvis, R. M., Young, T., Maharaj, K., & Petterson, M. (2024). The role of hope and conservation attitudes in current conservation actions and future conservation intentions. *Discover Sustainability*, *5*(1), 8. https://doi.org/10.1007/s43621-024-00186-6

Djosetro, M., & Behagel, J. (2024). Including local knowledge in conservation planning: The case of the western coastal protected areas in Suriname. *Ecosystems and People*, *20*(1), 2361683. https://doi.org/10.1080/26395916.2024.2361683

Ekwesaranna, F., Digitemie-Batubo, B. N., Saleh, M., Opara, M. M., Ikwoche, F. I., & Eze, E. (2025). Examining the impact of environmental education on connectedness to nature, environmental values and pro-environmental behavior among Nigerian undergraduates. *International Research in Geographical and Environmental Education*, 1–17. https://doi.org/10.1080/10382046.2025.2456823

Fettahlıoğlu, P., & Aydoğdu, M. (2020). Developing environmentally responsible behaviours through the implementation of argumentation- and problem-based learning models. *Research in Science Education*, *50*(3), 987–1025. https://doi.org/10.1007/s11165-018-9720-0

Gatersleben, B., Murtagh, N., & Abrahamse, W. (2014). Values, identity and pro-environmental behaviour. *Contemporary Social Science*, *9*(4), 374–392. https://doi.org/10.1080/21582041.2012.682086

Günther, J., Muster, S., Kaiser, K., & Rieckmann, M. (2024). A multi-stakeholder perspective on the development of key competencies for sustainability in Education for Sustainable Development at school. *Environmental Education Research*, *30*(10), 1651–1667. https://doi.org/10.1080/13504622.2024.2349934

Haywood, B. K., Parrish, J. K., & Dolliver, J. (2016). Place-based and data-rich citizen science as a precursor for conservation action. *Conservation Biology*, *30*(3), 476–486. https://doi.org/10.1111/cobi.12702

Hugh-Pennie, A. K., Hernandez, M., Uwayo, M., Johnson, G., & Ross, D. (2022). Culturally relevant pedagogy and applied behavior analysis: Addressing educational disparities in PK-12 schools. *Behavior Analysis in Practice*, *15*(4), 1161–1169. https://doi.org/10.1007/s40617-021-00655-8

Hung, W. (2019). Problem design in PBL. In M. Moallem, W. Hung, & N. Dabbagh (Eds.), *The Wiley Handbook of Problem-Based Learning* (1st ed., pp. 249–272). Wiley. https://doi.org/10.1002/9781119173243.ch11

Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). (2019). *Summary for policymakers of the global assessment report on biodiversity and ecosystem services* (summary for policy makers). IPBES https://doi.org/10.5281/zenodo.3553579

Karris, G., Martinis, A., Kabassi, K., Dalakiari, A., & Korbetis, M. (2020). Changing social awareness of the illegal killing of migratory birds in the Ionian Islands, western Greece. *Journal of Biological Education*, *54*(2), 162–175. https://doi.org/10.1080/00219266.2018.1554597

Loyens, S. M. M., Wijnia, L., & Rikers, R. M. J. P. (2023). Student-centered instruction: Inquiry-, problem-, project-, and case-based learning. In *International encyclopedia of education* (4th ed., pp. 701–711). Elsevier. https://doi.org/10.1016/B978-0-12-818630-5.14080-1

Lyamuya, R. D., Strande Straube, A. C., Guttu, A. M., Masenga, E. H., Mbise, F. P., Fyumagwa, R. D., Stokke, B. G., Jackson, C. R., & Røskaft, E. (2016). Can enhanced awareness change local school children's knowledge of carnivores in northern Tanzania? *Human Dimensions of Wildlife*, *21*(5), 403–413. https://doi.org/10.1080/10871209.2016.1180566

Martinis, A., Kabassi, K., Dimitriadou, C., & Karris, G. (2018). Pupils' environmental awareness of natural protected areas: The case of Zakynthos Island. *Applied Environmental Education & Communication*, *17*(2), 106–123. https://doi.org/10.1080/1533015X.2017.1366883

Mukhacheva, A. S., Derugina, V. V., Maksimova, G. D., & Soutyrina, S. V. (2015). Amur tiger conservation education program: A pilot study on program effectiveness. *Integrative Zoology*, *10*(4), 403–407. https://doi.org/10.1111/1749-4877.12145

Mutisya, S. M., Kipgetich, K. E., & Rono, K. J. (2013). Positive attitude towards environmental conservation: The role of primary education in Kenya. *Asian Journal of Management Sciences & Education, 2*(4), 203–215.

Neff, P. K., Weiss, N. M., Middlesworth, L., Wierich, J., Beilke, E., Lee, J., Rohlinger, S., & Pletzer, J. (2017). Using nonfiction scientific literature for conservation biology education: The *Tigerland* effect. *Applied Environmental Education & Communication*, *16*(2), 71–83. https://doi.org/10.1080/1533015X.2017.1304296

Niemiller, K. D. K., Davis, M. A., & Niemiller, M. L. (2021). Addressing 'biodiversity naivety' through project-based learning using iNaturalist. *Journal for Nature Conservation*, *64*, 126070. https://doi.org/10.1016/j.jnc.2021.126070

Organisation for Economic Co-operation and Development (OECD). (2023). *Education policy outlook 2023: Empowering all learners to go green*. OECD. https://doi.org/10.1787/f5063653-en

Olsen, E. K., Lawson, D. F., McClain, L. R., & Plummer, J. D. (2024). Heads, hearts, and hands: A systematic review of empirical studies about eco/climate anxiety and environmental education. *Environmental Education Research*, *30*(12), 2131–2158. https://doi.org/10.1080/13504622.2024.2315572

Parker, L., & Prabawa-Sear, K. (2019). *Environmental education in Indonesia: Creating responsible citizens in the global South?* (1st ed.). Routledge. https://doi.org/10.4324/9780429397981

Sakti, S. A., Endraswara, S., & Rohman, A. (2024). Revitalizing local wisdom within character education through ethnopedagogy approach: A case study on a preschool in Yogyakarta. *Heliyon*, *10*(10), e31370. https://doi.org/10.1016/j.heliyon.2024.e31370

Shingote, R. J. (2013). The predators of Junnar: Local peoples' knowledge, beliefs, and attitudes toward leopards and leopard conservation. *Human Dimensions of Wildlife*, *18*(1), 32–44. https://doi.org/10.1080/10871209.2012.694578

Smith, S. E., Mason, J. C., & Bowden, M. (2020). Local wisdom in regenerative teacher practices. *Australian Journal of Teacher Education*, *45*(9), 92–104. https://doi.org/10.14221/ajte.2020v45n9.6

Suwono, H., Permana, T., Saefi, M., & Fachrunnisa, R. (2023). The problem-based learning (PBL) of biology for promoting health literacy in secondary school students. *Journal of Biological Education*, *57*(1), 230–244. https://doi.org/10.1080/00219266.2021.1884586

Tamar, M., Wirawan, H., Arfah, T., & Putri, R. P. S. (2020). Predicting pro-environmental behaviours: The role of environmental values, attitudes and knowledge. *Management of Environmental Quality: An International Journal*, *32*(2), 328–343. https://doi.org/10.1108/MEQ-12-2019-0264

Tarhan, L., & Ayyıldız, Y. (2015). The views of undergraduates about problem-based learning applications in a biochemistry course. *Journal of Biological Education*, *49*(2), 116–126. https://doi.org/10.1080/00219266.2014.888364

Taylor, S., & Sobel, D. (2011). *Culturally responsive pedagogy: Teaching like our students' lives matter*. BRILL. https://doi.org/10.1163/9781780520315

Trombulak, S. C., Omland, K. S., Robinson, J. A., Lusk, J. J., Fleischner, T. L., Brown, G., & Domroese, M. (2004). Principles of conservation biology: Recommended guidelines for conservation literacy from the education committee of the Society for Conservation Biology. *Conservation Biology*, *18*(5), 1180–1190. https://doi.org/10.1111/j.1523-1739.2004.01851.x

Vasconcelos, C. (2012). Teaching environmental education through PBL: Evaluation of a teaching intervention program. *Research in Science Education*, *42*(2), 219–232. https://doi.org/10.1007/s11165-010-9192-3

Wang, Y., & Li, L. M. W. (2025). Mastery goal orientations and pro-environmental behavior among secondary students across cultures: The mediating role of environmental knowledge. *Environmental Education Research*, 1–15. https://doi.org/10.1080/13504622.2025.2527831

Wijnia, L., Noordzij, G., Arends, L. R., Rikers, R. M. J. P., & Loyens, S. M. M. (2024). The effects of problem-based, project-based, and case-based learning on students' motivation: A meta-analysis. *Educational Psychology Review*, *36*(1), 29. https://doi.org/10.1007/s10648-024-09864-3

Woosnam, K. M., Strzelecka, M., Nisbett, G. S., & Keith, S. J. (2019). Examining millennials' global citizenship attitudes and behavioral intentions to engage in environmental volunteering. *Sustainability*, *11*(8), 2324. https://doi.org/10.3390/su11082324

Wuebold, J., Pearlstein, E., Shelley, W., & Wharton, G. (2022). Preliminary research into education for sustainability in cultural heritage conservation. *Studies in Conservation*, *67*(sup1), 326–333. https://doi.org/10.1080/00393630.2022.2059642

Yadav, S. K., Banerjee, A., Jhariya, M. K., Meena, R. S., Raj, A., Khan, N., Kumar, S., & Sheoran, S. (2022). Environmental education for sustainable development. In M. K. Jhariya, A. Banerjee, & S. Yadav (Eds.), *Natural resources conservation and advances for sustainability* (pp. 415–431). Elsevier. https://doi.org/10.1016/B978-0-12-822976-7.00010-7

Zheng, Q., Xu, A., & Kong, D. (2017). Environmental education, knowledge management and professional performance in eco-tourism: The impact relatedness. *EURASIA Journal of Mathematics, Science and Technology Education*, *13*(8). https://doi.org/10.12973/eurasia.2017.00958a

Zidny, R., Sjöström, J., & Eilks, I. (2020). A multi-perspective reflection on how indigenous knowledge and related ideas can improve science education for sustainability. *Science & Education*, *29*(1), 145–185. https://doi.org/10.1007/s11191-019-00100-x

Zylstra, M. J., Knight, A. T., Esler, K. J., & Le Grange, L. L. L. (2014). Connectedness as a core conservation concern: An interdisciplinary review of theory and a call for practice. *Springer Science Reviews*, *2*(1–2), 119–143. https://doi.org/10.1007/s40362-014-0021-3