

Integrating Edutourism and Epistemic Learning Patterns in Science Modules: A Strategy to Enhance Students' Ecological Awareness

Raden Didi Kuswara^{1,*}, Ahmad Fadli¹, Marham Jupri Hadi², Sahratullah³,
Wirentake⁴, & Naif Mastoor Alsulami⁵

¹Department of Biology Education, Universitas Nahdlatul Wathan Mataram, Indonesia

²Department of English Language Education, Universitas Nahdlatul Wathan Mataram, Indonesia

³Department of Biology Education, Universitas Cordova, Indonesia

⁴Department of English Language and Culture, Universitas Teknologi Sumbawa, Indonesia

⁵Department of Curriculum and Instruction, University of Jeddah, Saudi Arabia

*Corresponding email: r.didi@unwmataram.ac.id

Received: 29 December 2025

Accepted: 31 January 2026

Published: 10 February 2026

Abstract: Education is a key factor in tackling climate change, and educational tourism (edutourism) is a new approach to environmental education with supporting teaching materials. This research aims to develop and evaluate the effectiveness of a science module on educational tourism, integrated with environmental education, for enhancing students' ecological awareness. The module was designed using the 4D development model (define, design, develop, and disseminate) within an ELP approach. Validation by 10 experts, including experts in learning, environmental, and educational tourism, as well as research instruments, confirmed that the module and instrument were suitable for use. The implementation phase tested module effectiveness using a quasi-experimental design with a non-equivalent control group across three meetings, including field observations, presentations of observational results, and the design of simple solutions to environmental problems. A total of 75 students from 3 secondary schools participated in this study, with 43 in the experimental group and 33 in the control group. Descriptive analysis indicated an increase in ecological awareness in both groups, with a larger increase in the experimental group, as evidenced by post-test averages of 19.79 and 16.03, respectively. Further analysis with ANCOVA showed a significant effect of the instructional treatment on post-test scores after controlling for pre-test differences ($F(1, 73) = 9.066, p = 0.004$, partial $\eta^2 = 0.110$). The findings suggest that edutourism-based learning, which emphasizes direct interaction with nature, observation activities, and student-designed solutions to environmental problems, effectively promotes student ecological awareness. This study contributes to contextual and constructivist learning literature by demonstrating the role of authentic, ecology-based learning experiences in science education. However, implementation challenges related to access, logistics, and limited intervention duration remain. Future research should explore longitudinal and interdisciplinary approaches, including technology-supported alternatives, to overcome contextual constraints.

Keywords: environmental education, educational tourism, ecological awareness, integration, science module.

Article's DOI: <https://doi.org/10.23960/jpmipa.v27i1.pp261-286>

■ INTRODUCTION

The importance of environmental awareness in modern society requires education that fosters a deep understanding of ecosystems and environmental responsibility (Ramírez Suárez et al., 2023; Susbiyanto et al., 2024). Education plays an important role in addressing climate

change, shaping human understanding of environmental issues, and fostering environmentally friendly lifestyles (I. Erhabora & U. Don, 2018; Ma et al., 2023; Makrooni et al., 2025). Education is essential to address environmental problems, and raising ecological awareness through education is critical (Hajj-

Hassan et al., 2024; Ibáñez et al., 2020). Environmental education plays a vital role in addressing global challenges, including climate change, pollution, and ecosystem degradation (Husin et al., 2025; Velepini, 2025). The integration of environmental education into science learning is highly relevant, as science subjects inherently examine interactions among humans, living organisms, and the environment (Littledyke, 2008; Punzalan, 2024; Sukma et al., 2020; Wals et al., 2014). Science education must therefore aim to shape global citizens who are environmentally, socially, and ethically conscious (Picardal, 2025).

Given these considerations, it becomes essential to integrate environmental education into subject matter content, including science, which is highly relevant to shaping students' character and concern for the environment (Carvache-Franco et al., 2019; Mwendwa et al., 2017). Environmental awareness requires contextual learning experiences in which students not only understand ecological concepts but also experience their connection to everyday life and the surrounding environment. In this context, edutourism offers a pedagogical alternative that is both theoretically and practically relevant. Edutourism integrates the principles of contextual learning and authentic environmental exploration into the science learning process. This learning approach is rooted in the concept of ecotourism, which emphasises the educational component of the ecological system and associated practices, and the responsibility to the natural environment (Torsney et al., 2025). This learning approach can enhance students' ecological awareness, as experiences in nature can promote environmental education and strengthen commitment to conservation action (Whitburn et al., 2023). Therefore, the development of integrated science modules for environmental education based on educational tourism is important, as it supports the development of teaching materials and

simultaneously bridges activities within and outside the classroom.

The module is adapted to the learning context, namely the tourist site, to ensure contextual relevance. Contextual-based modules in environmental education learning are suitable for use as additional teaching materials (Byla et al., 2024). Module developed following an *Epistemic Learning Pattern* (ELP), adapting it to student characteristics and the desired module specifications. ELP conceptualizes learning as an active epistemic process involving the construction, evaluation, and reflective use of knowledge through meaningful engagement with authentic problems. ELP involves an active process of constructing, evaluating, and using knowledge reflectively and collaboratively (Richter & Tiffin-Richards, 2024). These principles make ELP particularly suitable for an integrated science module based on educational tourism, in which real environmental issues encountered at tourism sites serve as the core learning context. ELP is integrated with real-life experiences, enabling them to transfer the knowledge they have developed to real-world situations. "Authentic learning", which combines academic content with activities that resemble professional or real-life practices, is a key component of ELP (Nachtigall & Firstein, 2024).

Edutourism provides authentic ecological phenomena that naturally position problems at the center of learning, aligning with ELP's problem-centered orientation (Sridana et al., 2025). Through collaborative observation, discussion, and reflection during field-based learning, students engage in epistemic practices that deepen conceptual understanding while simultaneously shaping environmental attitudes and awareness. Prior studies indicate that constructive and collaborative epistemic learning environments support deeper understanding and meaningful learning outcomes (Ko et al., 2025; Moon et al.,

2024). ELP emphasizes collaboration and reflection in building shared knowledge (Singh, 2022). Therefore, integrating ELP within an edutourism-based environmental science module offers a theoretically framework for fostering students' ecological awareness by connecting scientific knowledge construction with authentic environmental experiences.

This integration represents a novel contribution to the development of science modules by incorporating a framework that places greater emphasis on students' active engagement in constructing their own knowledge. To the best of our knowledge, research that explicitly examines the possible role of the edutorism learning concept has not yet been conducted. Many researchers have examined teaching modules designed to build students' environmental awareness. However, only a few have developed integrated science modules for

environmental education based on edutourism. Several studies (Arslan & Karaku°, 2024; Diez-Ojeda et al., 2025; Ma'rufah et al., 2021; Sueb et al., 2021; Wai Ying et al., 2024) have shown that integrating environmental issues in various forms, such as game education, Service-Learning (SL) Program, whether through socioscientific, contextual, or digital technology approaches, can strengthen learning outcomes while building students' ecological awareness. However, these studies did not specifically integrate environmental science learning into students' environmental conditions and develop supporting learning modules. Therefore, this study aims to develop and test the effectiveness of an integrated environmental education science learning module based on edutourism on students' ecological awareness. In summary, the differences between the current research and previous studies have been outlined in Table 1.

Table 1. Differences between current research and previous studies

Researchers	Research Design	Integration - Level school	Types of Teaching Materials
(Arslan & Karakuş, 2024)	quasi-experimental	No- fifth-grade level of secondary school	Web 2.0-Based Digital Games Materials
(Diez-Ojeda et al., 2025)	quasi-experimental	No-Primary Education Degree	Service-Learning (SL) program
(Ma'rufah et al., 2021)	R&D	No - Senior High School	based on socioscientific Issues
Sueb et al. (2021)	Quasi-experimental	No - Senior High School	Ecosystem module-based on inquiry
Wai Ying et al. (2024)	Quasi-experimental	No - Junior High School	Virtual reality-modul
Current research	4D	Science - Junior High School	Science Module - Environmental Education based on edutourism

The studies presented in Table 1 consistently demonstrate that integrating environmental education into science learning improves students' pro-environmental knowledge, attitudes, and behaviors. However, most previous studies remain confined to

classroom-based contexts and are not integrated with science instruction. Moreover, environmental contexts are often used illustratively rather than functionally, and only a limited number of studies explicitly employ an ELP framework. Empirical research that systematically integrates edutourism

as a core learning context within science modules is still scarce. Addressing this gap, the present study develops an integrated science module grounded in ELP and embedded within an edutourism setting, positioning real-world environmental locations as epistemic spaces for fostering students' ecological awareness.

Based on the description above, this research aims to develop a module and test its effectiveness. To achieve this objective, several research questions are formulated.

RQ1: What is the form of an integrated science teaching module for environmental education based on edutourism?

RQ2: Is the integrated science module of environmental education based on edutourism effective in increasing students' ecological awareness?

■ **METHOD**

Participans

The participants in the current study were secondary school students in North Lombok, Nusa Tenggara Barat, Indonesia. The population comprised all seventh-grade classes in public junior high schools in North Lombok that shared similar characteristics. They were selected using purposive sampling. The purpose is to select participants for the ecotourism program. In this case, the selection criteria for schools in the experimental group are that they have an ecotourism program and are located near ecotourism sites. In the selection process, three schools, with a total of 76 students, participated in this research. They were divided into experiment and control groups. There were two schools in the experimental group: MTs NW Nipah (26 students) and SMP Satap Tanjung (17 students). In total, 43 students were in the experimental group. In the control group, there was one school, namely SMP 1 Pemenang, with

33 students. Initial equivalence was tested using ANOVA (Levene's test) and confirmed to be equal (sig. p-value > 0.05).

Design and Procedure

This research was in the research and development category and used the 4D model (Figure 1). This model was chosen for its systematic nature and the clarity of its functions at each stage, which facilitates the organization of learning media development steps and provides validation and testing phases to ensure product feasibility (Hariyanto et al., 2022; Indaryanti et al., 2025). To assess effectiveness, a quasi-experimental design was employed. The research was conducted in May-August 2025. This research used a 4D development model consisting of the stages define (identification of problems and objectives), design (initial design and product specifications), develop (creation and validation), and disseminate (limited implementation and distribution) (Figure 1) (Montori & Jacobus, 2025; Syam & Furwana, 2022; Tampubolon & Sipahutar, 2024). During the define stage, researchers identified teacher challenges, suitable characteristics of science learning, and the potential of educational tourism. The design stage involved selecting module type and creating learning steps, worksheets, and assessments. In the development stage, the module was completed and validated by experts. Finally, the implementation phase tested module effectiveness using a quasi-experimental design with a non-equivalent control group (Table 2) and intervention comprising three meetings (Table 3). Information:

O : pretest and posttest

X : treatment (the experimental class learning with the science module of environmental education based on edutourism and the control class learning with discussion, as always done by science teachers, and did not use the module).

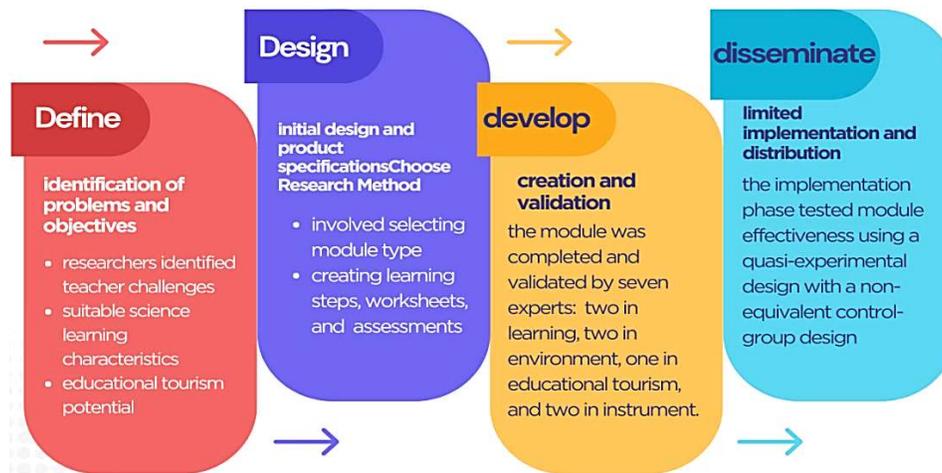


Figure 1. Research procedure

Table 2. A non-equivalent control-group design

Group	Pretest	Treatment	Posttest
Experimental class	O ₁	X	O ₂
Control class	O ₁	–	O ₂

Table 3. Intervention procedure

Phase	Description
Pre-Intervention (meeting 1)	Pretest to determine students' initial ecological awareness. To explore students' initial knowledge in the experimental class related to environmental knowledge, especially the concept of ecosystems
Intervention (meeting 2-4)	The experimental class employed an integrated environmental education approach grounded in educational tourism, with exploration of the surrounding environment. In contrast, the control class used conventional instruction without environmental exploration outside the classroom and did not use the module.
Post-Intervention (meeting 5)	Post-tests for both groups. repetition to reinforce concepts.

Instruments

The instrument used in this study was a student ecological awareness test consisting of four essay questions representing four indicators: environmental knowledge, environmental attitudes and values, pro-environmental behavior, and environmental problem-solving skills. The instrument was developed by synthesizing ecological awareness indicators proposed by Ikhsan et al. (2025), Liu & Green (2024), and

Maleknia & Zamani (2025). Students' responses to the essay test were assessed using an analytic rubric consisting of several main components (Rani et al., 2023; Shodiq et al., 2025). Each component was scored based on the completeness and accuracy of the students' answers, with a maximum total score of 10. For example, the environmental knowledge indicator comprised identifying human activities (3 points), analyzing their impacts on interactions among

living organisms (3 points), and linking these activities to climate change (4 points).

Content validity was evaluated through expert judgment involving five experts (three subject-matter experts and two experts in statistics and research methodology), yielding an average feasibility score of 3.56, which falls within the acceptable range (3.41 – 4.20) suitable for use with minor revisions (Creswell & Guetterman, 2019; Riduwan, 2015; Sugiyono, 2020). Reliability analysis indicated a Cronbach's Alpha coefficient of 0.715, which falls within the acceptable range (0.70–0.79), indicating that the instrument is reliable and suitable for use (DeVellis, 2017).

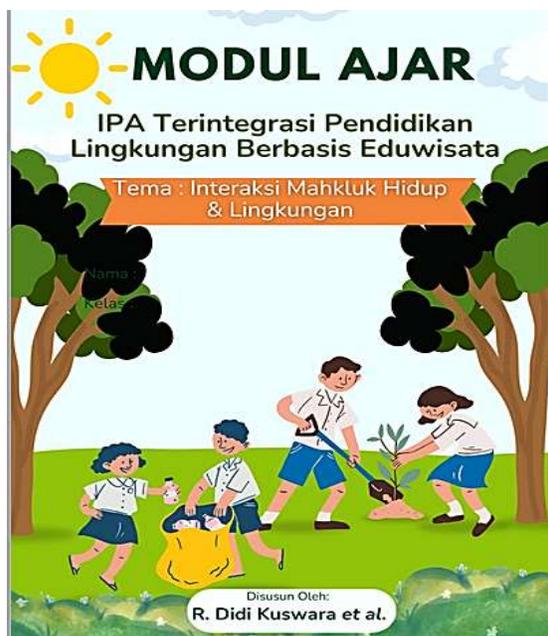
Data Analysis

To evaluate the effectiveness of a module, using Analysis of Covariance (ANCOVA) after meeting the assumptions (Shapiro-Wilk normality and Levene's homogeneity). The criteria were that if the sig. (p-value) < 0,05, there was a significant difference, and if the sig. (p-value) > 0,05, there was no significant difference (Ocakodlu & Macunluoglu, 2023; Tomarken & Serlin, 1986).

■ RESULT AND DISCUSSION

RQ1: What is the form of an integrated science teaching module for environmental education based on edutourism?

After analyzing the problems and needs, suitable characteristics of science learning, and educational tourism potential, including the textbooks used by teachers, it was found that environmental education was not directly integrated. Therefore, there was a need for additional supporting teaching materials, namely modules integrated with environmental education. Several studies have shown that using modules can increase student motivation (Fidiastuti et al., 2021; Rofisian & Rahmawati, 2020; Triyanto & Aryani, 2022) and enable independent learning outside the classroom, either in the form of distance learning or project-based learning (Sabila et al., 2024; Tabuena & Villareal, 2024). The module content follows a pattern (Figure 2): the initial activities consist of *Let's Listen*, *Let's Read*, and *Let's Guess*. The second activity consists of *Let's Find Out*, *Let's Discuss*, *Let's Tell a Story*, *Let's Conclude*, and *Let's Practice*. The final activity includes *My Reflection*.



DAFTAR ISI

	Hal
Cover	i
Halaman Judul	ii
Kata Pengantar	iii
Daftar Isi	iv
Capaian Pembelajaran dan Rangkian Tujuan Pembelajaran	v
Pertemuan Ke-1	
Ayo Menyimak	2
Ayo Membaca	3
Ayo Menebak	4
Ayo Mencari Tahu	5
Refleksi	9
Pertemuan Ke-2	
Ayo Menyimak	11
Ayo Menonton	11
Ayo Ber cerita	12
Ayo Menyimpulkan	13
Ayo Berlatih	14
Refleksi	15
Pertemuan Ke-3	
Ayo Menyimak	17
Ayo Membaca	18
Ayo Mencari Tahu	19
Ayo Berdiskusi	21
Ayo Menyimpulkan	22
Refleksi	23
Daftar Pustaka	24
Instrumen Pengukuran Kesadaran Ekologis Siswa	26
Lembar Observasi Pembelajaran	29
Dokumentasi	31

Figure 2. The module cover and content

Next, identify relevant scientific materials to integrate into environmental education. Science learning is the most suitable area for integration with environmental education (Sukma et al., 2020). The integrated learning material is “the interaction of living things with their environment.” The selection of materials is aligned with the learning outcomes and goals of

environmental education. Research by Punzalan (2024) and Sabatini et al. (2023) indicates that integrating environmental education into science instruction in secondary schools can enhance students’ environmental knowledge and awareness. Topics such as energy, living systems, pollution, waste management, and conservation are highly relevant integration of environmental education.

Let's Practice (15 Minutes)
Complete the table below, by describing the types of interactions and their impacts on the environment based on the images provided.

Ecosystem components	Types of interactions	Forms of interaction	Ecosystem impact	Simple Solution Alternative (if pollution occurs)
	Fish need water as a place to live.	1. Fish absorb dissolved oxygen in water through their gills and release carbon dioxide 2. Fish need aquatic plants as food source.	If water is polluted (by industrial, agricultural, or domestic waste), fish populations can decline drastically. This disrupts the food chain and the balance of the aquatic ecosystem,	




Kegiatan Inti

Let's Find Out (25 Minutes)
Work in groups. Identify and describe images of activities that have positive and negative impacts on our environment.

Figure 3. Example of the form of environmental education integration

<p><i>Let's Read (10 Minutes)</i> Read the story below carefully. Then, tell your friends what message the story conveys.</p>	
<p>Ecosystem</p>	
	
<p>The image shows several components, such as water, trees, grass, snails, frogs, and other components. From this image, you can see how important the environment is to our lives and how everything interacts with each other.</p>	
<p><i>Let's Read (5 Minutes)</i> Read the story below carefully. Then, tell your friends what message the story conveys.</p>	
<p>Comparison of Clean and Polluted Environments</p>	
	
<p>Do you love clean beach? Clean beach offer beautiful and refreshing natural scenery. the air around the beach feels cool and fresh, accompanied by a gentle breeze that carries the distinctive scent of the sea. Along the shoreline, coastal plants grow green, providing a natural balance to the environment. Birds fly in the sky, while small crabs crawl among the clean, waste-free coral.</p>	<p>The supposedly clear seawater appears murky and polluted, while an unpleasant odor emanates from piles of rotting garbage. Marine animals such as crabs and birds appear to be avoiding or trapped by the waste that pollutes their habitat. Coastal plants also wither and die due to pollution. This dirty beach reflects a lack of human awareness of environmental clearliness. If not addressed immediately, damage to the coastal ecosystem will worsen, harming all living things, including humans.</p>
	
<p>Do you ride a bicycle or motorcycle to school? Cycling is an alternative way to reduce air pollution because it doesn't emit harmful substances it carbon monoxide</p>	<p>In big cities, people use many vehicles which can cause an increase in air pollution. Cycling is helpful in reducing pollution because it doesn't emit harmful substances like carbon monoxide</p>

Figure 4. Example of environmental education integration in the *let's read* activity

Figures 3 and 4 show the integration of environmental education into several student activities. This integration adapts to the students' local environment to make learning more contextual. Several studies have concluded that students who learn using an environmentally

contextual approach demonstrate improved learning outcomes and active engagement in learning, both in science, mathematics, and geography (Nurdin et al., 2017; Nurmiati et al., 2022; Ratnasari et al., 2024). Students who are directly involved in environmental research-based

learning and the integration of environmental values exhibit increased curiosity and strengthen their morals and ethics (Hadi et al., 2022; Hermino & Arifin, 2020; Safri et al., 2024). Additionally, Wildan et al. (2021) stated that an environment-based contextual approach develops students' character and critical thinking skills.

Contextual, environment-based learning is also evident in the "Let's Find Out" activity (Figure 5), in which students directly observe their surroundings and tourist attractions, such as ecosystems around beaches, zoos, and/or turtle conservation areas. This is because the module uses an educational tourism approach. Educational tourism-based learning provides

direct learning experiences in real environments, enabling students to be more active and interactive in understanding environmental material (González-Herrera & Giralt-Escobar, 2021; Nur Fitria, 2024; Pratami et al., 2025). Structured educational tourism learning, accompanied by effective modules and guides, has been shown to foster environmental care, including students' understanding of conservation and the responsible use of resources (Jufri, 2023; Romlah et al., 2024). Furthermore, Zatsepina et al. (2020) reported high student interest in educational tourism. The full version of the module can be seen at the following link: <https://drive.google.com/file/d/1E4DYgnSPnU-6cwM7bushReIn1jCK5rM/view?usp=sharing>.

Kegiatan Inti

Let's Find Out (95 Minutes)
 Gather in your groups and go to the beach near your school, to the zoo, or to a turtle conservation area to observe the interactions between living things and their environment. Observe and record the interactions between living things and their environment, as well as any environmental pollution found, on the worksheet provided.

STUDENT WORKSHEETS (LKS) I

A. Work Instructions

1. Observe the environment around your observation site.
2. Record your findings in the observation table below.
3. Interview the local community around your observation site.
4. Discuss your observations with your group.
5. Draw simple conclusions based on the collected data.

B. Tools and Materials

1. Observation sheet
2. Pencil/pen
3. Documentation tool (optional: cell phone/recorder)
4. Watch/timer/Lembar

Ecosystem Type: Coastal areas or areas around coastal areas which are often used as tourist and ecotourism destinations

No.	Type of living creature (biotic)	Environmental components (biotic/abiotic)	Type of interaction	Influence on the environment
1.	Sand crabs	Eat leaf litter.	Eating the remaining leaves	Helps decompose organic matter.
2.	.....	.....	.....	.....
3.	.....	.....	.....	.....
dst	.....	.....	.....	.....

Conduct interviews with local people:

1. Mr/Mrs, has the air temperature increased or feels hotter than in previous years? Explain!.....
2. Is the sea level rising? Explain!.....
3. Are there any fishermen here who catch fish by bombing or using potassium poison?.....

.....

4. Where do local people throw away/collect rubbish?.....

STUDENT WORKSHEETS (LKS) II

D. Observation Sheet

Ecosystem Type: Local Zoo or Turtle Conservation Area

No.	Animal Names (Biotic)	Natural Habitat	Adaptation	Interaction with the environment (Biotic/Abiotic)	Threats from Climate Change
1.	Elephant	Forest	Limited space	Eating grass and drinking water	Forest fires occur due to hot weather

Conduct interviews with zookeepers or turtle conservation area staff:

1. Why is it important to protect or preserve the animals that live here?.....
2. What would happen if these animals died or became extinct?.....
3. Is there any impact on our lives if these animals in nature are not protected?.....

Figure 5. Form of educational tourism-based learning in the *let's find out* activity

Validated by experts involved five experts: two in learning, two in environment, and one in educational tourism. Learning experts assessed curriculum alignment, objectives, material, strategies, assessments, and readability. Environmental experts evaluated integration with respect to issues, relevance, activities, character

development, the use of real data, and attitude change. Educational tourism experts assessed integration, local resources, location suitability, activities, and potential student impact. The validation results showed learning experts', environmental experts', educational tourism experts', and instrument experts' (Table 3).

Table 3. Module validation results

Validator	Score	Score Range	Decision
Learning experts'	3.75	3.42-4.20	Used with minor revisions
Environmental experts'	3.69	3.42-4.20	Used with minor revisions
Educational tourism experts'	3.63	3.42-4.20	Used with minor revisions

Source: (Fraenkel et al., 2012; Riduwan, 2015; Sugiyono, 2020)

This indicated that the module met the eligibility criteria for content, presentation, and relevance to environmental education and educational tourism. It was suitable for use, with minor revisions based on validator input, as it was developed with environmental considerations and students' learning environments in mind. This aligned with Slovinsky et al. (2021), who showed that a socio-scientific context-based science learning module, developed with students' needs and environment in mind, improved intrinsic motivation and student satisfaction in science learning. Developing student worksheets oriented toward local environmental wisdom has also been shown to improve student motivation and learning outcomes in environmental pollution (Muliawan et al., 2024).

After validation, the module was implemented in three meetings. In the first meeting, lasting 3×40 -minute sessions (120 minutes), students analyzed interactions and pollution and then proposed solutions. Learning ran smoothly, with active and motivated student participation, especially at the tourist site. They identified interactions between living things and their environment, including the problems/pollution they encountered, and conducted interviews. This

is a *"let's find out"* activity in the module (Figures 6 & 7). Whitburn et al. (2023) reported that environmental education fieldtrips were associated with increases in pro-environmental behaviour and support for conservation compared with control conditions. These findings are in line with the research results. Pulido et al. (2025) state that learning activities conducted outside the classroom environment can increase student engagement, motivation, and academic achievement. Furthermore, quasi-experimental studies comparing field-trip-based instruction with conventional instruction indicate that students participating in field trips exhibit significantly higher levels of active participation and improved learning outcomes (Supaida et al., 2025).

In the second meeting, lasting 2×40 minutes (80 minutes), students discuss and present the results of their field observations. This is a *"let's tell a story"* (presentation) and a *practice* activity in the module (figure 8). Activities such as these provide students with a platform to improve their literacy, practice communication, and hone their critical thinking skills. Romlah et al. (2024) and Sugiharti et al. (2025) state that the use of modules, both print and electronic, improves learning outcomes, scientific literacy,

and higher-order thinking skills. Sudarman & Ardian (2021) report that students respond well to the use of modules, find the material easier to understand, and are more motivated to learn. Moreover, Kholik et al. (2025) state that the use of modul in learning increases student involvement, motivation, understanding, and competence.

In the final 3×40 -minute sessions (120 minutes), students attempt to design simple solutions to the environmental problems they encounter. This is a “let’s discuss and let’s conclude” module activity (Figure 9). This activity trains students to think critically and develop

environmental problem-solving skills. Empirical research shows that when students engage in environmental science projects, including designing and completing real-world environmental tasks, there is a significant increase in students’ environmental knowledge and scientific attitudes (Al-Balushi & Al-Aamri, 2014). In addition, the problem identification and solution design process not only strengthens environmental knowledge but also fosters critical thinking and problem-solving skills as students design solutions to real environmental issues (Syamsudin et al., 2025).



Figure 6. Students studying at a tourist location (turtle conservation)



Figure 7. The coastal ecosystem and interviews with conservation officers



Figure 8. Students discussing and presenting observation results



Figure 9. Students designing simple solutions and presentation design results

RQ2. Is the integrated IPA module of environmental education based on educational tourism effective in increasing students' ecological awareness?

The descriptive analysis provides a preliminary picture of the impact of the environmental education science module, based on edutourism, on students' ecological

awareness. Table 5 depicts the result of the descriptive analysis. The pre-test mean score in the experimental group was 14.17, whereas the post-test mean score was 19.79. This result indicates an improvement in the students' ecological awareness in the experimental group. However, a similar pattern was observed in the control group, with a pre-test mean score of

11.33 that was lower than the post-test mean of 16.03. It explains that students who did not learn through the module also increased their ecological awareness. However, the experimental group's mean score was higher than that of the control group.

Table 4. Descriptive data on student ecological awareness in the experiment and control group

	Group	Mean	Std. Deviation	N	Minimum	Maximum
Pretest	Experiment	14.17	4.178	42	7	23
	Control	11.33	3.647	33	4	24
	Total	25.5	7.825	75	11	47
Posttest	Experiment	19.79	4.786	42	9	32
	Control	16.03	4.448	33	9	27
	Total	35.82	9.234	75	18	59

To further emphasize the significant difference between the experimental and control groups, an ANCOVA was conducted. Before the ANCOVA test, an assumption test was carried out with the results (sig. > 0.05) of normally distributed and homogeneous data (Table 5). The analysis shows a significant main effect of group on students' ecological awareness scores (Table 7). The ANCOVA results indicated a statistically significant effect of the overall model on students' ecological awareness, $F(2, 73) = 8.046$, $p = .001$, with a partial η^2 of 0.181, accounting for

18.1% of the variance in posttest scores. The pretest score, used as a covariate, had a significant effect on the posttest scores, $F(1, 73) = 7.718$, $p = 0.007$, partial $\eta^2 = 0.096$, suggesting that students' prior knowledge contributed moderately to learning outcomes. After controlling for pretest scores, the class variable showed a significant effect on posttest scores, $F(1, 73) = 9.066$, $p = .004$, partial $\eta^2 = .110$, indicating a meaningful difference in learning outcomes between groups attributable to the instructional treatment.

Table 5. Results of normality and homogeneity assumption tests

Measure	Group	Shapiro-Wilk	Normal Assumption	Levene's Test	Homogeneous Assumption
Pretest	Experiment	0.411	Normal	0.305	Homogen
	Control	0.784	Normal		
Posttest	Experiment	0.924	Normal	0.821	Homogen
	Control	0.158	Normal		

Table 6. ANCOVA test results

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	389.620 ^a	2	194.810	8.046	.001	.181
Intercept	766.111	1	766.111	31.641	.000	.302
pretest	186.874	1	186.874	7.718	.007	.096
kelas	219.507	1	219.507	9.066	.004	.110
Error	1767,538	73	24,213			

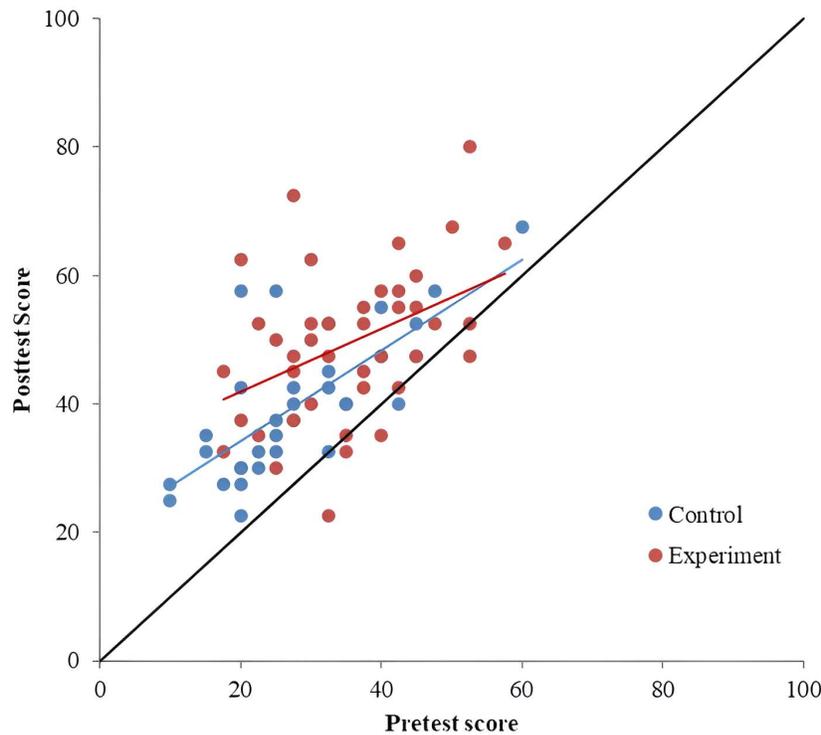


Figure 10. Scatter plot of pretest and posttest

These results indicated that the module had proven effective in building students' ecological awareness, including understanding concepts related to environmental education. These results are supported by Suryanti et al. (2018), which reveals the use of integrated environmental science materials on pollution improves students' knowledge, skills, attitudes, and behavior. Similarly, integrated biology modules enhance environmental attitudes, awareness, learning outcomes, and participation in conservation (Herlanti et al., 2025; Muchlisa et al., 2024; Retnowati et al., 2020). This study empirically demonstrates that ecology-based learning significantly enhances secondary school students' ecological awareness in science education. To see the distribution of student improvement in both groups simultaneously, here is a *Scatter Plot* comparing pretest and posttest.

Figure 10 presents a scatter plot comparing pretest and posttest scores for both experimental

and control groups with a diagonal reference line. The distribution shows that most students in the experimental group are positioned above the diagonal line, indicating greater learning gains compared to the control group, whose scores tend to cluster closer to the line. This visual evidence supports the effectiveness of the edutourism-based integrated science module in enhancing students' ecological awareness.

One important reason for this is that Edutourism-based learning encourages direct interaction with nature, particularly through "let's find out" (observation) activities. During these observations, students directly analyze the types of organisms, the interactions between living organisms and their environment, analyze the impact of these interactions on environmental conditions, and investigate the effects of climate change on specific living organisms. As seen in the student worksheet (Figure 11), students wrote about several types of animals they encountered,

their interactions with biotic resources (including their food sources), threats such as hunting and forest destruction, and the types of damage caused by littering. Although this analysis is simple, it indicates students' collaborative construction of knowledge. This experience can generate in-depth insights into ecological processes and

biodiversity, ultimately fostering a sense of conservation among students (Lo et al., 2021). This aligns with the findings of Goluboviæ-Iliæ and Mikariæ (2023), who highlighted that outdoor learning significantly enhances students' cognitive and emotional development and increases their engagement with nature.

LEMBAR KERJA SISWA (LKS) II				
D. Lembar Observasi				
Jenis Ekosistem: Kebun Binatang Setempat atau Daerah Konservasi Penyus.				
No.	Nama Hewan (Biotik)	Habitat Alami	Adaptasi	Ancaman karena Perubahan Iklim
1.	Gajah	Hutan	Tempat yang terbatas	Terjadi kebakaran hutan karena cuaca panas
	Buaya muara	sungai	Tempat yang terbatasi	Terancam di buru manusia
	Burung kakatua jambu keuning	Hutan	Tempat Terbatas	Terancam oleh kebakaran hutan
	orang utan	Hutan batang lori	Tempat Terbatas	di buru oleh manusia
	orang utan	MTB NTT/ Pulau Jawa	Tempat Terbatas	di tangkap untuk di perjual belikan
	Bekantan	Sulawesi	Tempat Terbatas	di buru
	ular sanca	Sumatra	Tempat Terbatas	Terancam di buru manusia
	berong gajah	Jawa	Tempat Terbatas	Pencemaran lingkungan

Lakukan wawancara pada petugas/penjaga kebun binatang atau daerah konservasi penyus:

- Mengapa penting menjaga atau melestarikan hewan-hewan yang ada disini?
karena manusia bisa di buru di hutan-hutan dan bisa di buru karena sudah bisa di buru.
- Apakah ada dampaknya terhadap kehidupan kita jika hewan-hewan ini di alam tidak dilindungi?
bisa merugikan manusia bisa merusak lingkungan bisa merusak tanaman

LEMBAR KERJA SISWA (LKS) II				
D. Lembar Observasi				
Jenis Ekosistem: Kebun Binatang Setempat atau Daerah Konservasi Penyus.				
No.	Nama Hewan (Biotik)	Habitat Alami	Adaptasi	Ancaman karena Perubahan Iklim
1.	Gajah	Hutan	Tempat yang terbatas	Terjadi kebakaran hutan karena cuaca panas
2.	Penyu laut	laut	Darat	Terancam karena cuaca panas

Lakukan wawancara pada petugas/penjaga kebun binatang atau daerah konservasi penyus:

- Mengapa penting menjaga atau melestarikan hewan-hewan yang ada disini?
karena penyu adalah hewan yg sangat dilindungi karena hewan yg bisa menjaga ekosistem laut.
- Apakah ada dampaknya terhadap kehidupan kita jika hewan-hewan ini di alam tidak dilindungi?
sangat berbahaya karena jika kita tidak melindungi dia akan punah.

7 | IPA Terintegrasi Pendidikan Lingkungan

Jenis Ekosistem: Daerah Pegunungan/Dataran tinggi			
No.	Jenis Pencemaran yang terlihat	Aktivitas manusia penyebab	Dampak terhadap komponen ekosistem
1.	Kerusakan hutan	Pembukaan lahan perkebunan	Hilangnya sumber mata air
2.	Banyak sampah	Membuang sampah sembarangan	Dapat merusak alam / Pencemaran lingkungan

Solusi sederhana yang ditawarkan

Membuat aturan batas pembukaan lahan sekitar mata air

Membuang sampah pada tempatnya

Jawab pertanyaan di bawah ini:

- Bagaimana interaksi manusia dan lingkungan dapat merusak lingkungan?
membuang sampah sembarangan, menebang pohon secara liar, menapak jalan di daerah-daerah perbukitan
- Menurutmu, bagaimana seharusnya orang yang datang menikmati pemandangan disini menjaga ekosistem?
membuang sampah pada tempatnya, tidak merusak tanaman, tanaman yang ada pada tempat tersebut

Jenis Ekosistem: Pesisir pantai atau daerah sekitar pesisir pantai yang sering dijadikan sebagai tempat wisata.				
No.	Jenis makhluk hidup (biotik)	Komponen lingkungan (biotik/abiotik)	Jenis intraksi	Pengaruh terhadap lingkungan
1.	Kepting pasir	sisa dedaunan	Memakan sisa dedaunan	Membantu menguraikan bahan organik
2.	sapi	Rumput hijau	memakan rumput	tidak panjang, yg dpt menutupi jalan
3.	ayak manusia	Dedaunan dan sampah plastik	menyebarkan sampah	risak dari sampah, membuat lingkungan tercemar

Lakukan wawancara pada masyarakat sekitar:

- Bapak/Ibu, apakah suhu udara meningkat atau terasa lebih panas dari tahun-tahun sebelumnya? Jelaskan!
ada perubahannya, kondisi kali ini / tahun ini... agak sedikit panas
- Apakah permukaan air laut mengalami kenaikan? Jelaskan!
peningkatan pasang surut air laut... dan kenaikan air laut
- Apakah ada nelayan disini yang menangkap ikan dengan cara di bom atau dengan racun potas?
dari tahun... go an... sampai saat ini... belum ada
- Kemana masyarakat sekitar membuang/mengumpulkan sampah?
sebanyak... masing-masing... membuang... ke...
belum ada... selain dari pemerintah

Gambar 11. Examples of observation and interview results of students

Direct interaction with nature is essential for cultivating students' environmental literacy and their capacity to make sustainable choices. Through edutourism-based learning, students are encouraged to take ownership of their learning by being given opportunities to explore nature freely, engage in hands-on activities, and experience natural phenomena directly. This view is supported by Moshura (2023), who emphasized that fostering environmental awareness requires an active learning approach that enables students to interact directly with the natural environment. Flanagan et al. (2019) explain that the more students grasp the nuance of the ecological environment, the more likely they are to be aware of and engage in pro-environment activities.

This contextual approach aligns with the ELP principle that places real-world problems at the center of learning, enabling students to construct knowledge through epistemic activities such as collaboratively observing, interpreting, evaluating, and reflecting on environmental phenomena (Sridana et al., 2025; Richter & Tiffin-Richards, 2024). When students are actively involved in discussions, problem-solving, and decision-making related to environmental issues, they develop a deeper conceptual understanding while simultaneously building attitudes and concern for the environment. This is consistent with the findings of Ko et al. (2025) and Moon et al. (2024), who show that an epistemic profile emphasizing collaboration and reflection supports better learning outcomes and deeper conceptual understanding. This is supported by the analysis of students' responses in the *Let's Practice* activity (Figure 12), which shows that students can explain types and forms of interactions, ecosystem impacts, and simple alternative solutions when pollution occurs. Examples of students' responses include “replacing gasoline engines with electric ones”, “protecting forests and avoiding illegal

logging”, and “not using fish bombing practices because they damage marine ecosystems”.

Furthermore, students are involved in designing simple solutions to environmental problems, such as creating posters encouraging people to dispose of trash properly, reduce plastic use, refrain from using explosives to catch fish, and refrain from illegal logging (Figure 13). This requires students to think critically and to take action to protect the environment. Several findings indicate that students' activities in which they design simple solutions to environmental problems can increase ecological awareness, regardless of learning approaches (Aripin et al., 2024; Mahsun et al., 2025; Mochcco & Reyna, 2026; Murti et al., 2025; Syamsudin et al., 2025).

Overall, the integrated science module based on educational tourism is a viable alternative for building students' ecological awareness, while accounting for their needs, the integrated materials, and the surrounding learning environment. In line with (Muchlisa et al., 2024), utilizing the surrounding environment as a learning resource for students is a supporting factor in improving student learning outcomes and creativity in discovering learning concepts. Furthermore, building students' ecological awareness cannot be achieved through short-term learning activities alone, but rather through ongoing and active student involvement in maintaining the school environment, including their family environment. Actively involving students in maintaining the school grounds teaches them key values: that their involvement matters and contributes to a healthier and more enjoyable environment (Delaliaë, 2022). Furthermore, Zahrawati (2023) emphasizes that increasing ecological awareness cannot be separated from the challenges faced by teachers, namely students with diverse family backgrounds, students with diverse characteristics and learning styles, and the influence of students' social interactions. Based

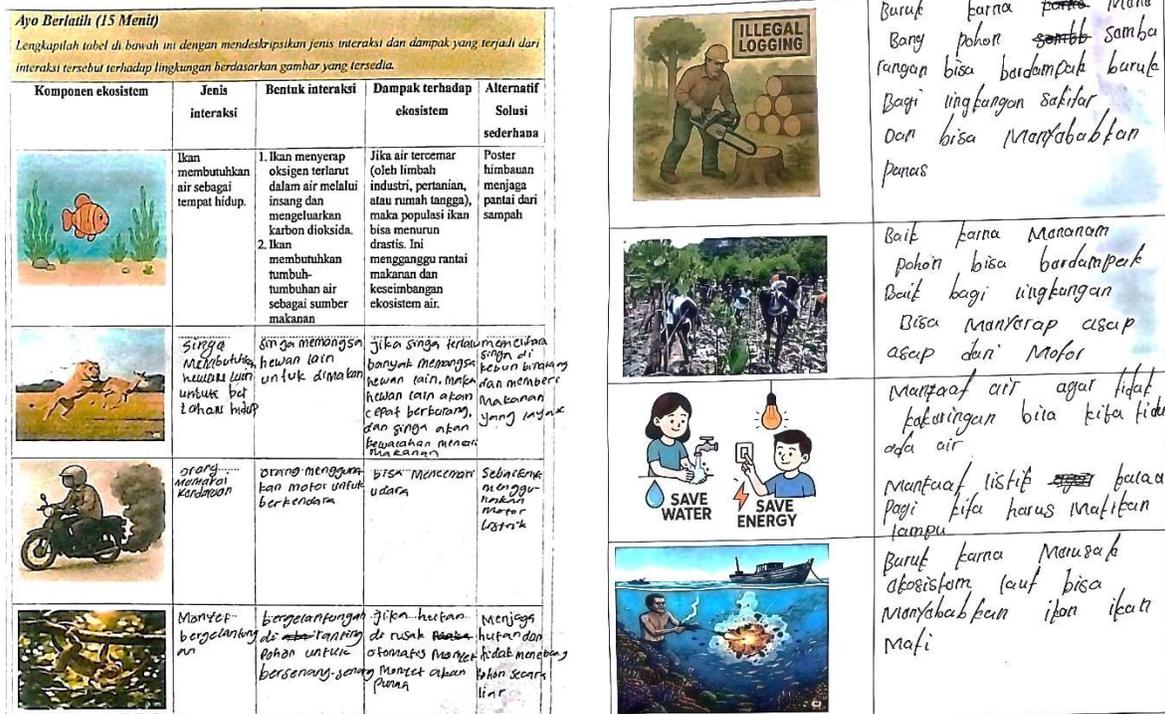


Figure 12. Examples of students' activity results in the 'let's practice' section

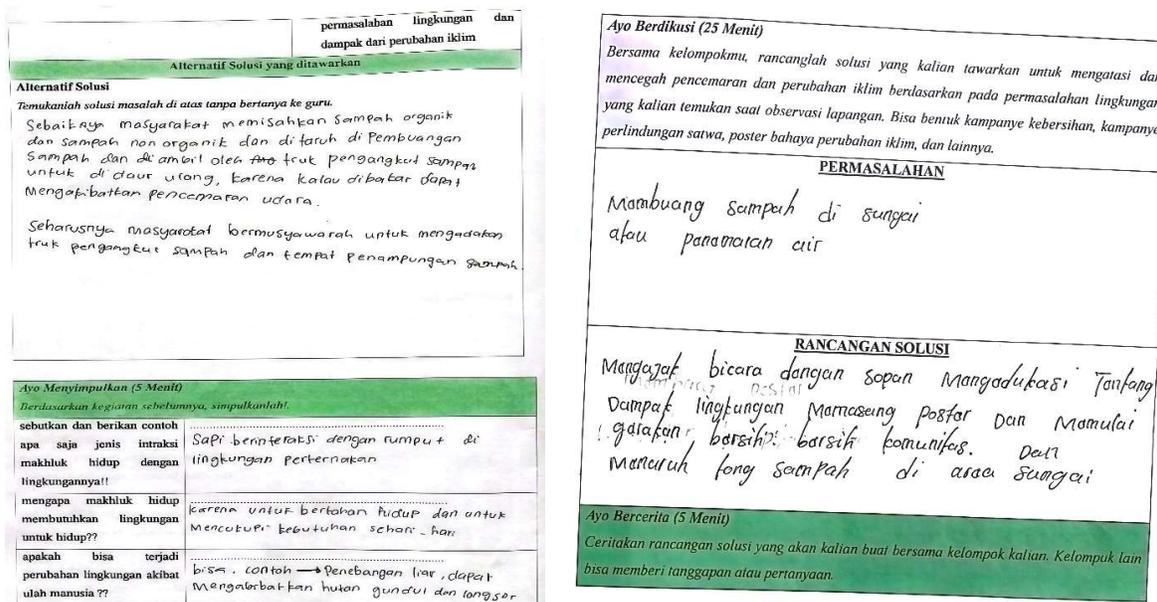


Figure 13. Examples of students' simple solution designs

on this, environmental education is integrated not only in science subjects but also in other subjects. Božak et al. (2023) conclude that students should be exposed to environmental issues in as many ways and subjects as possible.

Although this study was implemented in a context with access to edutourism sites, the findings are transferable to schools with limited access to edutourism-based learning environments. The effectiveness of the module

lies in its contextual, inquiry-based, and solution-oriented design. Schools with limited access can adapt the module by utilizing local and micro-ecological contexts, such as schoolyards, waste management systems, nearby rivers, agricultural areas, or community environments. However, when direct outdoor access is constrained, teachers may complement the module with alternative contextual strategies, including virtual field trips and documentary-based observations. Students can remain actively engaged in designing solution-based outputs, such as posters, campaigns, or action plans.

This study contributes to the growing body of research on contextual learning in science education by empirically demonstrating that ecology-based learning experiences significantly enhance students' ecological awareness. By integrating environmental concepts with real-world contexts and student-designed solutions, the module supports constructivist learning theory. It reinforces the importance of authentic learning experiences in fostering ecological literacy and pro-environmental attitudes among secondary school students. However, implementing ecotourism-based learning requires access, limited time, and resources, including funding, logistics, and a team of teachers to supervise students at the observation sites. This presents a challenge in ecotourism learning. Edutourism often requires significant logistical support and resources to ensure student access to tourist sites, which can be difficult for schools with limited budgets or without strong policy support to meet (Behrendt & Franklin, 2014; Nismara, 2025).

This study has several limitations. First, it was conducted within a specific geographic and educational context, which may limit the generalizability of the findings to a wider range of school settings. Second, the intervention duration was relatively short, preventing the examination of long-term retention and behavioral changes. Finally, this study focused on science subjects;

future research should explore interdisciplinary implementation and longitudinal designs to strengthen the evidence base and develop virtual reality learning tools for learning environments with limited access.

■ CONCLUSION

This study demonstrates that an integrated science module based on educational tourism effectively enhances students' ecological awareness, including conceptual understanding, environmental attitudes, and engagement in pro-environmental actions. This module enables students to meaningfully connect scientific concepts with real environmental issues, thereby addressing the research objectives holistically. The findings highlight that direct interaction with nature fosters a deeper understanding of ecological processes and biodiversity, while involving students in designing simple solutions to environmental problems strengthens critical thinking, student agency, and a sense of environmental responsibility.

These results reinforce the importance of experiential and solution-oriented learning in environmental education. This study contributes uniquely to the literature by integrating science content, environmental education, edutourism, and student-designed solutions within a single instructional framework, namely the ELP framework, which is easily applied to different learning environments, especially in developing teaching modules. However, this study was conducted in a specific sample of schools near tourism sites, thereby limiting the generalizability of the findings to a wider range of school environments, and employed a relatively short intervention period. Future research should examine longer-term behavioral impacts, incorporate qualitative behavioral data, and explore low-cost or alternative contextual strategies to address access and funding limitations, such as developing virtual reality as a

learning medium for integrated science in environmental education.

■ DECLARATION USE OF AI TOOLS

The authors acknowledge the use of artificial intelligence (AI) tools during the preparation of this manuscript, which was limited to assistance in improving language quality, sentence structure, and readability, and in locating several relevant references. All scientific ideas, research data, analyses, interpretations, and conclusions were developed entirely by the authors. The authors remain fully responsible for the content of this manuscript.

■ REFERENCES

- Al-Balushi, S. M., & Al-Aamri, S. S. (2014). The effect of environmental science projects on students' environmental knowledge and science attitudes. *International Research in Geographical and Environmental Education*, 23(3), 213–227. <https://doi.org/10.1080/10382046.2014.927167>
- Aripin, N., Kurniati, T., Festiyed, F., Asrizal, A., Diliarosta, S., Helendra, H., & Mufit, F. (2024). Enhancing critical thinking skills and environmental awareness through problem-based learning: a meta-analytical approach. *Jurnal Pendidikan MIPA*, 25(3), 1480–1497. <https://doi.org/10.23960/jpmipa/v25i3.pp1480-1497>
- Arslan, K., & Karaku°, N. (2024). Environmental teaching supported by web 2.0-based digital games for a sustainable life. *Sustainability*, 16(22), 9691. <https://doi.org/10.3390/su16229691>
- Behrendt, M., & Franklin, T. (2014). A review of research on school field trips and their value in education. *International Journal of Environmental and Science Education*, 9(3), 235–245. <https://doi.org/10.12973/ijese.2014.213a>
- Božak, S., Hegediš, P. J., & Hus, V. (2023). Ecological awareness among 3rd grade students of primary school. *Creative Education*, 14(02), 367–376. <https://doi.org/10.4236/ce.2023.142024>
- Byla, N. S., Taryana, D., & Suharto, Y. (2024). Transformation of environmental education (plh) learning with contextual-based e-modules at pabentengang TPA. *Jurnal Pendidikan Humaniora*, 12(4), 180. <https://doi.org/10.17977/um011v12i42024p180-187>
- Cartono, C. (2022). The importance of environmental education in biology learning to increase students' environmental awareness. *Jurnal Info Sains: Informatika Dan Sains*, 12(2), 91–97. <http://ejournal.seaninstitute.or.id/index.php/InfoSains>
- Carvache-franco, M., Segarra-oña, M., & Carrascosa-l, C. (2019). Segmentation by motivation in ecotourism/ : application to protected areas in guayas, ecuador. *Sustainability*, 11(1), 1–19. <https://doi.org/10.3390/su11010240>
- Creswell, J. W., & Guetterman, T. C. (2019). *Educational research: planning, conducting, and evaluating quantitative and qualitative research*, 6th edition (Sixth Edit). Pearson Education. https://books.google.co.id/books/about/Educational_Research.html?hl=id&id=s7rNtAEACAAJ&redir_esc=y
- Delaliæ, V. (2022). Developing ecological education through extracurricular activities. *Društvene i Humanistièke Studije (Online)*, 7(1(18)), 435–450. <https://doi.org/10.51558/2490-3647.2022.7.1.435>
- DeVellis, R. F. (2017). *Scale development: theory and applications* (4th ed.). SAGE Publications, Inc.
- Diez-Ojeda, M., Queiruga-Dios, M., &

- Queiruga-Dios, M. (2025). Service-Learning in environmental education of primary preservice teachers: advancing sdgs and improving attitudes towards sustainable development. *Education Sciences, 15*(1), 98. <https://doi.org/10.3390/educsci15010098>
- Fidiastuti, H. R., Lathifah, A. S., Amin, M., Utomo, Y., & Aldya, R. F. (2021). Improving students' motivation and learning outcomes through genetics e-module. *Jurnal Ilmiah Peuradeun, 9*(1), 189. <https://doi.org/10.26811/peuradeun.v9i1.477>
- Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2012). *How to Design and Evaluate Research in Education*. McGraw-Hill Higher Education.
- González-Herrera, M.-R., & Giralt-Escobar, S. (2021). Tourism experiential learning through academic fieldtrips in higher education. *Tourism, 69*(4), 471–493. <https://doi.org/10.37741/t.69.4.1>
- Goode, E., Nieuwoudt, J., & Roche, T. (2022). Does online engagement matter? the impact of interactive learning modules and synchronous class attendance on student achievement in an immersive delivery model. *Australasian Journal of Educational Technology, 38*(4), 76–94. <https://doi.org/10.14742/ajet.7929>
- Hadi, K., . D., Susantini, E., & Kuntjoro, S. (2022). The influence of environment-based biology learning integrated with local wisdom and character education on students' higher order thinking skills and environmental care attitude. *International Journal of Early Childhood Special Education, 14*(1), 663–672. <https://doi.org/10.9756/INT-JECSE/V14I1.221079>
- Hajj-Hassan, M., Chaker, R., & Cederqvist, A. M. (2024). Environmental education: a systematic review on the use of digital tools for fostering sustainability awareness. *Sustainability (Switzerland), 16*(9), 1–25. <https://doi.org/10.3390/su16093733>
- Hariyanto, B., MZ, I., SU, W., & Rindawati. (2022). 4D model learning device development method of the physical geography field work guidance book *MATEC Web of Conferences, 372*, 05008. <https://doi.org/10.1051/matecconf/202237205008>
- Herlanti, Y., Nobira, S., Kuboki, Y., & Qumilaila, Q. (2025). Online lesson study design: integrating environmental issues with science learning to enhance students' environmental literacy. *International Journal for Lesson & Learning Studies, 14*(1), 27–40. <https://doi.org/10.1108/IJLLS-08-2024-0169>
- Hermiono, A., & Arifin, I. (2020). Contextual character education for students in the senior high school. *European Journal of Educational Research, volume-9-2*(volume-9-issue-3-july-2020), 1009–1023. <https://doi.org/10.12973/euler.9.3.1009>
- Husin, A., Helmi, H., Nengsih, Y. K., & Rendana, M. (2025). Environmental education in schools: sustainability and hope. *Discover Sustainability, 6*(1). <https://doi.org/10.1007/s43621-025-00837-2>
- I. Erhabora, N., & U. Don, J. (2018). Impact of environmental education on the knowledge and attitude of students towards the environment. *Tjip Chí Nghiên Cứu Dân Tộc, 11*(24), 5367–5375. <https://doi.org/10.25073/0866-773X/68>
- Ibáñez, M. E., Cid, I. V. L., Muñoz, L. V. A., & Claros, F. M. (2020). Environmental education, an essential instrument to implement the sustainable development goals in the university context. *Sustainability (Switzerland), 12*(19), 1–

23. <https://doi.org/10.3390/su12197883>
- Ikhsan, M., Atun, S., Agusta, F., Unayah, H., Buhera, R., Pamungkas, O., Sarip, M., & Sitorus, P. A. (2025). Development of critical thinking essay test instrument and prosocial intention questionnaire for environmental care in students. *Journal Evaluation in Education (JEE)*, 6(1), 66–78. <https://doi.org/10.37251/jee.v6i1.1273>
- Indaryanti, R. B., Harsono, H., Sutarna, S., Murtiyasa, B., & Soemardjoko, B. (2025). 4D research and development model: Trends, challenges, and opportunities review. *Jurnal Kajian Ilmiah*, 25(1), 91–98.
- Jufri, M. (2023). Introducing the concept of energy conservation for elementary students through the Eduwisata program. *SCI-TECH MEDIA Community Service Journal of Science and Technology*, 1(1), 25–32. <https://doi.org/10.22219/scitechmedia.v1i1.25880>
- Kholik, R. N., Wijanarka, B. S., Rahdiyanta, D., Paryanto, P., & Nuryanto, A. (2025). Implementation of learning modules to improve student competence. *International Journal of Research and Innovation in Social Science*, IX(II), 1852–1858. <https://doi.org/10.47772/IJRISS.2025.9020151>
- Ko, P., Liu, C., Law, N., Tan, Y., & Shaffer, D. W. (2025). Exploring students' epistemic orientation, learning trajectories, and outcomes. *Proceedings of the 15th International Learning Analytics and Knowledge Conference*, 317–327. <https://doi.org/10.1145/3706468.3706509>
- Littledyke, M. (2008). Science education for environmental awareness: approaches to integrating cognitive and affective domains. *Environmental Education Research*, 14(1), 1–17. <https://doi.org/10.1080/13504620701843301>
- Liu, J., & Green, R. J. (2024). Children's pro-environmental behaviour: a systematic review of the literature. *Resources, Conservation and Recycling*, 205, 107524. <https://doi.org/10.1016/j.resconrec.2024.107524>
- Ma'rufah, M. D., Ngabekti, S., & Setiati, N. (2021). Development of socioscientific issues-based teaching materials to improve learning outcomes and students' environment careness on the environmental changing material. *Journal of Innovative Science Education*, 9(3), 87–94. <https://doi.org/10.15294/jise.v9i2.39911>
- Ma, L., Shahbaz, P., Haq, S. ul, & Boz, I. (2023). Exploring the moderating role of environmental education in promoting a clean environment. *Sustainability*, 15(10), 8127. <https://doi.org/10.3390/su15108127>
- Mahsun, S., Utaya, S., Handoyo, B., & Wibowo, N. A. (2025). Enhancing environmental awareness: evaluating the impact of project-based hybrid learning on critical thinking for high school students. *International Journal of Environmental Impacts*, 08(01), 123–135. <https://doi.org/10.18280/ije.080113>
- Makrooni, G., Zen, S., Azhar, K., & Ropo, E. (2025). Once upon a time/ : Teachers' narratives on climate change education. *International Review of Education*, 0123456789. <https://doi.org/10.1007/s11159-024-10114-5>
- Maleknia, R., & Zamani, N. (2025). Extending the knowledge-attitude-practice model to exploring the role of environmental literacy in shaping ecotourists' pro-environmental behavior. *Acta Psychologica*, 261, 105910. <https://doi.org/10.1016/j.actpsy.2025.105910>
- Mocheco, A. E. N., & Reyna, Q. T. (2026).

- Problem-based learning as a strategy to promote environmental culture/ : a systematic review study. *InveCom Journal*, 6(1). <https://doi.org/https://doi.org/10.5281/zenodo.15400666>
- Montori, S., & Jacobus, S. N. H. (2025). *Penerapan model four-d (4d) dalam pengembangan media video materi keanekaragaman/ : meningkatkan toleransi dan kebhinekaan pada peserta didik* [application of the four-d (4d) model in the development of video media on diversity material: increasing tolerance and diversity in students]. *INNOVATIVE: Journal of Social Science Research*, 5(4), 3234–3246.
- Moon, J., McNeill, L., Edmonds, C. T., Banihashem, S. K., & Noroozi, O. (2024). Using learning analytics to explore peer learning patterns in asynchronous gamified environments. *International Journal of Educational Technology in Higher Education*, 21(1), 45. <https://doi.org/10.1186/s41239-024-00476-z>
- Muchlisa, N., Arsyad, M., & Helmi, H. (2024). Development of science teaching module based on environmentally for students at MTsN Barru. *International Journal of Social Science and Human Research*, 07(01). <https://doi.org/10.47191/ijsshr/v7-i01-32>
- Muliawan, W., Marzuki, M., & Amalia, L. R. (2024). Development of student worksheets on environmental pollution based on problem-based learning oriented to local wisdom to increase students' learning motivation. *PAEDAGOGIA*, 27(3), 424. <https://doi.org/10.20961/paedagogia.v27i3.93951>
- Murti, W., Rohman, F., Saptasari, M., & Ibrohim, I. (2025). Ecoliteracy competencies: a systematic literature review of domains, approaches, and impacts in education. *Eurasia Journal of Mathematics, Science and Technology Education*, 21(8), em2677. <https://doi.org/10.29333/ejmste/16658>
- Mwendwa, B., Ecosystem, S., Management, B., & Education, S. (2017). Learning for sustainable development: integrating environmental education in the curriculum of ordinary secondary schools in Tanzania. *Journal of Sustainability Education*, 12(February).
- Nachtigall, V., & Firstein, A. (2024). Exploring the impact of authentic learning activities on school students' epistemic beliefs in the social sciences and humanities. *European Journal of Psychology of Education*, 39(4), 3351–3379. <https://doi.org/10.1007/s10212-023-00773-7>
- Nismara, M. I. (2025). *Rethinking edutourism in indonesia/ : a systematic review of global evidence and policy implications*. <https://doi.org/10.36256/ijtl.v6i2.548>
- Nur Fitria, T. (2024). Field trip teaching method: introducing educational tourism (edutourism) for learning english. *Journal on Language, Education, Literature, and Culture*, 2(1), 10–24. <https://doi.org/10.33323/l.v2i1.15>
- Nurdin, E. A., Ikhsan, F. A., Kurnianto, F. A., & Apriyanto, B. (2017). Application of contextual teaching learning to learning results in understanding the life environment in smp negeri 2 sukodono. *Geosfera Indonesia*, 1(1), 13. <https://doi.org/10.19184/geosi.v1i1.6189>
- Nurmiati, N., Arismunandar, A., & Rauf, B. A. (2022). Development of environmental-based contextual learning models to increase student creativity at the high school level. *Proceedings of the 1st World Conference on Social and Humanities Research (W-SHARE 2021)*, Atlantis Press. <https://doi.org/10.2991/>

- assehr.k.220402.055
- Ocakodlu, G., & Macunluoglu, A. C. (2023). Comparison of the performances of parametric k-sample test procedures as an alternative to one-way analysis of variance. *The European Research Journal*, *9*(1), 39–48. <https://doi.org/10.18621/eurj.1030038>
- Picardal, M. (2025). Shaping future science education: post pandemic perspectives of preservice science teachers in central visayas, Philippines. *Journal of Technology and Science Education*, *15*(1), 129–141. <https://doi.org/10.3926/JOTSE.3136>
- Pratami, M., Sahid, S., Mustofa, A. N. A., Refaldy, M. A., & Rahman, K. Z. (2025). *Pengembangan zonasi eduwisata di kawasan pendidikan institut teknologi sumatera (ITERA) untuk mendukung pariwisata berkelanjutan* [Development of educational tourism zoning in the sumatra institute of technology (ITERA) educational area to support sustainable tourism]. *Ranah Research/ : Journal of Multidisciplinary Research and Development*, *7*(2), 1417–1432. <https://doi.org/10.38035/rj.v7i2.1351>
- Pulido, L., Pépin, A., Bergeron-Leclerc, C., Cherblanc, J., Godue-Couture, C., Laprise, C., Paquette, L., Nadeau-Tremblay, S., & Simard, S. (2025). The effects of outdoor teaching on academic achievement and its associated factors a scoping review. *Education Sciences*, *15*(8), 1060. <https://doi.org/10.3390/educsci15081060>
- Punzalan, C. (2024). Environmental education in junior high school science: teachers' integration perceptions through distance learning modality. *Jurnal Pendidikan IPA Indonesia*, *13*(2). <https://doi.org/10.15294/jjqkgi45>
- Ramírez Suárez, V., Acosta-Castellanos, P. M., Castro Ortegón, Y. A., & Queiruga-Dios, A. (2023). Current state of environmental education and education for sustainable development in primary and secondary (k-12) schools in boyacá, Colombia. *Sustainability*, *15*(13), 10139. <https://doi.org/10.3390/su151310139>
- Rani, A., Gupta, S., Sehgal, G., & Singhal, R. (2023). Development of analytic rubric for assessing written assignments for evaluating higher order cognition in the first phase neuroanatomy module. *National Journal of Clinical Anatomy*, *12*(4), 178–185. https://doi.org/10.4103/NJCA.NJCA_103_23
- Ratnasari, J., Hakam, K. A., Hidayat, M., & Kosasih, A. (2024). Strengthening environmental care character through contextual approach in science learning. *Jurnal Penelitian Pendidikan IPA*, *10*(11), 9234–9241. <https://doi.org/10.29303/jppipa.v10i11.9024>
- Retnowati, R., Awaludin, M. T., & Heryawati, E. R. (2020). Developing an integrated biology module for students' environmental attitude instruments. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *6*(2), 327–334. <https://doi.org/10.22219/jpbi.v6i2.11163>
- Richter, T., & Tiffin-Richards, S. P. (2024). Learning as an epistemic activity / el aprendizaje como actividad epistémica. *Journal for the Study of Education and Development: Infancia y Aprendizaje*, *47*(1), 3–48. <https://doi.org/10.1177/02103702231224633>
- Riduwan. (2015). *Skala pengukuran variabel-variabel penelitian*. ALFABETA.
- Rofisian, N., & Rahmawati, I. (2020). Developing problem-based learning module to improve the fourth-grade students' learning achievement motivation.

- Indonesian Journal of Elementary Teachers Education*, 1(2). <https://doi.org/10.25134/ijete.v1i2.3674>
- Romlah, L. S., Purnama, R., Ambarwati, R., Hijriyah, U., Amriyah, C., & Jamaluddin Z, W. (2024). Environmental-based learning management in islamic education institutions. *E3S Web of Conferences*, 482, 04019. <https://doi.org/10.1051/e3sconf/202448204019>
- Sabatini, S., Manurung, B., & Sudiby, M. (2023). Developing ecology and environmental learning materials based on integration curriculum and scientific literacy for national plus school students in Indonesia. *Quaerite Veritatem/ : Jurnal Pendidikan*, 2(2), 151–165. <https://doi.org/10.53842/qvj.v2i2.34>
- Sabila, A. P., Rochani, R., Rahmawati, R., & Dwinurnala, M. (2024). Development of a self management module to improve student learning discipline at MAN 1 Lebak. *Konseling Edukasi "Journal of Guidance and Counseling,"* 8(2), 166. <https://doi.org/10.21043/konseling.v8i2.26729>
- Safri, Z., Hasanah, S., Mahmudah, S., F., & Siregar, T. S. (2024). Implementation of contextual teaching and learning model in nature-based learning to improve morals and concern for the school environment at smp s alam leuser. *Jurnal Profesi Guru Indonesia*, 1(4), 162–169. <https://doi.org/10.62945/jpgi.v1i4.636>
- Shodiq, A., Barriroh, H., Alimah, N., & Suparto, S. (2025). *Pengembangan instrumen dan rubrik penilaian untuk evaluasi pembelajaran di madrasah ibtidaiyah* [Development of assessment instruments and rubrics for learning evaluation in elementary madrasahs]. *Journal of Education Research*, 6(4), 850–860. <https://doi.org/10.37985/jer.v6i4.2299>
- Singh, A. B. (2022). Examining students' collaborative epistemic actions in a mooc learning environment. *Journal of University Teaching and Learning Practice*, 19(4). <https://doi.org/10.53761/1.19.4.18>
- Slovinsky, E., Kapanadze, M., & Bolte, C. (2021). The effect of a socio-scientific context-based science teaching program on motivational aspects of the learning environment. *Eurasia Journal of Mathematics, Science and Technology Education*, 17(8), em1992. <https://doi.org/10.29333/ejmste/11070>
- Sridana, N., Alsulami, N. M., Isnawan, M. G., & Sukarma, I. K. (2025). Problem-Solving based epistemic learning pattern: optimizing mathematical representation ability of prospective teachers and pharmacists. *Educational Process International Journal*, 14(1). <https://doi.org/10.22521/edupij.2025.14.21>
- Sudarman, S., & Ardian, A. (2021). The development of interactive module to support student centered learning. *Akademika*, 10(01), 77–92. <https://doi.org/10.34005/akademika.v10i01.1344>
- Sueb, S., Suhadi, S., & Zahroh, V. R. A. (2021). The effect of ecosystem module based on inquiry with fishpond as a learning resource to improve environmental attitude. *AIP Conference Proceedings: The 4TH International Conference on Mathematics and Science Education (ICoMSE) 2020*, 030058. <https://doi.org/10.1063/5.0043587>
- Sugiharti, G., Dalimunthe, M., Sari, D. P., & Anugrah, A. N. (2025). Effectiveness of implementing problem-based learning modules to improve students' science literacy and higher-order thinking. *Journal of Posthumanism*, 5(3). <https://doi.org/>

- 10.63332/joph.v5i3.812
- Sugiyono. (2020). *Metodologi penelitian kuantitatif, kualitatif dan R & D* (k-13). Alfabeta Bandung.
- Sukma, E., Ramadhan, S., & Indriyani, V. (2020). Integration of environmental education in elementary schools. *Journal of Physics: Conference Series*, 1481(1), 012136. <https://doi.org/10.1088/1742-6596/1481/1/012136>
- Supaida, T., Kustiyowati, K., & Triwahyuni, E. (2025). The effect of the field trip learning method on student activeness and learning outcomes at junior high school. *Jurnal Penelitian Pendidikan IPA*, 11(10), 780–786. <https://doi.org/10.29303/jppipa.v11i10.12662>
- Suryanti, D., Sinaga, P., & Surakusumah, W. (2018). Improvement of students' environmental literacy by using integrated science teaching materials. *IOP Conference Series: Materials Science and Engineering*, 306, 012031. <https://doi.org/10.1088/1757-899X/306/1/012031>
- Susbiyanto, S., Hidayat, T., Surtikanti, H. K., & Riandi, R. (2024). Citizen science project design for ecology course: reducing pollution caused by gold mining. *Jurnal Ilmiah Ilmu Terapan Universitas Jambi*, 8(1), 117–135. <https://doi.org/10.22437/jiituj.v8i1.32348>
- Syam, A. T., & Furwana, D. (2022). The 4-D model on the development of english learning materials for islamic education learners. *Dinamika Ilmu*, 17–39. <https://doi.org/10.21093/di.v22i1.4235>
- Syamsudin, F. I., Saputro, S., Sarwanto, K., P., & Kamari, A. (2025). Enhancing students' environmental awareness in rural and urban schools through problem and design process based learning model with steam. *Discover Education*, 4(1), 555. <https://doi.org/10.1007/s44217-025-01006-3>
- Tabuena, A. C., & Villareal, E. G. (2024). Usefulness and challenges of clustered self-directed learning modules in entrepreneurship for senior high school distance learning. *Turkish Online Journal of Distance Education*, 25(1), 155–178. <https://doi.org/10.17718/tojde.1143460>
- Tampubolon, M. L. V., & Sipahutar, H. (2024). Development of project-based modules to improve learning outcomes, critical thinking and problem-solving skills. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, 10(2), 531–541. <https://doi.org/10.22219/jpbi.v10i2.32958>
- Tomarken, A. J., & Serlin, R. C. (1986). Comparison of anova alternatives under variance heterogeneity and specific noncentrality structures. *Psychological Bulletin*, 99(1), 90–99. <https://doi.org/10.1037/0033-2909.99.1.90>
- Torsney, A., O'Driscoll, P., & Buckley, Y. M. (2025). Defining ecotourism for mainstream application and to support sustainable tourism governance. *Ecological Solutions and Evidence*, 6(2). <https://doi.org/10.1002/2688-8319.70050>
- Triyanto, A. T., & Aryani, I. K. (2022). Increasing learning motivation and learning outcomes in mathematics using modules for elementary school students. *Dinamika Jurnal Ilmiah Pendidikan Dasar*, 14(1), 54. <https://doi.org/10.30595/dinamika.v14i1.11541>
- Velempini, K. (2025). Assessing the role of environmental education practices towards the attainment of the 2030 sustainable development goals. *Sustainability*, 17(5), 2043. <https://doi.org/10.3390/su17052043>
- Wai Ying, T., Alias, N., & DeWitt, D. (2024). Sustainable environmental education using

- virtual reality: a module for improving environmental citizenship competences in secondary schools. *Eurasia Journal of Mathematics, Science and Technology Education*, 20(10), em2511. <https://doi.org/10.29333/ejmste/15177>
- Wals, A. E. J., Brody, M., Dillon, J., & Stevenson, R. B. (2014). Convergence between science and environmental education. *Science*, 344(6184), 583–584. <https://doi.org/10.1126/science.1250515>
- Whitburn, J., Abrahamse, W., & Linklater, W. (2023). Do environmental education fieldtrips strengthen children’s connection to nature and promote environmental behaviour or wellbeing? *Current Research in Ecological and Social Psychology*, 5, 100163. <https://doi.org/10.1016/j.cresp.2023.100163>
- Wildan, W., Supriadi, S., Laksmiwati, D., & Analita, R. N. (2021). Environmental chemistry course assisted problem-based learning in developing students’ higher-order thinking skills and characters. *Acta Chimica Asiana*, 4(2), 141–146. <https://doi.org/10.29303/aca.v4i2.54>
- Zahrawati, F. (2023). Eco pedagogic based on local wisdom as an effort to grow students’ ecological awareness. *ENTITA: Jurnal Pendidikan Ilmu Pengetahuan Sosial Dan Ilmu-Ilmu Sosial*, 5(1), 1–14. <https://doi.org/10.19105/ejpis.v5i1.8241>
- Zatsepina, M. B., Kriskovets, T. N., Vorobyev, V. K., Kolobova, L. V., Grigor’eva, N. V., Fedulov, V. I., & Stolyarova, A. N. (2020). Educational tourism: tribute to fashion or new educational opportunities? *Propósitos y Representaciones*, 8 (SPE2). <https://doi.org/10.20511/pyr.2020.v8nSPE2.642>