



## Improving Environmental Literacy through Problem-Based Learning E-Modules: A Pre-Experimental Study in Islamic Senior High Schools Bekasi, Indonesia

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### Keywords

Environmental Literacy; Environmental Issues; e-module

### ABSTRACT

Environmental literacy is an individual's ability to understand environmental systems and their problems, and to have the knowledge, attitudes, and skills to solve them responsibly. This study aims to improve environmental literacy involving the knowledge, skills, and attitudes of individuals needed to understand, analyze, and solve environmental problems effectively. The quantitative research method with a one-group pretest-posttest design. The study was conducted at Al-Fajar Islamic High School, Bekasi. The research sample involved 20 grade X students. Data collection was carried out through a written pretest (secondary data) and posttest (primary data). Data analysis: descriptive analysis and t-test. The results of the study showed a significant difference in environmental literacy scores seen from the pretest (Mean = 60.50, SD = 6.669) and posttest (Mean = 82.00, SD = 4.401) scores. Hypothesis testing with p-Value (sig. (2-tailed) = .000, then .000 < 0.05. means Ho is rejected, Ha is accepted, meaning there is a difference. The conclusion is that there is a difference in student learning outcomes (pretest-posttest) after being given treatment using a problem-based learning module to improve environmental literacy involving students' knowledge, attitudes, and environmental problem-solving skills.

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## INTRODUCTION

Technological developments and globalization have transformed the landscape of human activity. Therefore, education needs to adapt its curriculum and teaching methods to develop skills relevant to future needs. Education in this 21st-century era needs to address this challenge by developing 21st-century skills (Yusuf et al., 2023).

One of the main functions of the curriculum in 21st century education is to integrate critical thinking skills, communication, collaboration, creativity (4C), digital

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literacy, and complex problem solving into the learning process (Trilling & Fadel., 2019; (Daga, 2025).

Skills or literacy. Functional literacy is seen as a set of reading, writing, and arithmetic skills that students can use in everyday life (Abbott et al., 2020). (Maurer & Bogner, 2020) explain that literacy has now expanded to various fields of study related to community life, such as natural sciences and social sciences. Literacy in the field of environmental education can be defined as environmental literacy. This literacy focuses on four main aspects, namely: a) attitudes, such as sensitivity, b) responsible behavior, and active involvement, and c) scientific knowledge, and d) skills, such as dealing with environmental problems.

Zuhriyah (2025) suggests that it is necessary to develop students' attitudes, values, knowledge, dispositions and skills to carry out pro-environmental actions, environmental education will encourage harmony between humans and nature over time. This, refers to (Fang et al., 2023) that Roth's ideas in Environmental Education Research News, which represent the delivery of information about environmental literacy.

Experts state that environmental literacy is a key concept in encouraging individual attitudes towards lifestyle changes that are aware of sustainable environmental challenges (Bissinger & Bogner, 2018; (Rofiqi, 2024). (Nurwidodo et al., 2021) agrees that environmental literacy is an individual's ability to understand and interpret environmental conditions. Based on this understanding and interpretation, the individual can decide on appropriate actions to maintain, restore, and improve environmental conditions.

Based on the above definition, which leads to positive attitudes and behaviors toward the environment, (Rofiqi, 2024b) suggests that environmental literacy needs to be instilled from an early age, for example, through implementation in education (Saribas, 2015). Environmental literacy in education plays a role in shaping individual character to care for the environment, so that individuals know and are able to do what needs to be done for the environment (Hollweg et al., 2011).

The results of the 2022 PISA environmental literacy assessment paint a worrying picture. Indonesian students' environmental literacy score (396) remains far below the OECD average (492), placing us in 72nd place out of 79 countries. This finding indicates

that current approaches to environmental education have not been successful in fostering a deep understanding of sustainability issues (Erdogan & Ok, 2021; (Setiawan et al., 2025).

The solution in this research is to improve environmental literacy by providing environmental education integrated with environmental issues. To ensure effective learning, this research also utilizes a variety of media and methods that can engage students and help them understand environmental concepts in a concrete and interactive manner. In previous research, (Ahmadi Z.S, 2022), efforts to increase environmental literacy can implement learning that provides direct experience supported by active learning using various varied methods and its implementation can be done inside or outside the classroom.

This learning encourages students to interact and collaborate by utilizing the surrounding environment, so that students can participate in the learning process to improve conceptual understanding through exploration, discussion and problem solving directly with their peers.

This learning aligns with the ideas of the 1992 Rio de Janeiro Conference, initiated by the United Nations, on Environment and Sustainable Development. This conference aimed to address global environmental issues such as climate change, biodiversity loss, and pollution. A prominent environmental issue is climate change. It has become a pressing global issue, affecting not only natural ecosystems but also crucial aspects of human life. Its impacts extend to various areas, including human health, economic stability, and social justice. Rising global temperatures, changes in extreme weather patterns, and threats to the sustainability of natural resources are clear evidence that climate change is no longer merely an environmental issue but also one closely related to overall human well-being (Agustin 2023; (Mahardhika et al., 2024).

Various environmental problems around us originate from waste problems. This problem can lead to flooding, if this problem is not anticipated then it will have a major impact on economic, social and environmental aspects. For example, damage to infrastructure will result in hampered food transportation or crop failure (economic), disruption of community activities and psychological trauma (social as well as environmental pollution and ecosystem damage (environment). This opinion is supported

by (Khansa et al., 2024). various environmental problems are currently occurring, one of which is related to waste. (Seprina et al., 2025) added that if the condition of the problem is not addressed, it will get worse if people are still accustomed to throwing waste into rivers, this will result in water pollution, blockage of water channels and cause flooding during the rainy season.

Based on the facts, just on November 27, 2025, natural disasters such as floods and landslides occurred in three provinces on the island of Sumatra (Aceh, North Sumatra, West Sumatra) which claimed many lives. (K.Indra, 2025) reported information from the National Disaster Management Agency (BNPB), that as of December 16, 2025, the total number of deaths due to floods and landslides in three provinces in Sumatra (Aceh, North Sumatra, and West Sumatra) was 1,053. Seeing this natural disaster should serve as a reminder for all of us to care more about the environment. Environmental damage, such as large-scale deforestation, often exacerbates the impact of natural disasters.

Flooding also frequently occurs at Al-Fajar Islamic Senior High School, located in the Villa Nusa Bekasi housing complex, caused by the overflowing Cileungsi-Cikeas rivers, which meet in the area. This occurs every year during the rainy season. As a result of the flooding, many school facilities are damaged.

Currently there is no definite solution, even though there has been repair of the embankment but flooding still recurs, experienced by Al-Fajar Islamic Senior High School and its surrounding environment. With this incident, the Government instructed educational institutions or schools to continue to increase the knowledge of the younger generation so that teachers continue to actively provide Environmental Education that has been integrated into various subject matter in schools, either implicitly or through environmental-based school activities. Based on government instructions, researchers as educators who have knowledge of Environmental Education participated in providing environmental education knowledge to class X students of Al-Fajar Islamic Senior High School Bekasi. The provision of Environmental Education at the school is a series of research activities that aim to increase knowledge, pro-environmental attitudes and skills in solving environmental problems, so that these provisions can improve environmental literacy in students.

This research activity provides students with a problem-based learning e-module for biology, specifically on environmental change. This e-module, in addition to the material, also contains assignments that students must complete after the material is presented. This e-module, in addition to containing material, there are also assignments that must be completed by students after the material is given. (Wulansari et al., 2018), explain that e-modules are teaching materials that can help students learn subject matter independently, using electronic media. Furthermore, e-modules are designed with a variety of displays to increase student learning motivation (Hardanti. et al., 20224).

Based on the theory and problems above, the formulation of the research problem is whether the use of problem-based learning modules can improve environmental literacy in 10th-grade students of Al-Fajar Islamic Senior High School, Bekasi. The purpose of this study is to improve environmental literacy, which includes the knowledge, skills, and attitudes of individuals needed to understand, analyze, and solve environmental problems effectively through the Problem-Based Learning E-Module.

## **METHOD**

This study employed a quantitative approach with a single-group pretest-posttest design to evaluate the effectiveness of an educational intervention by comparing the same participants' performance before and after treatment (Creswell & Creswell, 2018). This design is appropriate for initial investigations where random assignment to control groups is not feasible (Fraenkel et al., 2019).

The research was conducted at Al-Fajar Islamic High School, Bekasi, during the second semester of the 2024/2025 academic year. Participants consisted of a single intact class of 20 tenth-grade students (mean age = 15.7 years, SD = 0.5) selected through purposive sampling based on their enrollment in the target course. According to Cohen et al. (2018), purposive sampling is justified when researchers seek information-rich cases relevant to the phenomenon under study. All participants provided informed assent, and parental consent was obtained prior to data collection, following American Psychological Association (APA, 2020) ethical guidelines.

Following the pretest, participants received a four-session inquiry-based learning intervention (2 hours per session over two weeks) focused on developing critical thinking

skills in biology. The intervention was designed based on constructivist principles (Vygotsky, 1978) and incorporated collaborative problem-solving activities with scaffolded guidance from the instructor, consistent with recommendations for effective science pedagogy (National Research Council, 2012).

The primary dependent variable was conceptual understanding measured through a researcher-developed essay test. The initial instrument contained 10 essay items, each scored using a 5-point analytic rubric assessing conceptual accuracy, reasoning quality, and evidence use (maximum score = 50).

Validity was established through multiple approaches. Content validity was ensured by aligning items with specific curriculum standards and having them reviewed by two subject matter experts (Sugiyono, 2019). Construct validity was examined through pilot testing with 30 students from a parallel class (not included in the main study). Item analysis using Pearson Product-Moment correlation revealed 5 items met the validity criterion ( $r > 0.361$ ,  $p < .05$ ) (Fraenkel et al., 2019). These items were retained for the main study (Table 1).

Reliability of the 5-item instrument was assessed using Cronbach's alpha, yielding  $\alpha = .82$ , exceeding the recommended threshold of .70 for established instruments (Tabachnick & Fidell, 2019).

**Table 1.** *Item Validity Analysis of Research Instrument (Pilot Study, n=30)*

Item	$\Sigma X$	$\Sigma X^2$	r_calculated	r_critical	Validity Status
1	117	471	0.417	0.361	Valid
2	121	513	0.332	0.361	Not valid
3	125	541	0.324	0.361	Not valid
4	130	582	0.528	0.361	Valid
5	117	477	0.664	0.361	Valid
6	125	547	0.675	0.361	Valid
7	128	568	0.262	0.361	Not valid
8	117	479	0.821	0.361	Valid
9	99	349	0.287	0.361	Not valid
10	105	397	0.358	0.361	Not valid

*Note.* Validity criterion:  $r > r_{\text{critical}}$  (0.361) at  $\alpha = .05$ , two-tailed.

Data collection followed a standardized, three-phase protocol. First, the pretest was administered using the validated 5-item essay instrument to establish a baseline of students' conceptual understanding. Subsequently, participants engaged in the core

intervention, consisting of four structured inquiry-based learning sessions. To measure learning gains and assess retention, a parallel-form posttest was administered one week after the final intervention session. To ensure consistency, both the pretest and posttest were delivered online via the school's learning management system, proctored by the classroom teacher, with a standardized time allotment of 60 minutes for each assessment.

Data were analyzed using IBM SPSS Statistics Version 26. Descriptive statistics (means, standard deviations, ranges) characterized pretest and posttest performance. The primary analysis employed a paired samples t-test to compare mean pretest and posttest scores. The Shapiro-Wilk test confirmed normality of difference scores ( $W = 0.96$ ,  $p = .42$ ), satisfying the parametric test assumption (Pallant, 2020). The hypotheses were:

$H_0: \mu_{\text{pretest}} = \mu_{\text{posttest}}$  (no significant difference)

$H_1: \mu_{\text{pretest}} < \mu_{\text{posttest}}$  (significant improvement)

Statistical significance was set at  $\alpha = .05$ , with Cohen's  $d$  calculated to report effect size magnitude, where  $d = 0.2$ ,  $0.5$ , and  $0.8$  represent small, medium, and large effects respectively (Cohen, 1988).

## RESULT AND DISCUSSION

### Results

The data for this study were obtained from the results of the pretest and posttest and presented using descriptive statistics. Description of data statistics see the table below:

**Table 2.** *Data Description Statistics*

		Statistics	
		Pretest	Posttest
N	Valid	20	20
	Missin g	20	20
Mean		60.50	82.00
Median		60.00	82.00
Mode		60 <sup>a</sup>	84
Std. Deviation		6.669	4.401
Minimum		50	76
Maximum		75	92

Table 1 above shows the pretest learning results with an average score of 60.50, while the posttest average score was 82.00.  $SD_{\text{Pretest}} = 6.669$ ,  $SD_{\text{Posttest}} = 4.401$ . The

results of this data are also presented in the form of a descriptive statistical diagram, see Figures 1 & 2, as follows:

**Figure 1.** *Pretest Data Graph*

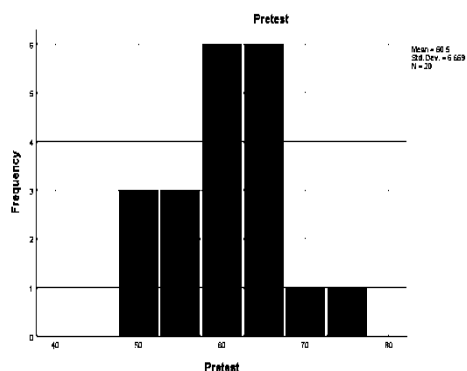


Figure 1 shows a bar chart on the X axis indicating the pretest value, while the Y axis indicates the frequency, meanwhile, the lowest values are 50 and 55, (frequency 3), the values that frequently appear are 60 and 65, frequency 6), and the highest values are 70 and 75, frequency 1).

**Figure 2.** *Posttest Data Graph*

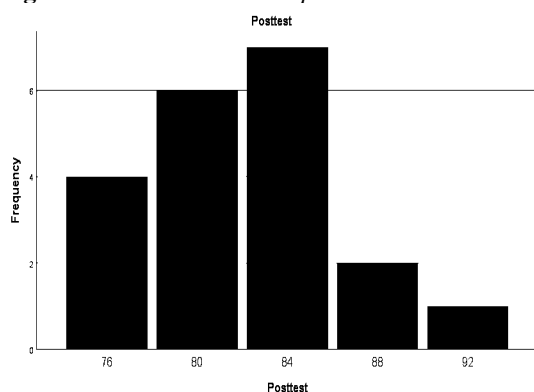


Figure 2 shows a bar chart of the posttest data, with the X-axis representing scores and the Y-axis representing frequencies. Here are the details: the lowest score was 76 (frequency 4), the most frequent score was 84 (frequency 7, the highest score was 92 (frequency 1).

#### Hypothesis Test (t test)

The results of hypothesis testing using the Paired Samples T-Test can be seen in the table below.

**Figure 3. Paired Samples T-Test Results**

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Paired Sample 1	Pre test	-21.500	6.378	1.426	-24.485	-18.515	-15.0	19	.000
	Post test						74		

In Figure 3, The results of the hypothesis test show a p-value (sig. (2-tailed) = .000),  $.000 < 0.05$ , so reject  $H_0$  and accept  $H_a$ , meaning there is a significant difference between the two measurement results (pretest-posttest).

The conclusion is that there is a difference in learning outcomes (pretest - posttest) after being given treatment by utilizing problem-based learning modules to improve environmental literacy by involving knowledge, attitudes and skills in solving environmental problems.

### Discussion

Based on the calculation results of Data Description Statistics, there is an increase in student learning outcomes, seen from the pretest results, which obtained a Mean value = 60.50, SD = 6.669. This value is still below the Minimum Competency (KKM). And the posttest value obtained a Mean value = 82.00, SD = 4.401. This learning outcome has reached above the Minimum Competency (KKM) = 75. This difference in learning outcomes is due to students being given learning treatment using problem-based learning e-modules on environmental change material related to environmental issues. From this treatment, evidence shows that students acquire knowledge, which can change their views on environmental issue (Arif, M., & Changxiao, 2022) who said that if students are aware of the process of worsening environmental conditions that underlie actions that lack environmental understanding, perhaps they will adopt information or knowledge that can encourage ecological phenomena.

E-modules, or electronic modules, are teaching materials designed in digital format and accessible through electronic devices. These e-modules contain systematic learning materials and are supplemented with assignments, practice questions, and self-assessments (evaluations). (Suryani et al., 2024) explained that the development of electronic modules combined with learning models can improve students' critical thinking skills, one of which is problem-based learning. PBL is an approach that teaches students to think about practical, unstructured, or open-ended problems through stimulation.

The problem-based learning e-module for grade X students in this study is an electronic module designed to integrate Environmental Education into biology subjects with environmental change material related to environmental issues, by presenting authentic problems for students to study independently. Students use this module to identify, analyze, and evaluate environmental issues, so they can develop understanding, thinking skills, as well as critical and caring attitudes towards the environment.

This problem-based learning activity refers to Polya's theory related to environmental issues. (Gulam & Arenas, 2024) stated that the Polya method remains a valuable tool for fostering problem-solving skills in students, demonstrating its continued effectiveness in modern teaching. According to experts (Awaluddin & Firmansyah, 2025), the major challenges facing the world today are environmental problems. Issues such as climate change, air and water pollution, deforestation, and biodiversity loss are pressing global concerns that must be addressed (Nurdiana et al., 2024). These problems require not only a scientific approach but also awareness and caring attitudes from all levels of society, including students.

According to (Fitri et al., 2024), providing story problems is very necessary so that students can relate to contextual problems and require students to think more deeply. (S.A.E.Sartika., I.G.P. Suharta, 2024) added that to solve story problems, students' literacy skills can be used, by going through problem-solving stages so that they can solve problems correctly and precisely.

E-module Problem-based learning is student-centered and encourages independent learning by seeking relevant reading resources. Furthermore, this learning encourages student creativity by providing real-life challenges that develop thinking, collaboration, and peer communication skills, as well as helping students acquire new

knowledge and skills. This learning involves e-modules as a learning medium to guide students through the stages of Problem Based Learning (PBL). The implementation of this learning within the independent curriculum can be an educational solution by providing knowledge, skills, and a responsible attitude needed to address various environmental issues. This activity can increase environmental literacy to address the challenges of the 21st century.

After studying the material on environmental changes related to environmental issues through e-modules, it is expected to improve environmental literacy in class X students of SMA Islam Al-Fajar. The learning process implemented in this study received support from the students. This learning achievement can be proven from the results of the t-test which shows that the p-value is 0.00. This value is smaller than the specified significance level of 0.05. The conclusion  $H_0$  is rejected because the p-value = 0.00 is smaller than the significance level of 0.05, so there is a statistically significant difference in the pretest and posttest learning outcomes of the impact of treatment by utilizing problem-based learning e-modules to improve environmental literacy.

It is important to improve environmental literacy in students as the future generation to face the challenges of the 21st century. Experts say there are several reasons behind the importance of the younger generation receiving environmental literacy education, as follows: a) Positive interactions with the environment are important for children's health development, b) Environmental literacy education can improve learning abilities and the quality of life's journey, c) Children will view nature as a source of awe, joy, and charm, d) Children's souls will be enriched by nature, and children will find sources of human sensitivity through it (Kurniasih, et al., 2015; (Sidiq, M N. et al., 2020).

This problem-based learning e-module is effectively applied to today's students and those whose lifestyles are involved in the digital world. This can help achieve the expected learning objectives, to increase environmental literacy which involves students' knowledge, skills, attitudes and behavior to respond and act on environmental issues around them.

## CONCLUSION

The development of 21st-century learning focuses on student-centered learning, which develops the 4C skills (critical thinking, creativity, collaboration, and communication) through the use of information technology. To achieve these skills, teachers need to prepare problem-based learning e-modules. These modules integrate technology with environmental problem-based learning. This approach encourages students to actively develop their potential and connect learning to the real world.

Environmental issues serve as a real-world learning tool, addressing issues facing the earth due to human and natural activities, including climate change due to greenhouse gas emissions, pollution (air, water, and soil), biodiversity loss, natural resource depletion, waste, and flooding. These issues are closely interconnected and have a significant impact on human life.

To mitigate these problems, it is crucial to provide students with problem-based environmental education to gain knowledge and skills. This provision will motivate students' environmental intentions, ultimately improving environmental literacy in future generations.

The role of environmental education in the future is crucial in increasing environmental literacy and shaping a generation that cares about and is able to take concrete action for environmental sustainability through environmentally conscious understanding, attitudes, and behaviors. This includes the ability to understand global environmental issues, such as climate change, and apply practical solutions in everyday life, such as reducing plastic waste, conserving energy, and participating in reforestation.

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