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ENVIRONMENTAL LITERACY OF STUDENTS IN ENVIRONMENTAL POLLUTION LEARNING USING THE EDUCATION FOR SUSTAINABLE DEVELOPMENT FRAMEWORK

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Abstract

Education for Sustainability Development (ESD) is one of the 17 Sustainability Development Goals. The research was tried to implement the ESD framework in environment pollution subjects to enhance the environmental literacy of 7th graders. The research was initiated by the development of teaching materials which were characterized by ESD framework and the assessment was arranged using environmental literacy based. The learning was then conducted involving 32 students of private schools in West Java-Indonesia, as the subject of research. The validation by five experts on the teaching materials shows that the learning has included the effort to build system thinking, anticipative, normative, strategic, collaborative, critical thinking, and problem-solving competencies toward environmental problems. The instruments were adapted from the Middle Schools Environmental Literacy Survey/ Instrument (MSELS/I, by NELA 2008) with the modification of environmental content. The validation result included 4 indicators of environment literacy those were knowledge (multiple choice), cognitive skills (essay), attitude toward the environment (questionary), and pro-environmental behavior (questionary) showing 98% of appropriateness. The research on the environmental literacy profile of students shows the different levels of achievement. However, the student's score was in the middle category with the N-gain = 0.49.

Keywords: Environmental Pollution, Education for Sustainable Development, Environmental Literacy

INTRODUCTION

Education for Sustainable Development (ESD) is a concept that originated from environmental education (UNESCO, 2018). ESD encompasses eight key competencies essential for advancing sustainable development. Therefore, the implementation of ESD in learning can shape individuals who are broad-minded and innovative, expanding opportunities and perspectives to solve complex environmental problems in support of sustainable development (Khoa & Santos, 2025).

Pressing environmental issues make education and competencies in the environmental field crucial for addressing current challenges and creating a better future environment. Environmental literacy must be instilled within society, especially in formal educational settings, to develop sustainable human resources who are aware of the importance of the environment in supporting their present and future lives. Science learning aimed at building environmental literacy has strong potential to be implemented within the framework of Education for Sustainable Development (Pangsuma et al., 2024). Science education grounded

in ESD can contribute to caring for the planet and addressing issues of social inequality and well-being (Hummels & Argyrou, 2021).

The rapid growth of digitalization represents a critical skill required in the era of the Industrial Revolution 4.0. As is well recognized, the Fourth Industrial Revolution has profound implications for technological development and utilization, particularly in the field of education (Witczak et al., 2022). Websites are a potentially effective medium in today's learning environment, as they can integrate various multimedia elements, create engaging and non-monotonous experiences, facilitate content delivery, and support independent learning (Ningrum et al., 2025). The development of educational websites is therefore expected to serve as a solution for introducing and integrating ESD into learning processes, equipping learners with essential competencies, addressing current environmental challenges, and protecting the environment for future generations.

METODE

This study employed a research and development (R&D) approach to develop a learning medium and utilized an Experimental Pre–Post One Group design to obtain data on students' improvement in environmental literacy before and after using the developed media in instruction. The developed medium was a website based on the ESD framework, focusing on environmental pollution topics relevant to students' surroundings. The environmental issues presented on the website were contextual and drawn from real-life situations. Data collection was conducted over four meetings, with a pre-test administered before the treatment and a post-test after the treatment. The study involved 32 junior high school students in Bogor City. Survey respondents were selected using a purposive sampling technique. The students were aged between 12 and 13 years.

Data on students' environmental literacy before and after the treatment were collected using test instruments and questionnaires. The instrument used in this study was an environmental literacy instrument adapted from the Middle School Environmental Literacy Survey/Instrument (MSELS/I) developed by NELA (2008), with modifications to the content related to environmental pollution. Prior to implementation, the instrument was tested for validity using the Pearson product–moment correlation technique and for reliability using Cronbach's Alpha analysis.

In addition to the environmental literacy instrument, the developed media also underwent validity testing using expert validation instruments for learning media. The media validity test included assessments of content validity, website media validity, and the alignment of ESD indicators within the website. Furthermore, a feasibility test of the media was conducted by 20 science teachers, and the results were analyzed using the Content Validity Ratio (CVR) method. The analysis results indicated that the instrument was valid and reliable.

RESULTS AND DISCUSSION

The integration of the ESD framework transforms the learning website into a platform that facilitates active, critical, and collaborative learning. By addressing the topic of environmental pollution, the website presents various articles on environmental issues occurring in students' surroundings, making it contextual and relevant to the problems they face. Within the ESD framework, the website is structured into several features:

1. Anticipatory Activities represent the transformation of the anticipatory thinking competency. In this activity, students are asked to explain the relationship between environmental pollution phenomena and potential future conditions, as well as possible evaluations or solutions. This section trains students to understand and evaluate various future possibilities and to assess the consequences of actions in addressing risks and changes.

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2. Let's Think is derived from the critical thinking competency. In this activity, students analyze the relationship between population growth and the waste produced. This section is designed to develop students' critical thinking skills.
3. Discussion Forum represents the transformation of the participation in decision-making competency. This section presents articles about environmental problems occurring around the school. Students are asked to propose solutions to address these issues. Their responses can be written in the available comment column, allowing others to view and reply, thereby encouraging interactive discussion and peer feedback.
4. Systems Thinking is derived from the systems thinking competency. In this section, students analyze environmental issues presented in articles and examine how these problems affect the environment, economy, and surrounding community. This feature trains students to recognize interrelationships and analyze complex systems.
5. My Experience consists of a series of project-based learning activities resulting from the transformation of ESD indicators. These activities are intended to develop decision-making and collaborative problem-solving skills, ultimately fostering improvements in environmental attitudes and behavior.

The media validation results indicate that the learning website is suitable for instructional use, with validation scores of 94% from media experts, 79% from subject-matter experts, and 98% from instrument experts. Based on these validation results, the developed website was declared valid. Furthermore, validation conducted by 20 science teachers using the CVR and CVI tests yielded a highly appropriate category with a score of 0.98.

The environmental literacy instrument was adapted from the Middle School Environmental Literacy Survey/Instrument (MSELS/I) developed by NELA (2008), with modifications to environmental pollution content. The instrument consisted of multiple-choice questions for the knowledge domain, essay questions for the cognitive skills domain, and Likert-scale questionnaires for the attitude and behavior domains. This adaptation was chosen because the instrument had previously demonstrated validity and reliability (Mardiani et al., 2021). The validity and reliability testing confirmed that the instrument was appropriate for research use.

The study was conducted over four days, concluding with a pre-test and post-test. Students participated in learning activities in the school computer laboratory under teacher supervision. The pre-test and post-test results were analyzed using the N-gain formula. The results are presented below:

Table 1. Improvement of Students' Environmental Literacy (N-gain)

Indicator	N-gain	Category
Environmental Knowledge	0.81	High
Cognitive Skills	0.67	Moderate
Environmental Attitudes	0.51	Moderate
Pro-environmental Behavior	0.36	Moderate
Average N-gain	0.49	Moderate

Based on Table 1, the ESD-based learning website significantly improved environmental literacy in the high category for the environmental knowledge indicator and in the moderate category for cognitive skills, environmental attitudes, and pro-environmental behavior.

The environmental knowledge indicator achieved an N-gain of 0.81, indicating substantial improvement. This increase can be attributed to supporting knowledge features within the website, including interactive multimedia materials, instructional videos, online news features, and downloadable resources. These features broaden students' understanding and facilitate enjoyable concept mastery.

The integration of the ESD framework also contributed to knowledge enhancement. ESD adopts a holistic approach that integrates environmental, social, and economic

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dimensions with local, regional, and global sustainability issues, both present and future. This integration enables students to gain broader and deeper conceptual understanding.

The cognitive skills indicator achieved an N-gain of 0.67, categorized as moderate but approaching the upper threshold of high qualification. Improvement in cognitive skills was reflected in students' ability to answer questions with sound reasoning and justification. Learning experiences involving scientific approaches—observing, questioning, experimenting, associating, and communicating—contributed to this development. The transformation of ESD competencies into interactive website features facilitated higher-order thinking skills, including identifying, analyzing, and evaluating complex issues.

The environmental attitude indicator achieved an N-gain of 0.51, and pro-environmental behavior achieved 0.36, both categorized as moderate. These findings suggest that while the website contributed to improvement, the results were not yet optimal. The "My Experience" project-based feature encouraged students to implement solutions based on their analyses. Project-based learning provides meaningful learning experiences that can enhance attitudes and creative thinking.

However, limited teacher supervision during project implementation reduced its effectiveness. Students submitted group proposals and uploaded project results without continuous monitoring. Teachers play a crucial role as facilitators who provide guidance, feedback, and reinforcement to cultivate positive attitudes and behaviors. Additionally, the relatively short duration of four meetings limited the maximization of attitude and behavior changes. Behavioral formation requires repeated and consistent learning experiences over time.

Overall, the ESD-based website improved environmental literacy in the moderate category, with an average N-gain of 0.49. This improvement resulted from integrating five ESD competencies: systems thinking, critical thinking, anticipatory thinking, problem-solving, and collaboration, which collectively provided meaningful knowledge and learning experiences.

The limited improvement in certain indicators may be attributed to insufficient teacher supervision, limited instructional duration, complex questionnaire wording that was difficult for some students to understand, and external factors such as family background, social environment, and socioeconomic conditions. These findings suggest that website-based learning should not be implemented entirely independently but requires active teacher involvement.

To enhance effectiveness, the website could incorporate additional features such as live chat, group discussion rooms, project progress upload menus, comment sections for each stage of project development, and integrated links to synchronous meeting platforms (e.g., Zoom or Google Meet) to enable direct teacher–student interaction and monitoring. Furthermore, questionnaire statements should be tailored to students' characteristics to ensure clarity and accurate responses. These recommendations are expected to optimize the website's role in facilitating effective learning processes and strengthening environmental attitudes and behaviors.

CONCLUSION

Based on the results and discussion, the researchers draw the following conclusions: The ESD-based learning website was developed in accordance with the characteristics of instructional website design and in alignment with ESD indicators that were transformed into several learning features. The website is suitable for use in the learning process, as indicated by validation results of 94% from media experts, 79% from subject-matter experts, and 98% from instrument experts. In addition, validation conducted by 20 science teachers using the CVR and CVI tests demonstrated valid results in the "highly appropriate" category, with a score of 0.98. The use of the ESD-based learning website improved environmental literacy, with an average N-gain score of 0.81 (high category) for knowledge competency, 0.61 (moderate category) for cognitive skills competency, 0.58 (moderate category) for environmental attitude competency, and 0.36 (moderate category) for pro-environmental

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behavior competency. Overall, the ESD-based website improved environmental literacy with an average N-gain score of 0.49, categorized as moderate.

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