Pro-life
Jurnal Pendidikan Biologi, Biologi, dan Ilmu Serumpun
https://ejournal.uki.ac.id/index.php/prolife

Development of Geoheritage-based Media Education for Sustainable Development to Improve Ecoliteracy in Elementary Schools

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Article History

Received: 13 June 2025
Approved: 25 July 2025
Published:27 July 2025

Keywords
geoheritage, education for sustainable development, ecoliteracy

ABSTRACT

The lack of students' ecoliteracy skills due to the absence of appropriate Education for Sustainable Development (ESD)-based learning materials is a significant problem that must be addressed immediately by educators. This study aims to develop and test the feasibility and effectiveness of using ESD-based learning media, in the form of e-modules, to cover the essential material on ecosystems and environmental change. The type of research used is research and development (R&D), with a sequence of potential and problem analysis, data collection, product design, design validation, design revision, product trial, product revision, usage trial, and mass production. Data were collected through tests (pretest and posttest), interviews, observations, and questionnaires. Data analysis employed both descriptive statistics and parametric inferential statistics. The study's results showed that, based on media expert assessments, the level of media feasibility was in the very feasible category, with a score of 92%. Similarly, based on material expert assessments, it was also categorized as very feasible, with a score of 94%. The level of significance obtained was 0.004 on a small scale and 0.00 on a large scale, indicating a statistically significant difference. It can be concluded that the e-module on the Geoheritage of Semarang City has been successfully developed as a sustainable development education medium that is both feasible and effective for use as a learning tool in Elementary Schools. This research product can serve as a learning medium and can be followed up on for further research.

INTRODUCTION

A lack of literacy skills, including ecoliteracy, is now a significant problem for educators to address (Primasti, 2021). Students in Semarang City also experience similar problems. Therefore, to enhance the effective and promising learning process, teachers should implement more innovative learning methods. The School Literacy Movement, a program designed to enhance

students' literacy skills is integrated into the curriculum, including science literacy, which encompasses ecoliteracy skills (Rusmana & Aulia, 2017). Based on pre-research data, it is known that learning at SDN Tugurejo 02, SDN Karanganyar 01, and SDN Bulustalan had not implemented ESD (Education for Sustainable Development)-based learning. Learning has attempted to activate students, but it is unclear whether to use a particular learning model or to determine the learning model within the teaching module; however, the implementation is not appropriate.

Ecoliteracy is the understanding that students demonstrate, manifested in attitudes, knowledge, and skills, by prioritizing environmental sustainability for the sake of survival (Safitri et al., 2024). These skills need to be built, starting from the installation of concepts and the development of critical thinking skills, especially by incorporating real-world problems into class discussion activities. Critical thinking skills during learning are influenced by the background of previous fields of science, including the concept of constructing understanding through meaningful learning (Tyas et al., 2023). Efforts made through learning to improve students' ecoliteracy skills in elementary school education are achieved by using ESD-based learning, namely learning related to environmental conditions or learning derived from sustainable environmental education with dynamic concepts through education that embodies noble values to realize a sustainable future (Rokhmawati et al., 2023).

Education for Sustainable Development aims to enhance individual abilities in making informed decisions and taking responsible actions for a sustainable environment and society. The three main perspectives in Education for Sustainable Development include socio-cultural, environmental, and economic perspectives. ESD-based learning can be applied in the world of elementary school education in all subject areas, including educational studies: 1) environment; 2) global/education for global responsibility; 3) citizenship/political education; 4) fighting violence and racism; 5) health. One study that can be associated with ESD-based learning in elementary school education is the Story of My Region Chapter in the Science subject, which discusses the landscape, regional wealth, and its management. This chapter aligns with the concept of ecoliteracy in sustainable development (Yudiawati, 2019).

ESD-based learning will encourage students to think critically and learn to solve problems in their learning by considering the consequences for the environment, society, and economy (Faizah et al., 2020; Salam & Hamdu, 2022). To support this, Semarang City has a unique Geodiversity, or

geological diversity, that holds high value as a heritage (Wildani et al., 2023). It is because it provides evidence of what has happened or is happening on Earth, resulting in a unique and beautiful landscape with high scientific value.

The condition of the Brown Canyon area, which is quite remote and hot, poses a challenge for students to observe and manage environmental conditions. The role of technology is vital in learning activities (Chairunnisak, 2020). Through innovation in learning media that can display a comprehensive picture of this area, it is crucial to develop, considering that ESD-based learning media that adapt to regional potential for application in schools have not been developed.

The appropriate medium to overcome this problem is the e-module, a module with an electronic format that is operated using a computer capable of displaying images, text, animation, and video. It can help the learning process (Setyaningrum & Gunasyah, 2020). The advantage of an e-module is that it can overcome space and time limitations, allowing it to be used anywhere and at any time (Alfatonah et al., 2023). The developed e-module is a self-instructional e-learning module that prioritizes students' learning independence. Independent learning is a learning process that can be carried out in either the school environment or outside it, involving the study and understanding of knowledge according to the material being studied. With this e-module, it is hoped that students can learn independently at their own learning pace.

It is reinforced by research which states that practice of learning about ESD-oriented ecoliteracy for sustainable development at the public elementary school level shows that the media developed is in the fairly good category by paying attention to learning conditions, learning methods, and learning outcomes (Setyaningrum & Gunasyah, 2020) Based on the explanation above, the following problems can be formulated: how to develop an e-module based on the Semarang City geoheritage as an ESD media to improve ecoliteracy in elementary schools; how is the feasibility and effectiveness of the Semarang City geoheritage-based e-module as an ESD media to improve ecoliteracy in elementary schools.

RESEARCH METHODS

Method

The research method employed in this study is the Research and Development (R&D) method, which adopts a quantitative approach, as described by Sugiyono (2019).

Procedures

The research procedure includes: analysis of potential and problems; data collection; product design; design

validation; design revision; product revision; product trial with purposive sampling technique; product revision; carried out according to suggestions for improvement from teachers as practitioners and students as media users; trial usage, product revision (carried out if there is input related to the final product that has been developed); mass production (sharing links to the developed media and its learning tools).

Data Collection

Data were collected using non-test techniques, including interview sheets, observation sheets, questionnaires, and teacher and student response sheets, to assess the feasibility of the developed product. Additionally, it employs test techniques through pretest and posttest questions to assess the impact of media education for sustainable development on improving ecoliteracy in elementary schools.

Data Analysis

The research was conducted in the Brown Canyon area (as a learning resource that will be packaged in the e-module) and at Purwoyoso 03 Public Elementary School as a research sampling for product trials and usage. The research was conducted from April to November 2024. The quantitative data obtained in this study were in the form of students' ecoliteracy ability scores. At the same time, the qualitative data obtained were in the form of questionnaire results, interviews conducted, and observation results from research subjects.

The data obtained from the pretest and posttest were tested for normality, a Paired Sample T-Test, and the N-Gain test. The normality test was conducted to assess the normality of the pretest and posttest data distributions. If the data show a normal distribution, the analysis is carried out using parametric statistical techniques. The Paired Sample T-test was used to test the difference in the average pretest and posttest scores on the use of Education for Sustainable Development. The N-gain test was conducted to determine the average increase in students' pretest and posttest results.

RESULTS AND DISCUSSION

Analysis of Potential and Problems

The researcher analyzed learning problems in elementary schools that were used as samples. It was found that students at SDN Tugurejo 02, SDN Karanganyar 01, and SDN Bulustalan had poor ecoliteracy skills. One of the causes is that the appropriate learning approach or model has not been implemented. Researchers also analyze existing potential as well as the potential of the Brown Canyon area as a learning resource. This area is Brown Canyon, often considered similar to the Grand Canyon in Arizona. This area was originally a mine, but it is now managed as

an ecotourism site with significant geological and historical significance (Jaya et al., 2023).

Data Collection

This data collection stage is conducted to inform the design of the product to be developed. Data collection is carried out through learning analysis in elementary schools to determine the suitability of the learning media developed according to the topic of learning activities. Although the ESD concept can be applied to all subjects (Yolanita, 2024), one of the studies that is most by ESD-based learning in elementary school education is that it can be applied and linked to the Natural and Social Sciences subject, the Story about My Region Chapter in the Social Sciences subject which discusses the landscape, regional wealth and its management.

Product Design

This stage focuses on product development based on the data that has been collected. Both data on the Brown Canyon and data related to the implementation of ESD learning media in the form of e-modules in learning activities; making a prototype of the learning media to be developed followed by media development based on Brown Canyon area data that will be adapted as a learning media to adjust the stages of cognitive development/ characteristics of students and the scope of teaching materials. Researchers design learning media using the Canva application, which can then be imported into a flipbook that can be operated on a laptop or smartphone.

Figure 1. E-module display as media education for sustainable development

Pro-Life Journal, 12 (2): 208-219, July 2025

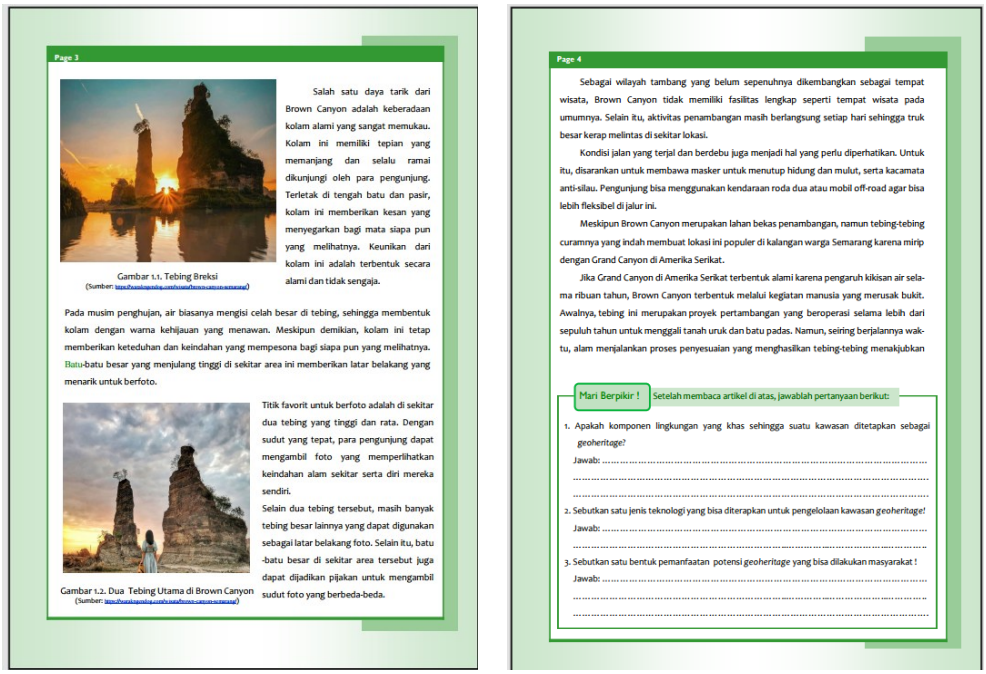

Figure 2. Material description section in the revised e-module

Design Validation and Design Revision

The validation of the Geoheritage-based e-module by material experts and media experts (expert judgment) is guided by a feasibility questionnaire, which serves as an assessment of the product and informs considerations for implementing improvements. The results obtained are improvements in the adjustment of sentences that are too complex for elementary school students **(Table 1)**. Furthermore, this e-module can be followed up for testing.

Table 1. Validation Results of the ESD Learning Media

Assessment Aspect	Percentage (%)	Category
Material Feasibility	92	Very Feasible
Media Feasibility	94	Very Feasible

Product trial

Before the product trial was conducted, a trial of questions was carried out to obtain valid and reliable questions, which had a good discrimination index and an appropriate difficulty index. After obtaining the appropriate questions, a product trial was conducted through a pretest, the use of media in learning, and a posttest. At this stage, students also filled out a questionnaire in response to the media that was developed.

A trial using the purposive sampling technique was conducted at Purwoyoso 03 Elementary School, selecting nine students from high, medium, and low cognitive ability categories. The trial was carried out through a pretest, the use of media in learning, and a posttest. Based on the pretest

and posttest data, it is known that there was an average increase in students' ecoliteracy abilities by 32%. The data obtained regarding students' ecoliteracy skills have not been analyzed in greater depth.

Product Revision

This stage was not carried out because there were no suggestions for improvement from teachers as practitioners or students as media users. The teacher gave a score of 100% for each aspect presented.

Trial of use

This stage is carried out through two learning processes, according to Anduweni et al. (2024), learning can be defined as a communication process between students and teachers. The technical adaptation was carried out by implementing a one-group pretest-posttest design experiment, allowing researchers to compare ecoliteracy skills before and after using the Geoheritage-based e-module, as well as assess the effectiveness of the media in improving ecoliteracy skills.

The trial was conducted in Purwoyoso 03 with 26 students as research subjects. The activity began with a pretest, followed by the first lesson, the second lesson, and the posttest.

Product revision

No product revision was carried out because there were no suggestions for improvement.

Figure 3. Technical explanation of the use of geoheritage-based e-modules

Mass production

It was accomplished by sharing a single link that contained both the developed e-module and its learning tools, making them easily accessible, especially at the school where the trial of use was conducted. After going through a series of product development and testing stages, as well as usage, data analysis will be carried out to determine the effectiveness of the product developed in enhancing students' ecoliteracy skills. The results of student ability tests and working on ecoliteracy ability questions are divided into pretest and posttest results. The questions used to measure critical thinking skills and scientific literacy have been validated by expert judgment and practitioners (teachers).

The implementation of media developed in learning is carried out by

considering the characteristics of the material and the students. Hence, the approach chosen is the SETS (Science, Environment, Technology, and Society) Approach. It is because this approach views a material or problem from the aspects of science, environment, technology, and society. It aligns closely with the research objectives of developing media education for sustainable development. Through the use of media content and the SETS approach can be optimally integrated to support sustainable development.

Based on **Figure 4**, it is evident that there is an increase in the average ecoliteracy ability. The average gain score for ecoliteracy ability is 0.76, which is in the high category. It can be interpreted as meaning that the use of an e-module based on the Brown Canyon geoheritage area can improve students' ecoliteracy abilities. The module also includes digital artsteps, a web-based platform that allows users to create and exhibit digital artwork in an interactive 3D virtual exhibition format (Sari et al., 2024).

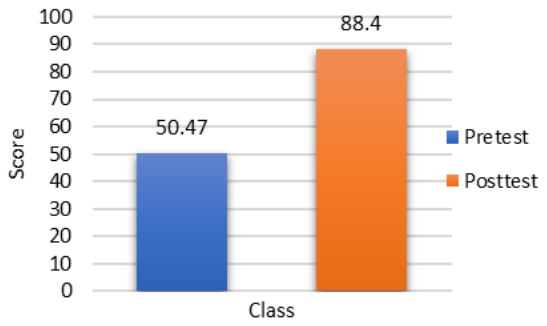

Figure 4. Graph of average ecoliteracy ability score in the usage trial

Sustainable development as part of Natural Resource conservation needs to be well understood, one of which is through the ecoliteracy movement (literacy that studies humans and the environment), so that students have a good understanding of the environment (Tyas et al., 2021). Hypothesis testing was conducted to evaluate the effectiveness of the developed product on students' ecoliteracy abilities. Hypothesis testing in this study was conducted using the analysis of variance (ANOVA) prerequisite test. Based on the results of the analysis prerequisite test, it is known that the significance value is greater than 0.05 (Sig > 0.05), which means that the data to be analyzed is regular and homogeneous, so that the parametric requirements are met. Furthermore, a Paired Sample T-Test was carried out.

The media developed is efficacious in improving the ecoliteracy skills of students in elementary schools. Based on the analysis results, it is evident that the significance level is 0.000 (2-tailed) for the ecoliteracy ability. Because the significance value is smaller than α (0.05), H_0 is rejected and H_a is accepted. The level of significance obtained, 0.004 on a small scale and 0.00 on a large scale, indicates a significant difference. This is reinforced by the N gain score of 0.76 (in the high category) and the significant results of the Paired Sample T-Test.

Figure 5. Learning activities in the usage trial

Based on the test results, it is interpreted that there is a significant difference between the ecoliteracy ability values of students before and after treatment. This finding aligns with research by Aruan et al. (2025) which plays a crucial role in students' cognitive development. The improvement of ecoliteracy skills is influenced by the treatment of the media developed. The SETS approach is the teaching and learning of science and technology in the context of human experience (Aryati et al., 2020). The core of the SETS approach is the involvement of students in experiences and problems that are directly related to life. This approach is effective in improving student learning outcomes (Nurhayati & Tanjong, 2022).

Associated with the geoheritage discussed in this module, the chosen approach and theme are appropriate. It is because geoheritage is a site or area of geological features that has scientific, educational, cultural, or aesthetic value. To ensure that the geoheritage area is scientifically and educationally rich in geological features and landscapes, which can be utilized for education and research. Environmental changes due to environmental management in the Brown Canyon area are contextual issues related to the Earth system and its relationship to sustainable resource provision. It is a contextual problem related to the Earth's system and its relationship to the provision of sustainable resources. Each value in the geoheritage area can be studied through the SETS approach, either individually for each element or collectively as a whole.

Through questions arranged according to the SETS approach steps, students practice developing ecoliteracy skills (Rahmasari et al., 2023). The steps in the SETS approach that enable the development of these abilities include finding and selecting problems from real-life situations, compiling questions based on the problems, which are then referred to as topics, collecting supporting information, and proposing suggestions. The final step is taking action, which involves estimating the impacts that arise from the proposed solutions (Widiastuti & Purnawijaya, 2021).

The effectiveness of the developed media is also related to students' willingness to use Geoheritage-based e-modules for independent learning. The data support the finding that 88.46% of users utilize the developed media designed for independent learning. Learning media can help improve focus and facilitate student understanding.

The follow-up research, as the final step, involves mass production, carried out to increase the reach of ESD media and improve students' ecoliteracy. It is because learning media can help improve focus and facilitate student understanding (Wulansari & Tyas, 2025).

The limitation of this study is that it focuses on developing education media for sustainable development in phase B of the elementary school only. Therefore, it would be beneficial to support the continuity of efforts to improve ecoliteracy and develop media for subsequent class levels and higher education levels. The limited number of research samples is also an important issue to address. It is better to use more research samples for large-scale trials, so that the generalizability of research results can be broader.

CONCLUSION

A geoheritage-based e-module was successfully developed as a sustainable development learning tool, and it is highly suitable for use in elementary education. The very feasible category was identified based on the results of the validation test, with scores of 92% from material experts and 94% from media experts. The media developed is effective in improving the ecoliteracy skills of students in elementary schools. The level of significance obtained, 0.004 on a small scale and 0.00 on a large scale, indicates a significant difference. It is reinforced by the N gain score of 0.76 (in the high category) and the significant results of the Paired Sample T-Test.

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