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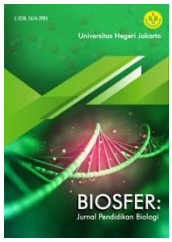

E-Module biology based on rawa danau nature reserve: To improve biodiversity literacy of high school students

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ABSTRACT

Based on data from the World Wide Fund for Nature (WWF) in the Living Planet Report 2022, it was reported that the biodiversity population experienced an average decline of 69% between 1970 and 2018. Therefore, instilling conservation values and biodiversity literacy is critical from an early age to foster knowledge about the environment. This study aims to develop a biodiversity-based Biology E-Module at CARD to improve the biodiversity literacy of high school students. This research method uses a type of development research using the ADDIE model. The ADDIE model stage begins with 1) needs analysis. 2) Design of product specifications and frameworks. 3) development of product design. 4) Implementation of products in the field. 5) evaluate the product and make improvements if necessary. The results of the media and material experts' assessment show that the biology e-module is very feasible. The study results show the average value of students' biodiversity literacy knowledge before and after using this e-module. The average posttest score of 84 is greater than the average pretest score of 70.8 in the ability to understand biodiversity literacy, and based on this, the Biodiversity-Based Biology e-module in the Rawa Danau Nature Reserve effectively increases students' biodiversity literacy.

INTRODUCTION

Indonesia is one of the countries with a high level of biodiversity (mega-biodiversity). The term "biodiversity" includes all forms of life, including microorganisms, genes, plant and animal species, and so on. Indonesia, which ranks second in the 2022 Global Biodiversity Index with a score of 418.78, has an extraordinary wealth of biodiversity, including 1,723 bird species, 282 amphibian species, 4,813 fish species, 729 mammal species, 773 reptile species, and 19,232 vascular plant species. However, Indonesia also faces significant threats as the country with the second-highest biodiversity decline worldwide, with 191 mammal species and 160 bird species threatened with extinction (Setiawan, 2022). The main factors causing this decline include exploitative fishing practices, increased consumption due to population growth, climate change, illegal logging for palm oil plantations, and illegal trade in endangered species. Urgent conservation efforts are needed to address these threats to biodiversity (Manzi, 2020).

Currently, biodiversity literacy of high school students is still relatively low due to the lack of relevant and contextual learning materials (Putri et al., 2023). The learning resources used are often generic, do not provide an in-depth understanding of local potential, and do not utilize digital technology that is familiar to the lives of today's students. As a result, students find it difficult to understand the biodiversity in their environment and its relationship to everyday life (Kismartanto, 2022).

The development of biodiversity-based e-module products is one strategic solution to overcome these challenges. This e-module integrates digital technology with relevant, interactive, and contextual learning materials. With a focus on local biodiversity, this e-module can introduce students to the flora, fauna, and ecosystems typical of their area so that they can recognize, understand, and appreciate the natural wealth around them (Anzelina, 2023). The advantages of e-modules lie in their flexibility and appeal. E-modules allow students to learn independently, anytime and anywhere, through the digital devices they have (Sholeh et al., 2023). In addition, multimedia elements such as images can help increase students' interest in learning and make it easier to understand complex concepts.

The development of biodiversity-based biology e-modules is also in line with efforts to create learning that is oriented toward 21st-century education, where digital literacy, critical thinking skills, and problem-solving skills are the main needs (Kusuma & Aprianti, 2021). By increasing biodiversity literacy, students not only understand the importance of biodiversity but are also motivated to play an active role in its preservation.

The urgency of this research is to increase literacy in biodiversity knowledge in Indonesia, which is important because Indonesia has a high level of biodiversity and extraordinary natural environmental potential. Based on Hadzami's research in 2023, the analysis of digital media and teaching material needs, it was obtained that students need digital media and teaching materials to increase student literacy in the environment and biodiversity. The instillation of biodiversity literacy aims to provide an attitude of awareness of knowledge in maintaining biodiversity so that its balance is maintained. Biodiversity literacy is closely related to science, which is related to students' ability to understand information, science, and facts that exist in everyday life. Science literacy does not only emphasize scientific knowledge but also science skills. Science literacy skills include science process skills, decision-making on social issues reviewed from a scientific perspective (socio-scientific issue), and problem-solving (Alti et al., 2021; Lema & Dewi, 2023). This conscious behavior involves not only knowledge but also an attitude of responsibility and solutions to environmental problems.

Cultivating student literacy in biodiversity is critical to increasing environmental awareness from an early age (Firmantika & Mukminan, 2014; Syafril et al., 2023). Through a deep understanding of biodiversity, students will be invited to understand the importance of each species in the ecosystem and how these interrelated relationships support life on Earth. Biodiversity literacy includes an introduction to various types of flora, fauna, and ecosystems and the complex interactions that occur within them (Raflia et al., 2024). By introducing this concept from school age, students will be able to understand the impact of human activities on nature and the importance of environmental conservation (Schneiderhan-Opel & Bogner, 2020; Sidik Katili & Rahmat, 2020).

This awareness will encourage students to appreciate and protect the surrounding environment more. They become more sensitive to threats such as deforestation, pollution, and habitat loss and are trained to play an active role in conservation efforts (Janžekovič, 2022). Through practical activities such as environmental observation, tree planting, or cleanliness campaigns, students can directly feel the

impact of their positive actions on nature. In addition, knowledge of biodiversity can foster a sense of responsibility to maintain the earth as a sustainable home for future generations.

With good biodiversity literacy, students will grow into a generation with a high awareness and concern for global environmental issues (Afifa, 2013; Fathu, 2018; Sundari et al., 2023). They will be more critical in assessing policies that affect nature and better prepared to take small and significant steps to protect the planet. Ultimately, education about biodiversity will shape a generation aware of the importance of maintaining the balance of nature and contribute to efforts to create a greener and more sustainable future for all living things (Munawar et al., 2019). The continued hope of this research is the development of innovative digital-based teaching materials that can be used by students in the learning process both inside and outside the classroom.

The purpose of this study is to evaluate the availability of innovative teaching materials in the form of e-modules on the biodiversity of the Rawa Danau Nature Reserve to improve students' biodiversity literacy. Using e-modules in learning will increase creativity and productive thinking habits and create a fun, active, effective, and innovative learning experience.

METHODS

Research Design

The research method used in this study is research and development (RnD), which aims to produce a particular product and test the effectiveness of the product (Branch, 2010). This R&D approach is relevant to producing innovation in education, technology, and other fields. The development model applied in this study is the ADDIE model (Analyze, Design, Develop, Implement, and evaluate), one of the systematic and structured development models (Figure 1). The first stage, analysis, identifies problems and needs underlying product development. In this stage, a study of existing conditions is carried out to determine the objectives and criteria that must be met by the product to be developed. The second stage, design, involves designing a product based on previous analysis results, including preparing scenarios, specifications, and product frameworks.

The third stage, development, is the phase where the formulated design begins to be realized as a natural product. After that, in the implementation stage, the product is tested in a natural environment to measure its effectiveness and efficiency. Finally, the evaluation stage is carried out to evaluate product performance and make improvements if necessary, both in the development process and its implementation in the field. With this ADDIE approach, the resulting product is expected to meet the needs and objectives set and can provide accurate contributions.

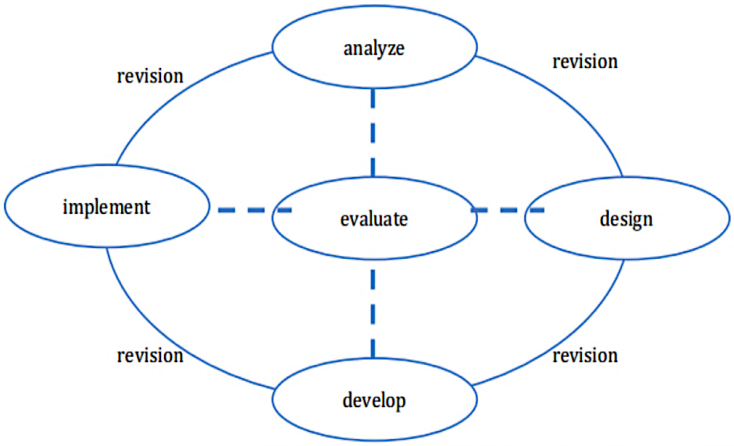

Figure 1. ADDIE model chart (Analyze, Design, Develop, Implement, and evaluate) (Branch, 2010)

Population and Samples

The selection of the sample population and this study was conducted using purposive sampling techniques in all State Senior High Schools in Serang Regency, then obtained from State Senior High School 1 Mancak. Furthermore, the selection of classes was carried out using the Cluster Random Sampling technique and obtained class X students. Then from all class X students, they were selected using Purposive Sampling and obtained class X1 students. The population of this study was all class X IPA which consisted of five classes. The selected samples were class X IPA which consisted of 31 students and class X IPA.

Instrument

Media experts and material experts validated the research instrument used. The task of media expert validation is to assess the feasibility aspects of the product being developed. This includes an evaluation of the media's design, appearance, and usability. The grid of instruments used in media expert assessment is 1) visual design and layout; 2) navigation and usability; 3) text readability and presentation; 4) student interactivity and engagement; 5) attraction and motivation to learn; 6) technology compatibility and compatibility; and 7) adherence to learning objectives.

Material expert validation assesses the teaching material product, an important process to ensure that the teaching materials developed meet quality and relevance standards for use in learning. The instrument grid used in the assessment of material experts is 1) suitability of material to learning objectives; 2) completeness of materials; 3) accuracy of information; 4) relevance to local biodiversity; 5) depth of discussion; 6) relationship to real life; 7) contextual presentation of concepts; 8) scientific language and terms; and 9) motivation for conservation.

To see the effectiveness of e-modules in learning, an assessment was carried out using an assessment of students' literacy attitudes before and after using the e-module by assessing students' biodiversity literacy aspects reviewed from five aspects, namely 1) knowledge and understanding of concepts; 2) analytical skills; 3) applications and solutions in everyday life; 4) attitudes and concerns for the environment; and 5) evaluation and reflection skills. The questionnaire used a Likert scale with four scales, namely Strongly Agree (S), Agree (S), Disagree (D), and Strongly Disagree (SD). Students' biodiversity literacy aspects were reviewed from five aspects, namely 1) knowledge and understanding of concepts; 2) analytical skills; 3) applications and solutions in everyday life; 4) attitudes and concerns for the environment; and 5) evaluation and reflection skills.

Procedure

The development of this e-module uses the ADDIE (Analysis, Design, Development, Implementation, Evaluation) stages. First, conducting analysis, namely identifying teaching materials, analyzing teaching material needs, and analyzing learning objectives on biodiversity materials with achievement indicators of the availability of observation and interview results documents and the availability of teaching material plans along with the objectives and biodiversity data of the Rawa Danau Nature Reserve. Second, design, namely by designing teaching materials, e-modules, and evaluation designs along with assessments with achievement indicators of the availability of e-module plans consisting of teaching material content and e-module graphic design and the availability of e-module evaluation and assessment questionnaire rubrics.

Third, development, namely media development and media testing with achievement indicators of the availability of e-module teaching materials based on CARD biodiversity data and the availability of media test results. Fourth, implementation, namely the implementation of e-modules through limited product trials and field trials with achievement indicators of the availability of evidence of implementation and assessment of limited product trials and the availability of evidence of implementation of evaluation and assessment of field trials. Fifth, evaluation, namely e-module evaluation through summative and formative evaluation and effectiveness testing with achievement indicators of the availability of summative and formative assessment results and the availability of results of processing e-module effectiveness test data.

Data Analysis Techniques

The data analysis techniques used in this study are qualitative and quantitative analysis. Qualitative data were obtained from teacher interviews and suggestions from validators. Quantitative data were obtained by distributing needs analysis questionnaires and media feasibility assessments from validators, teachers, and students. Qualitative data were analyzed descriptively by describing the data obtained in its entirety. This analysis began with data collection and was then interpreted descriptively. Quantitative data in this study used a Likert scale of 1 to 5. In the Likert score assessment, if the assessment gets a score of 81-100, then it can be categorized as very feasible; if the assessment score is 61-80, then it can be categorized as feasible; if the assessment score is 41-60 then it is categorized as sufficient feasible if the assessment score is 21-40 then it is categorized as not feasible, and if the assessment score is 0-20, it can be categorized as very not feasible. The Likert scale can be

seen in Table 1. Then, the effectiveness of the e-module on students' biodiversity literacy skills was analyzed through a hypothesis test, namely the t-test.

Table 1
Likert scale

No	Score	Category
1	81-100	Very feasible
2	61-80	Feasible
3	41-60	sufficient feasible
4	21-40	Not feasible
5	0-20	Very Not feasible

RESULTS AND DISCUSSION

The e-module was validated using expert validation. The e-module validator was assessed by several experts, namely media experts and material experts. The validation results based on media experts are presented in Table 2, and those based on material experts are presented in Table 3.

Experts validation

The media expert validity test presented in Table 2 used eight indicators. The average score was 83.68, with a very feasible category. Seven of the eight indicators received a very feasible category, and one indicator received a very feasible category.

Table 2
Validity results by media expert.

No	Indicators	Score	Category
1	Visual design and layout	89.00	Very feasible
2	Navigation and ease of use	75.86	Feasible
3	Readability and text presentation	81.31	Very feasible
4	Student interactivity and engagement	83.09	Very feasible
5	Attraction and motivation to learn	80.04	Very feasible
6	Technology compatibility and compatibility	86.67	Very feasible
7	Compliance with learning objectives	89.77	Very feasible
	Average	83.68	Very feasible

Suggestions and input from media experts are the layout of the e-module is attractive, but it is necessary to pay attention to the compatibility between the background color and the text to improve readability. Next, the navigation structure of the e-module is intuitive, but adding a "return to the main menu" feature on each page can improve user convenience. The interactivity of the quizzes and practice questions is good, but it is necessary to ensure that there are no technical problems when accessing them on various devices. Then, the E-module is compatible with students' digital devices. However, it needs to be tested further to ensure its appearance is consistent across all browsers and operating systems. Finally, the E-module generally supports digital-based learning well, but it needs minor revisions to the technical and aesthetic aspects to improve the user experience. This is by Wulandari & Jumadi (2023), with the opinion that good electronic teaching materials must pay attention to readability, navigation, and student interaction with the teaching materials.

Expert material

The validity test of material experts presented in Table 3 used nine indicators. The average score was 85.33, with a very feasible category. Eight of the nine indicators received a very feasible category, and one indicator received a very feasible category.

Based on the results of the validity test of media and material experts in Tables 2 and 3, the prepared e-module can be considered very feasible for use as teaching material in the learning process. Suggestions and input from material experts are. The material in the e-module is the essential competency of the biology curriculum for high school students. However, the mapping between sub-chapters and expected learning outcomes must be clarified. The emphasis on local biodiversity is good, but some sections need to expand the discussion of global diversity to provide a broader context. Then, using local biodiversity as the primary material is relevant to improving students' biodiversity literacy.

The module can be more interesting if it includes environment-based activities, such as direct observation or small projects that link the material to students' daily lives. This is in accordance Darmawan et al., (2017), who state that the material in electronic teaching materials must be in accordance with the learning objectives and student competencies that are to be achieved.

Table 3
Validity results by material expert.

No	Indicators	Score	Category
1	Suitability of material to learning objectives	90.04	Very feasible
2	Completeness of material	84.65	Very feasible
3	Accuracy of information	81.58	Very feasible
4	Relevance to local biodiversity	85.00	Very feasible
5	Depth of discussion	79.84	Feasible
6	Relationship to real life	89.72	Very feasible
7	Contextual presentation of concepts	88.41	Very feasible
8	Scientific language and terms	87.00	Very feasible
9	Motivation for conservation	81.75	Very feasible
	Average	**85.33**	**Very feasible**

To find out the differences in students' biodiversity literacy skills, namely by giving pretest questions before using the e-module and posttest after using the e-module. The way to measure the differences in students' biodiversity literacy skills is by using a paired t-test with the SPSS application. Furthermore, the indicators used in measuring students' biodiversity literacy skills are five aspects of knowledge and understanding of concepts, analytical skills, applications and solutions in daily life, environmental attitudes and concerns, and evaluation and reflection skills. Based on the study's results, students' biodiversity literacy skills before and after using the e-module showed a significant difference. This is supported by the results of the paired t-test using SPSS 25; the significance value (2-tailed) pretest and posttest was 0.001 (<0.05). Biodiversity e-module based on swamp lake nature reserves to improve students' biodiversity literacy.

Table 4
Average score of students' biodiversity literacy skills

No	Indicators	Prestest	Posttest
1	Knowledge and understanding of concepts	69.00	81.00
2	Analytical skills	71.00	79.00
3	Applications and solutions in daily life	77.00	83.00
4	Environmental attitudes and concerns	63.00	89.00
5	Evaluation and reflection skills	74.00	88.00
	Average	**70.80**	**84.00**

After implementing the biodiversity-based e-module, the improvement in the knowledge and understanding of concepts indicator was noticeable, where the pretest score was 69 and the post-test was 81. Students can more easily identify various species of flora and fauna in the Rawa Danau Nature Reserve area and understand the relationship between ecosystem components. They begin to understand how each species plays a vital role in the balance of the ecosystem, which improves their basic understanding of biodiversity concepts. This is by research results Ayuardini (2023), which state that using e-modules in the learning process can improve students' understanding of the material or concepts being studied. Hidayanti et al., (2022) also stated that the use of e-modules can improve students' scientific literacy skills.

Furthermore, students' analytical skills also experienced a significant increase from a pretest score of 71 and a posttest score of 79 (table 4). With this e-module, they are helped to understand the factors that threaten biodiversity, such as environmental change and the impact of human activities. Students show a more remarkable ability to critically dissect ecological problems and analyze solutions that can reduce negative impacts on the ecosystem, increasing analytical thinking on biodiversity issues. Based on the research results, Jayanti & Pertiwi (2023) stated that the use of e-modules can improve students' analytical abilities.

Students need analytical skills because they support deep understanding and critical thinking skills that are important in various aspects of life. With this ability, they can evaluate information more thoroughly, find patterns and relationships, and draw accurate conclusions based on available data (Kartikawati et al., 2020; Sari et al., 2022). In addition, analytical skills also make it easier for students to solve problems effectively because they can see various points of view and consider the impact of each decision. In the learning process, analysis allows students to understand information more broadly than just memorizing it, thus strengthening memory and logical thinking skills that are useful throughout life (Agnafia, 2019).

The application and solution indicators in everyday life have also developed well. Through this e-module, students are given practical case studies that motivate them to apply knowledge about biodiversity in everyday life. They began to understand concrete actions that can be taken to preserve the environment, such as choosing environmentally friendly products or maintaining environmental cleanliness, showing an increased ability to relate knowledge to everyday applications. Based on the research results of Hanida et al., (2023), it was stated that the application of problems in learning activities can improve students' understanding abilities. Applying learning materials in everyday life is essential for students because it helps them connect the theories learned in class with real situations. With this ability, students not only understand concepts abstractly but can also see the relevance of this knowledge in solving everyday problems (Ihsani et al., 2020).

In the indicators of attitudes and concerns for the environment, students showed positive changes after using the e-module. They better understand the importance of preserving biodiversity and show an attitude of caring for nature. This is reflected in their active participation in simple conservation activities at school and in the surrounding environment, indicating an increased sense of responsibility for preserving nature. The research results Yuono (2019) stated that attitudes and concerns for the environment can increase attitudes toward the environment, increasing students' biodiversity literacy.

Applying learning materials in everyday life is essential for students because it helps them connect the theories learned in class with real situations. With this ability, students not only understand concepts abstractly but can also see the relevance of this knowledge in solving everyday problems (Dewi & Atika Anggraini, 2022). For example, environmental science can be applied to maintain the cleanliness and sustainability of the surrounding environment, while an understanding of mathematics supports simple financial management. This enriches their learning experience and develops the practical skills needed to become independent, critical individuals ready to face future challenges (Herlina et al., 2021). This ability forms an adaptive mindset where students can respond to change and utilize knowledge for a better life.

Finally, students' evaluation and reflection skills also improved. They are now better able to assess and reflect on the impacts of human behavior on biodiversity. This e-module encourages them to not only evaluate these impacts objectively but also reflect on their role in preserving the environment. They are better able to identify concrete steps that can be taken to reduce negative impacts, thereby strengthening reflective awareness in everyday life.

Reflection and evaluation are essential for students to understand biodiversity literacy because both help students explore their understanding more deeply and critically (Herlina et al., 2021). Through reflection, students can identify things they already understand and aspects they need to explore further regarding biodiversity, such as the role of each organism in the ecosystem, the impact of human activities on the environment, and the importance of conservation. Meanwhile, evaluation allows students to assess the effectiveness of their learning and whether they can apply this knowledge in everyday life to maintain environmental desires (Titin et al., 2012). With these two processes, students can strengthen their awareness of biodiversity, develop an attitude of caring for the environment, and build adaptive and responsible learning habits.

CONCLUSION

Based on the discussion on biodiversity-based e-modules, it can be concluded that this e-module effectively improves high school students' biodiversity literacy in various aspects. First, students' understanding of the basic concepts of biodiversity and ecosystems has increased significantly. Second, their analytical skills have developed, as seen from their ability to identify threats to biodiversity and analyze solutions. Third, students can relate the knowledge gained to its application in everyday life, showing an increase in practical applications and solutions. In addition, their attitudes and concerns

towards the environment have shown positive changes, reflecting greater awareness and concern for nature conservation. Finally, their evaluation and reflection skills have also improved, allowing them to assess the impact of human activities and reflect on personal contributions to protecting the environment. This e-module has become an effective learning tool for improving students' biodiversity literacy through a holistic and applicable approach.

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