

Development of ESD-Integrated Flipped Classroom Supportive PBL E-Module on Environmental Change Material to Improve Critical Thinking Skills of Phase E Students

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ABSTRACT: Critical thinking skills are one of the important 21st century skills that students should have. However, preliminary research shows that many students still have low critical thinking skills. This is indicated by students' difficulty in answering analytical questions, interpreting readings, drawing conclusions, and often being afraid to express their opinions. Furthermore, the use of technology in the learning process is still lacking, and limited learning time allocation makes it difficult for students to practice critical thinking skills. E-module is one of the appropriate innovations to stimulate critical thinking skills. This study aims to determine the validity and practicality of PBL e-module supporting the flipped classroom integrated with ESD in environmental change material to train the critical thinking skills of phase E students. This study uses a research and development (R&D) method with the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). The results showed that the validity score of the e-module by subject matter expert was 95 (highly valid) and the validity score by media expert was 91 (very valid). The results of the e-module practicality test by teacher were 95 (very practical) and the practicality score by students was 88 (very practical). Thus, the conclusion is that the developed ESD-integrated PBL e-module supporting the flipped classroom is very valid and very practical.

KEYWORDS: Development, e-module; PBL; flipped classroom; ESD; environmental change.

I. INTRODUCTION

The 4.0 industrial revolution in education is a response to the rapidly developing world, which demands synergy between technology and humans to open up new opportunities through creative and innovative innovation (Sasikirana, 2020). In response to these demands, the Indonesian government has taken strategic steps in line with the Indonesia 4.0 roadmap, namely by aligning the education curriculum with the needs of future industries (Suyanto, 2022). One form of this alignment is the implementation of an independent curriculum. The independent curriculum is a response to the fierce competition for human resources in the 21st century (Amalia, 2022). This competition requires students to develop 4C skills, namely critical thinking, creative and innovative thinking, communication, and collaboration (Rosnaeni, 2021).

Critical thinking includes the ability to communicate, process information, examine, analyze, interpret, and evaluate that information. However, based on preliminary research at SMA Negeri 1 Woha in Bima Regency, West Nusa Tenggara, students' critical thinking skills are not yet optimal. Susilawati et al. (2020) reported that 64% of students had low critical thinking skills, characterized by a lack of skills in identifying questions, making hypotheses, determining appropriate actions, and interpreting observation results. Putri et al. (2022) also found similar results, with 55.23% of students falling into the low category. Factors contributing to this low ability include a lack of interest in reading, difficulty understanding the material, and fragmented knowledge, making it difficult for students to connect concepts. Interviews with biology teacher also reinforced these findings, stating that students had difficulty with analysis questions, interpreting readings, drawing conclusions, and were often afraid to express their opinions. These findings underscore the need to implement innovative learning methods to optimize students' critical thinking skills.

One form of innovative learning is the development of electronic teaching materials such as e-modules. E-modules offer flexibility, interactivity, and high accessibility that can increase students' interest in learning (Faizah & Muthi (2024). The combination of text, images, videos, and self-assessment quizzes in e-module not only makes learning more interesting, but also

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hones students' critical thinking skills. E-module equipped with evaluation questions can help correct misconceptions and improve student learning outcomes (Alias & Siraj, 2012). The use of e-module is also in line with the objectives of the independent curriculum, which encourages the optimal use of technology in the era of the 4.0 industrial revolution. Preliminary research data also shows that 100% of students have smartphones and the majority of students as Generation Z want teaching materials in electronic form.

In the context of biology education, the topic of environmental change is very important because it is a crucial issue in today's global problems. Unsustainable human activities cause major environmental changes, including the loss of forests due to population growth that exceeds the carrying capacity of the earth (Winkel et al., 2019). To overcome these negative impacts, the implementation of sustainable development principles or SDGs is very important. SDGs are also part of the learning outcomes in the independent curriculum. In addition, UNESCO emphasizes that education is the foundation of sustainable development through the competencies acquired to preserve the environment. One important approach that can be applied is Education for Sustainable Development (ESD), which deeply integrates environmental education. (Listiawati, 2011).

Education for Sustainable Development (ESD) is a long-term investment for a sustainable future. ESD aims to equip individuals with the knowledge, attitudes, and skills necessary to live in harmony with nature. Integrating ESD into the education curriculum can help students develop a deeper understanding of global environmental issues and take an active role in finding solutions (Vioreza et al., 2023). Education for Sustainable Development (ESD) is not merely about transferring information, but also a process of fostering deep environmental awareness and inspiring concrete actions for a sustainable future (Simanjuntak, 2017). Therefore, integrating environmental change material with ESD is seen as an appropriate solution to improve critical thinking skills.

The implementation of e-module in biology learning can be supported through the flipped classroom learning model. This concept allows students to study independently at home using teaching materials such as audio, video, and reading materials, while face-to-face sessions in class are focused on discussion, solving complex problems, and project activities (Apriani et al., 2024). Several studies related to the role of flipped classroom learning on critical thinking skills can be seen from previous studies, including research conducted by Suci *et al.* (2022); Siburian et al. (2023) in high schools in Muaro Jambi Regency, which reported that flipped classroom-based biology learning can improve students' critical thinking skills. Furthermore, research conducted by Simatupang et al. (2023) at SMAN 16 Medan showed that flipped classroom-based learning of human respiratory system biology can improve students' critical thinking skills. The increase in students' critical thinking skills is due to the fact that in flipped classroom learning activities, students are required to understand the material being studied independently and seek out their own sources of knowledge (Roudlo, 2020).

Supporting flipped classroom-based learning requires a learning model that helps students maximize their learning activities. One such model is Problem-Based Learning (PBL). Integrating the flipped classroom strategy with PBL can train students' critical thinking skills, in line with research (Lubis et al., 2020) which shows an increase in critical thinking skills after learning with the PBL model. This is because PBL is a contextual learning model that emphasizes constructivism. Students actively construct their own knowledge, enabling them to analyze information, connect concepts, and draw conclusions more effectively. In addition, activities such as questioning, reflection, authentic assessment, meaningful learning, and group work can help create a learning environment conducive to developing critical thinking skills. Thus, the PBL model can be integrated so that students discover concepts and principles through their own mental processes after studying independently at home.

Research on the development of PBL e-module that support flipped classrooms and are integrated with ESD has been conducted extensively, but it has only focused on one or two aspects, and rarely combines all three simultaneously. Therefore, this study aims to develop ESD-integrated PBL e-module that support flipped classrooms on environmental change material to optimally and contextually train the critical thinking skills of phase E students. The solution offered is to develop this e-module based on ESD principles and to test their validity and practicality in training students' critical thinking skills.

II. RESEARCH METHODS

This research is part of Research and Development. The product developed is an e-module PBL supporting integrated ESD flipped classroom on environmental change material. This research adopts the ADDIE model design with five stages, namely analysis, design, development, implementation, and evaluation (Branch, 2009). This model was chosen because it has the following advantages: 1) It is a rational and comprehensive development model; and 2) It can be used in the development of various products, including strategies, learning models, media, and so on (Rusmayana, 2018). The ADDIE design model is presented in Figure 1 below.

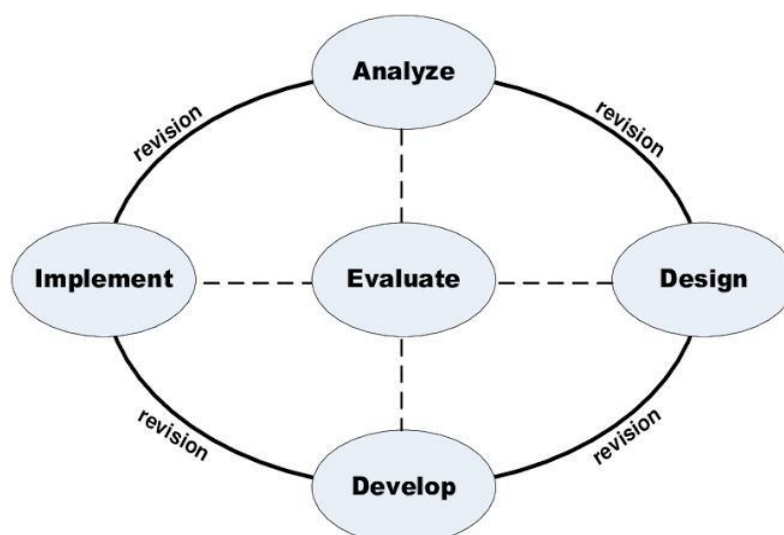


Figure 1. ADDIE model stages (Branch, 2009)

The analysis stage serves to determine the actual situation through facts and data about problems in biology learning. The design stage serves to produce conceptual designs for products and research instruments. The development stage serves to produce products based on the conceptual designs in the design stage, producing data on the validity and practicality of the products. In the implementation stage, the developed product is integrated into the learning process. In the evaluation stage, each stage is evaluated to determine the quality of the developed e-module. The creation of e-module involves several software programs, including Canva, Flip PDF Corporate Edition, and Website 2 APK Builder.

The e-module that has been developed is then validated by a team of experts, consisting of two experts in their respective fields, namely subject matter expert and learning media expert. The next stage is a practical test, which is trialed by one biology teacher and 33 students. The instruments used in this study were a validity questionnaire, which aimed to determine the validity of the e-module, and a practicality questionnaire, which aimed to determine the practicality of the developed e-module product. The data obtained were analyzed using a percentage formula adopted from Riduwan (2013).

$$\text{Value of each aspect} = \frac{\text{average score}}{\text{maximum score}} \times 100$$

The scores for each aspect were then interpreted using the assessment categories shown in Table 1 below.

Table 1. Product validity and practicality categories

Value	Category
$81 < P \leq 100$	Very valid/very practical
$61 < P \leq 80$	Valid/practical
$41 < P \leq 60$	Enough valid/enough practical
$21 < P \leq 40$	Less valid/less practical
$0 < P \leq 20$	Not valid/not practical

Source: Riduwan (2013)

III. RESULT AND DISCUSSION

A. Validity

The validity of the PBL e-module supporting the integrated ESD flipped classroom was assessed by two expert lecturers, including a subject matter expert and a media expert. The validity assessment of the e-module by subject matter expert was conducted by lecturers from the Department of Biology Education, Faculty of Mathematics and Natural Sciences, Yogyakarta State University. Subject matter expert is required to have a thorough understanding of environmental change, which is the main focus of the product. The assessment was based on two aspects, namely the learning aspect and the subject matter or content aspect. The results of the assessment by subject matter expert can be seen in Table 2 below.

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Table 2. Results of E-module Validity Assessment by Subject Matter Expert

No	Assessment Aspect	Score $\bar{x}$	Value	Category
1	Learning	4,00	100	Very valid
2	Material or content	3,67	92	Very valid
Total aspect score		3,80	95	Very valid

Based on the validity test results in Table 2, an average score of 3.80 was obtained, which is equivalent to a value of 95 (very valid). This shows that the ESD-integrated flipped classroom PBL e-module is suitable for implementation in the learning process with several revisions in accordance with the suggestions and input from subject matter expert. The validity test was then carried out by media expert. The media expert is a lecturer from the Department of Biology Education, Faculty of Mathematics and Natural Sciences, Yogyakarta State University. The media expert lecturer has the expertise to understand the media products developed. The media expert lecturer assessed the feasibility of the e-module product through six aspects, namely display quality, language, ease of operation, application reliability, illustration quality, and ease of use. The results of the assessment by the media expert can be seen in Table 3 below.

Table 3. Results of E-module Validity Assessment by Media Expert

No	Assessment Aspect	Score $\bar{x}$	Value	Category
1	Display quality	3,50	88	Very valid
2	Language	4,00	100	Very valid
3	Ease of operate	4,00	100	Very valid
4	Application reliability	3,67	92	Very valid
5	Illustration quality	3,00	75	Valid
6	Ease of use	4,00	100	Very valid
Total aspect score		3,64	91	Very valid

Based on the results of the media expert assessment in Table 3, an average score of 3.64 was obtained, which is equivalent to a value of 91 (very valid). This shows that in terms of learning media, the ESD-integrated flipped classroom support PBL e-module is suitable for application in the learning process with several revisions in accordance with the suggestions and input from media expert lecturers.

B. Practicality

During the implementation stage, a practicality assessment was conducted by one phase E biology teacher and 33 students. The students involved had previously studied material on environmental change in the previous phase. This assessment was conducted to determine the practicality level of the e-module that had been developed. There were three aspects of the practicality assessment, namely the appearance aspect, the material presentation aspect, and the usefulness aspect. The results of the practicality test by biology teacher can be seen in Table 4 below.

Table 4. Results of the practicality test of the e-module by biology teacher

No	Assessment Aspect	Score $\bar{x}$	Value	Category
1	Appearance	3,80	95	Very practical
2	Presentation of material	4,00	100	Very practical
3	Usefulness	3,63	91	Very practical
Total aspect score		3,78	95	Very practical

Based on Table 4, it is known that the practicality of the e-module by biology teacher shows an average score of 3.78, which is equivalent to a value of 95 (very practical). The assessment for the appearance aspect is 95, the material presentation aspect is 100, and the usefulness aspect is 91. These results confirm that the developed e-module is very practical and suitable for use in the learning process. Teacher appreciated the ease of use of the e-module and the role of the flipped classroom in deepening students' understanding before classroom discussions. The e-module is also easy to operate and demonstrates that it fulfills one

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of the characteristics of a module, namely being user friendly. Furthermore, the results of the practicality test by students are shown in Table 5 below.

Table 5. Results of the e-module practicality test by students

No	Assessment Aspect	Score $\bar{x}$	Value	Category
1	Appearance	3,48	87	Very practical
2	Presentation of material	3,56	89	Very practical
3	Usefulness	3,50	88	Very practical
Total aspect score		3,51	88	Very practical

Based on Table 5, it is known that the practicality of the e-module by students obtained an average score of 3.51, which is equivalent to a score of 88 (very practical). The assessment for the appearance aspect was 87, the material presentation aspect was 89, and the usefulness aspect was 88, so it can be said that the e-module is very practical and suitable for use in the learning process. The e-module developed in this study is electronic teaching material that supports flexible and efficient independent learning by students. Through the digitization of material, students can access learning materials anytime and anywhere, so that learning time can be used optimally. In addition, the flipped classroom integrated with the use of e-module plays an important role in training students' critical thinking skills. In flipped classroom learning, students study the material independently before face-to-face meetings in class, then use class time to discuss, solve problems, and reflect. This process significantly improves critical thinking skills because students are required to actively understand the material and seek sources of knowledge independently (Roudlo, 2020). The same results were also reported by *Suci et al.* (2022) and Siburian et al. (2023), who found that flipped classroom-based biology learning was effective in improving students' critical thinking skills. In addition, the flipped classroom not only improves conceptual understanding but also develops creativity and cooperation among students (Rosa et al., 2024). The appearance of the developed e-module is shown in Figures 2 and Figure 3 below.

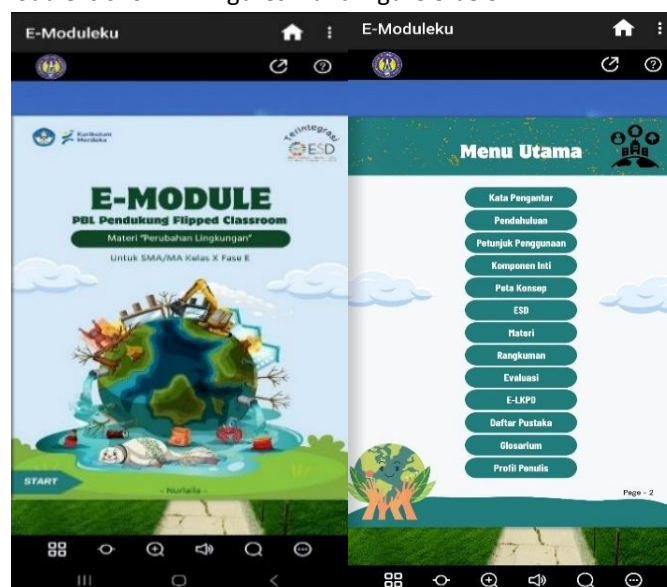


Figure 2. Cover and e-module menu

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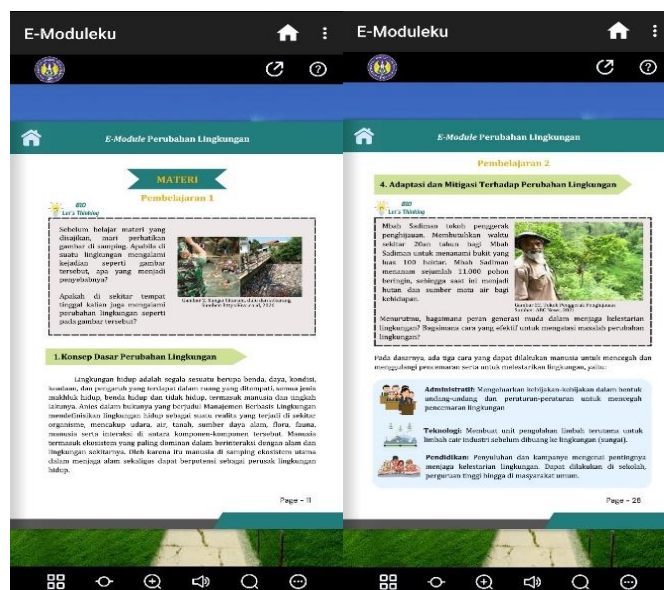


Figure 3. Learning materials

The appearance aspect received a result of very practical category from teacher and students. This allows the developed e-module to assist teacher and students in the learning process because it has an attractive cover, each title is clearly displayed so that it can describe the content of the e-module, the font type, size, and spacing used are appropriate, making it easier for students to learn using language that is appropriate for their level of maturity, and it contains clear instructions for using the e-module. This assessment is in line with Zomiyah (2023) opinion that a good e-module has a cover that students can read. The attractive elements of an e-module cover should combine colors, illustrations, shapes, and font sizes that are appropriate to create a harmonious impression (Ariyanto et al., 2023), using communicative and interactive language, and equipped with instructions for use (Kemendikbud, 2017).

The presentation of material aspect is also considered very practical by teacher and students. This assessment result is due to the fact that the e-module contains learning objectives that are in line with the learning outcomes of the independent curriculum, the material is presented in a logical sequence, the problems presented are contextual so that students find it easier to understand the material, the material competencies presented contain the learning outcomes that must be achieved, and the competencies presented contain issues related to the realities of the surrounding environment. This is supported by the opinion of Herdiana et al. (2021) that a good e-module is one that is tailored to the objectives that refer to the competencies that have been set, both in core competencies and basic competencies, paying attention to the content presented so that learning objectives can be achieved, including being linked to issues in the surrounding environment.

Furthermore, in terms of usefulness aspect, teacher and students found the e-module that had been developed to be very practical. This is because students can study the e-module independently, the material in the e-module can be studied in an engaging manner, the e-module can make it easier for teacher to teach students, provide good guidance in understanding the material, help teacher develop students' character values, help teacher explain the realities of the surrounding environment, and create better interactions with students. Teachers' assessments show that the e-module is very practical to use, as do students' assessments, which state that the e-module can be used practically during the learning process. This is in line with the advantages of e-module according to Kemendikbud (2018), namely that each lesson is clearly limited according to ability, thereby increasing student motivation.

E-module as electronic teaching materials offer flexibility, interactivity, and high accessibility, thereby attracting students' interest (Faizah & Muthi, 2024). The developed e-module present a combination of text, images, audio, video, and quizzes that are effective in making learning enjoyable and enhancing critical thinking. E-module can be accessed both online and offline via Android devices. Students can easily download and access the material anytime and anywhere. However, content such as practice questions or evaluations (online) requires an internet connection to be accessed. Overall, these e-module encourage student independence in learning. Flexibility in managing learning time and material is in line with the educational goal of producing independent and responsible individuals.

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IV. CONCLUSION

Based on the research results, it can be concluded that:

- A. The validity test results by subject matter expert and media expert show that the ESD-integrated flipped classroom PBL e-module is very valid and suitable for use in the learning process.
- B. The results of the practicality test conducted by biology teacher and students show that the ESD-integrated flipped classroom PBL e-module is very practical and therefore suitable for use in the learning process.

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