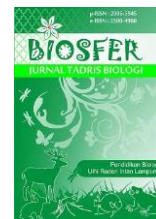




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# Feasibility of an E-Module Based on Problem-Based Learning Combined with Socratic Dialogue to Enhance Students' Critical Thinking Skills

Dewi Ekaputri Pitorini<sup>1\*</sup>, Suciati<sup>2</sup>, Harlita<sup>3</sup>

<sup>1,2,3</sup> Sebelas Maret University, Indonesia

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#### \*Correspondence email:

[dewiekaputri@student.uns.ac.id](mailto:dewiekaputri@student.uns.ac.id)

### ABSTRACT

Learning in the 21st century requires the use of technology. E-modules are one form of utilizing technology as a medium for teaching materials. The research aims to test the feasibility of an e-module based on problem-based learning combined with Socratic dialogue to enhance critical thinking skills. Feasibility test includes validity testing and practicality testing of e-modules. The e-module validity test was carried out by three expert validators, namely material expert validators, learning media experts, and learning instrument experts. The practicality test aims to determine the responses from educational practitioners and e-module users. The instrument used to assess the feasibility of e-modules was a questionnaire. The feasibility test results in the form of assessment scores were analyzed quantitatively. The results of the e-module validity test obtained a total average score of 92.67 (very good). The results of the e-module practicality test obtained a total average score of 92.66 (very good). The e-module based on PBL combined with Socratic dialogue has a very good level of feasibility and is suitable for application in the classroom.

#### ***Kelayakan E-modul Berbasis Problem-Based Learning Dipadu Dialog Socrates untuk Memberdayakan Kemampuan Berpikir Kritis Siswa***

**ABSTRAK:** Pembelajaran di abad 21 menuntut adanya pemanfaatan teknologi. E-modul adalah salah satu bentuk pemanfaatan teknologi sebagai media bahan ajar. Penelitian bertujuan untuk menguji kelayakan e-modul berbasis Problem-Based Learning dipadu Dialog Socrates untuk memberdayakan kemampuan berpikir kritis. Uji kelayakan meliputi uji validitas dan uji kepraktisan e-modul. Uji validitas e-modul dilakukan oleh tiga validator ahli, yaitu validator ahli materi, ahli media pembelajaran, dan ahli instrumen pembelajaran. Uji kepraktisan bertujuan untuk mengetahui respon dari praktisi pendidikan dan pengguna e-modul. Instrumen yang digunakan untuk menilai kelayakan e-modul adalah angket. Hasil uji kelayakan berupa skor penilaian dianalisis secara kuantitatif. Hasil uji validitas e-modul memperoleh nilai rata-rata total sebesar 92,67 (sangat baik). Hasil uji kepraktisan e-modul memperoleh nilai rata-rata total sebesar 92,66 (sangat baik). E-modul berbasis Problem-Based Learning dipadu Dialog Socrates memiliki tingkat kelayakan yang sangat baik dan layak untuk diterapkan di kelas.

## **INTRODUCTION**

In the twenty-first century, learning requires the use of technology. Over the last two decades, the rising availability of information and communication technology (ICT) in classrooms worldwide has transformed instructional methods (Labonté & Smith, 2022). According to Caton et al. (2022), technology has changed the way students and teachers think, interact, and process information. According to Windari et al. (2023), technology can help with personalized learning, participation, and equity, as well as contribute to a student-centered learning strategy.

E-modules are a type of technology-based instructional material that can enhance learning quality (Handayani et al., 2021). According to Widodo et al. (2023), modules are learning materials that are organized systematically (containing material, method, and evaluation) and are not contingent on obtaining specific required abilities. According to Damayanti et al. (2021), using e-modules can provide a more structured digital-based learning experience while also increasing learning efficiency and efficacy. According to Saragih & Tanjung (2023), modules can help students learn independently while also reducing teacher dominance in learning activities.

However, the results of a preliminary study conducted by researchers show that classroom learning has not utilized e-modules. The primary learning materials utilized in class are textbooks, which are not yet digitally based. Textbooks are still dominated by written explanations with only a few illustrations. The questionnaire results revealed that 78.8% of students believed their textbooks still had limitations and shortcomings. The disadvantages of textbooks include incomplete and difficult-to-understand material, less extensive explanations, fewer application examples, fewer and less colorful illustrations, and a less appealing presentation. This is

consistent with the findings of Haka et al. (2020) and Safitri et al. (2021), who discovered that textbooks continue to be the most commonly used teaching materials.

Aside from the use of technology in educational activities, 21st-century learning necessitates the development of students' critical thinking skills. In the twenty-first century, literacy is about validating and creating knowledge rather than extracting it. According to Santos-Meneses and Drugova (2023), critical thinking skills are increasingly important in today's digital world. According to Memiş and Akkaş (2020), learning should prepare students to acquire precise and reliable information while also teaching them to think critically about it.

However, facts in the field show that students' critical thinking abilities are still low. Trends in the results of the Program for International Student Assessment (PISA) show that the scientific literacy of Indonesian students is still below average, namely ranking 64th out of 72 countries (2015), 74th out of 79 countries (2018), and 63rd out of 81 countries (2022) (OECD, 2014; 2016; 2019; 2023). Critical thinking skills are required to answer PISA questions (OECD, 2020), hence poor PISA results demonstrate that critical thinking skills remain low. Previous studies conducted on Indonesian students have also found that students' critical thinking skills in biological topics remain inadequate, at less than 50% (Elisanti et al., 2018; Fausan et al., 2021; Ramadhani et al., 2023; Widodo et al., 2019).

Critical thinking skills can be developed through the application of learning models that are integrated into e-modules. One learning model that is suitable for training students' critical thinking skills is the problem-based learning (PBL) model combined with Socratic Dialogue. An e-module based on PBL combined with Socratic dialogue can encourage students' critical thinking through problem-solving activities. The Socratic Dialogue questions were added to the e-module function to help

students solve difficulties and develop critical thinking skills (Handoko et al., 2024; Moallem & Igoe, 2020).

The research aimed to test the feasibility of an e-module based on PBL combined with Socratic dialogue to enhance critical thinking skills.

## METHOD

E-module based on PBL combined with Socratic dialogue were developed by following the development research steps according to Borg and Gall (1983). This research was limited to the e-module feasibility test, which consisted of validity test and practicality test. The e-module validity test was carried out by three expert validators, namely a material expert validator with a master of science educational qualification, a learning media expert validator with a science education doctoral qualification, and a learning instrument expert validator with a biology education doctoral qualification. Validation by material experts aimed to obtain data in the form of an assessment of the accuracy and suitability of the environmental change material in the e-module. Validation by learning media experts aimed to obtain data in the form of an assessment of the presentation and readability of the e-module. Validation by learning instrument experts aimed to obtain data in the form of an assessment of the accuracy and suitability of the learning instrument construct.

The e-module practicality test aimed to determine the responses from educational practitioners (Biology subject teachers) and e-module users (students). The practicality

test was carried out at a high school in Karanganyar, Central Java, Indonesia. The teachers involved in the limited field test were four people. The small group of students consisted of 20 students in Grade X.

The instrument used to assess the feasibility of e-modules was a questionnaire. The questionnaire used a Likert scale with categories: 1 for strongly disagree, 2 for disagree, 3 for agree, and 4 for strongly agree. Aspects of the e-module validity test assessment are presented in Table 1.

**Table 1.** Assessment Aspects of the E-module Validity Test

Type of Validity Test	Aspects of Assessment	Items Number
Validity test by material experts	Material coverage	1-3
	Material accuracy	4-8
	Material is up to date	9-10
	The material is contextual	11-12
Validity test by learning media experts	Presentation of material	13-14
	E-module design	1-14
	Ease of use	15-16
Validity test by learning instrument experts	Completeness of e-module components	17
	Making learning plans	1
	Formulation of learning objectives	2-5
	Learning Activities	6-12
	Empowerment of critical thinking skills	13-14
	Language	15-16

The number of statements on the practicality test questionnaire was 20 items for teachers and 14 items for students. Aspects of the e-module practicality test assessment are presented in Table 2.

**Table 2.** Assessment Aspects of the E-module Practicality Test

Type of Practicality Test	Aspects of Assessment	Items Number
Practicality tests by Biology teachers	Material coverage	1-2
	Material accuracy	3-5
	Material is up to date	6
	Material is easy to understand	7-8
	Presentation of material	9
	E-modules are contextual	10-11
	Characteristics of learning models	12

Type of Practicality Test	Aspects of Assessment	Items Number
Practicality test by students	Empowerment of critical thinking skills	13
	Language	14-15
	E-module design	16-18
	Ease of use	19-20
	Material coverage	1
	Material is easy to understand	2-3
	Presentation of material	4
	E-modules are contextual	5-6
	Learning Activities	7
	Empowerment of critical thinking skills	8
	Language	9
	E-module design	10-12
	Ease of use	13-14

The results of the feasibility test in the form of assessment scores were analyzed quantitatively. The formula used in the analysis was as follows:

$$\text{Score} = \frac{\text{score obtained}}{\text{maximum score}} \times 100$$

The results of the score calculation are then interpreted using the criteria (Arikunto, 2013) which are presented in Table 3.

**Table 3.** The Category of Feasibility Test Result Score

Score	Category
81-100	Very good
61-80	Good
41-60	Enough
21-40	Not good
0-20	Very less

## RESULTS AND DISCUSSION

### E-module Overview

The e-module was developed based on the learning stages of the PBL model combined with Socratic Dialogue. PBL, according to Nurkhin et al. (2020), consists of five stages: (1) orienting students to the problem; (2) organizing students for study; (3) assisting independent and group investigation; (4) developing and presenting artifacts and exhibits; and (5) analyzing and evaluating the problem-solving process (Rizki et al., 2022). Socratic dialogue was inserted in the first, second, and third stages of the PBL model.

The e-module was developed on the topic of environmental change, which was divided into three subtopics, namely water pollution, air pollution, and soil pollution. Each subtopic discussed the causes of pollution, its consequences, and pollution solutions. The ultimate goal of learning using e-modules was to develop the following competencies: (1) interpreting data on environmental changes, their causes, and effects on life; and (2) developing solutions for solving problems caused by environmental changes in the environment around students.

The e-module consisted of the following components: (1) cover page; (2) Francis page; (3) table of contents; (4) e-module description; (5) e-module usage guide; (6) competencies that students must master; (7) concept map; (8) learning activities; (9) glossary; (10) bibliography. The e-module was developed in flipbook form. The e-module cover page is presented in Figure 1.

The e-module consisted of three learning activities, namely on the subtopics of water pollution, air pollution, and soil pollution. Each learning activity contained the following components: (1) subtopic title page; (2) learning objectives; (3) student worksheets; (4) explanation of concepts; and (5) evaluation questions. This agrees with Haka et al. (2020) that learning activities are one of the important points in the module.

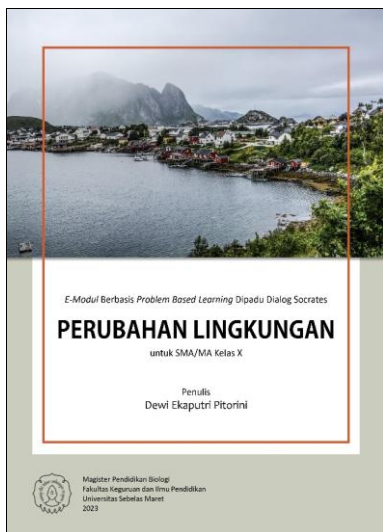


Figure 1. The E-module Cover Page

The title page of the learning activity contained the title of the sub-topic, learning objectives, images related to the sub-topic, and the source of the image. The subtopic title page is presented in Figure 2.

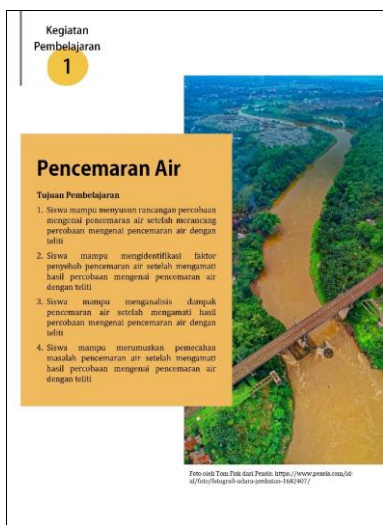


Figure 2. The Subtopic Title Page

Student worksheets were prepared based on PBL learning steps combined with Socratic Dialogue. The student worksheet directed students to conduct scientific investigations to solve environmental pollution problems in their surroundings. Socratic dialogue was provided in the form of a series of questions designed to assist students through learning exercises. The questions also aimed to improve students' critical thinking skills (Puspita, Rosa, et al,

2023). The student worksheet is shown in Figure 3.

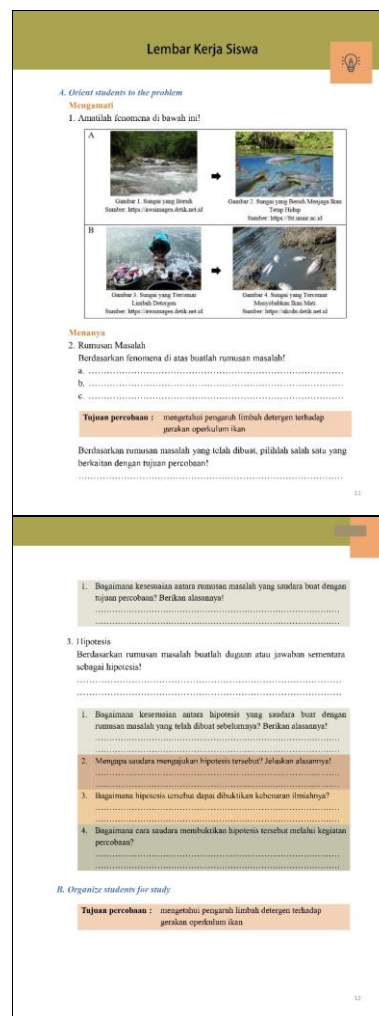


Figure 3. Student Worksheets Page

Concept explanations were intended to confirm and deepen students' understanding after they have completed student worksheets. The concept explanation included illustrations and examples of concept application. This agrees with Achmad et al. (2024), the concept by means of illustrations can make students drawn on the material studied. The concept explanation page is presented in Figure 4.

At the end of each learning activity, students had to answer evaluation questions. The evaluation's goal was to measure how well students understand the concepts they've studied. The questions were arranged based on the learning objectives.

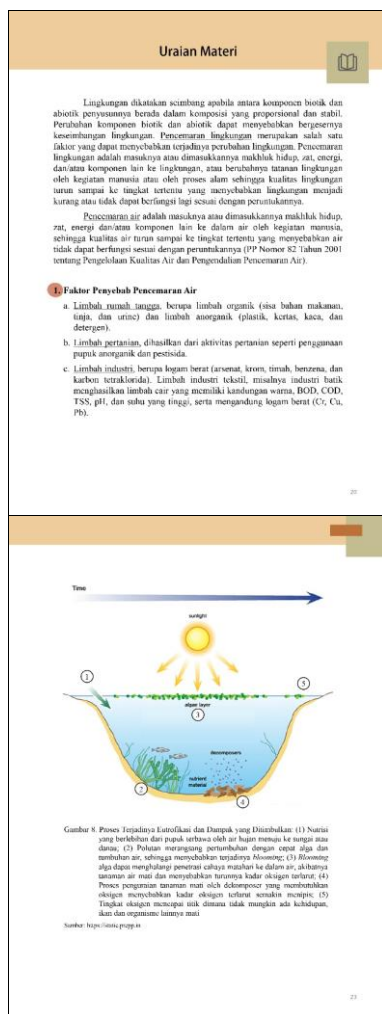


Figure 4. The Concept Explanation Page

The results of the validity test by material expert validators on the e-module are presented in Table 4.

Table 4. E-module Validity Test Results by Material Expert Validators

Aspects of Assessment	Score	Category
Material coverage	100	Very good
Material accuracy	100	Very good
Material is up to date	87.50	Very good
The material is contextual	87.50	Very good
Presentation of material	87.50	Very good
Average	94.64	Very good

Table 4 shows that the average score attained was 94.64, which fell into the very good category. The results of the assessment by material expert validators showed that the coverage of environmental change material presented in the e-module was in accordance with the competencies that students must master. The information

supplied reflected the explanation that drove competency achievement. The depth of the material offered was appropriate for the student's academic level. The material presented in the e-module was also accurate and relevant to scientific developments. Dewi & Primayana, (2019) and Wahyu et al. (2023) argue, the material in the e-module was contextual; that was, the material was relevant to students' real-world experiences and was able to help students draw connections between the knowledge they have and its application in everyday life. The material in the e-module was presented sequentially and coherently.

The results of validity tests by learning media expert validators on e-modules are presented in Table 5.

Table 5. E-module Validity Test Results by Learning Media Expert Validators

Aspects of Assessment	Score	Category
E-module design	91.07	Very good
Ease of use	100	Very good
Completeness of e-module components	75	Good
Average	91.18	Very good

Table 5 shows that the average score attained was 91.18, which fell into the very good category. The results of the assessment by learning media expert validators showed that the e-module design was good. The placement of layout elements was consistent based on patterns. The colors of the layout elements were harmonious and clarified the function. The presentation of the writing on the e-module was also good: (1) the writing could be read clearly; (2) the color of the writing was contrast with the background; (3) didn't use too many types of letters; and (4) the hierarchy of titles was clear, consistent, and proportional. The images presented on the e-module were also clear (not blurry) and were equipped with descriptions of images that were located nearby. The e-module was easy to operate using a smartphone or laptop. Instructions for using the e-module were clear and not confusing. The e-module contained complete

parts (introduction, worksheets, material descriptions, evaluation questions, glossary, and bibliography).

The results of validity tests by learning instrument expert validators on e-modules are presented in Table 6.

**Table 6.** E-module Validity Test Results by Learning Instrument Expert Validators

Aspects of Assessment	Score	Category
Making learning plans	100	Very good
Formulation of learning objectives	87.50	Very good
Learning Activities	92.86	Very good
Empowerment of critical thinking skills	87.50	Very good
Language	100	Very good
Average	92.19	Very good

Table 6 showed that the average score attained was 92.19, which fell into the very good category. The results of the assessment by learning instrument expert validators showed that the e-modules were arranged systematically. Learning objectives were suitably written and aligned with the competencies that students had to master. The learning steps in the e-module were in accordance with the stages of the PBL learning model combined with Socratic Dialogue. Learning activities in the e-module included empowering students' critical thinking skills. The language used was in accordance with Indonesian language rules and was communicative.

The results of the e-module validity test by material expert validators, learning media, and learning tools obtained a total average score of 92.67 and were included in the very good category.

The results of practicality tests by Biology teachers on e-modules are presented in Table 7.

**Table 7.** E-module Practicality Test Results by Biology Teachers

Aspects of Assessment	Score	Category
Material coverage	100	Very good
Material accuracy	100	Very good
Material is up to date	93.75	Very good
Material is easy to understand	96.88	Very good
Presentation of material	100	Very good

Aspects of Assessment	Score	Category
E-modules are contextual	96.88	Very good
Characteristics of learning models	100	Very good
Empowerment of critical thinking skills	100	Very good
Language	100	Very good
E-module design	97.92	Very good
Ease of use	100	Very good
Average	98.75	Very good

Table 7 shows that the average score attained was 92.19, which fell into the very good category. The test results showed that the biology teacher's response to the e-module was very good. The teacher stated that the e-module had material that was complete, accurate, up-to-date, easy to understand, coherent, and contextual. The e-module also included empowering critical thinking skills. The language used in the e-module was communicative. E-module had an attractive appearance and was easy to use.

The results of students' practical tests on e-modules are presented in Table 8.

**Table 8.** E-module Practicality Test Results by Students

Aspects of Assessment	Score	Category
Material coverage	92.50	Very good
Material is easy to understand	94.38	Very good
Presentation of material	90.00	Very good
E-modules are contextual	89.38	Very good
Learning Activities	93.75	Very good
Empowerment of critical thinking skills	92.50	Very good
Language	93.75	Very good
E-module design	93.75	Very good
Ease of use	96.25	Very good
Average	93.13	Very good

Table 8 shows that the average score attained was 93.13, which fell into the very good category. The test results showed that the student's response to the e-module was very good. Students stated that the material in the e-module was complete and was easy to understand (Suwandi et al., 2023). The images presented provided additional information and helped students understand the material better. The material presented

was related to students' real-world situations so that it was easier for students to apply the concepts they learned in everyday life. The learning activities contained in the e-module also helped students understand the material better. Students stated that e-modules could empower critical thinking skills. E-modules had an attractive appearance and a communicative language. E-modules were also easy to use (Sari et al., 2023).

The results of the e-module practicality test by the teacher and a small group of students obtained a total average score of 92.66 and was included in the very good category.

The e-module empowers students' critical thinking skills through a PBL model combined with Socratic Dialogue questions. Hursen (2021) states that problem-based learning encourages learners to become active learners and helps them think critically while solving problems. Previous studies show that the PBL model can improve students' critical thinking skills (Amin et al., 2020; Lubis et al., 2019; Zhou et al., 2023). Ravista et al. (2021), in their study, identified exposing students to real problems as one of the strategies that could improve students' critical thinking. In PBL, students face a situation or problem that challenges them to apply the knowledge they already have and encourages them to think of new solutions (Wijayanto et al., 2023). This process teaches students to think critically by changing the learning process from memorizing abstract scientific concepts to developing implementable knowledge, from passive to active learning in search of knowledge, and from developing understanding on their own to collaboratively sharing knowledge with others (Subarkah et al., 2021).

Socratic questioning is a disciplined method of engaging in content-driven discourse that can be used for a variety of purposes, including analyzing concepts, discovering the truth, examining assumptions, uncovering assumptions,

comprehending concepts, and following the logical consequences of thought. The results of research by Ho et al. (2023) show that Socratic Dialogue questions can develop students' critical thinking skills effectively. Socratic questioning allows students to justify their own preconceived assumptions and thoughts after a series of specific, targeted questions. Socratic dialogue can encourage students to evaluate their perspectives, and this can stimulate them to think critically about their own and others' thinking. This can help students recognize true understanding, which is more than just getting the right answer to a problem (Puspita et al., 2023).

The results of the feasibility test showed that the e-module based on PBL combined with Socratic dialogue had a very good level of feasibility and was suitable for implementation in the classroom. Validation tests included validation by material experts, learning media experts, and learning instrument experts. The validation test obtained an average score of 92.67 (very good). The practicality test, aimed at teachers and small groups of students, obtained an average score of 92.66 (very good).

The feasibility test results showed that the e-module contained complete, accurate, up-to-date, and coherent material. E-modules were easy to understand because concept explanations are equipped with visual representations (i.e., photographs and diagrams). The e-module contained photos of various environmental phenomena so that students have an idea of what these phenomena look like in the real world. In addition, the process of environmental problems was a complex concept. In the e-module, the concept was equipped with a diagram that showed the stages of the problem and the impacts it caused, making it easier for students to understand it. The processes of environmental problems presented in the e-module included the eutrophication process, the greenhouse effect, and acid rain. Cheung &



Winterbottom (2023) and Damayanti et al. (2021) stated that visual representations are needed to help students understand the material better. Çaka & Durzun (2022), stated that the use of visual representations has become part of science, and their use allows scientists to represent complex phenomena.

Preliminary studies conducted previously showed that textbooks had several shortcomings, including being difficult to understand, incomplete, lacking pictures, and lacking application examples. Previous research also revealed that textbooks are one of the main causes of students' difficulties in learning biology (Weng et al., 2020). Students think biology textbooks are less interesting because they are voluminous and have excessive content that must be memorized. The results of the feasibility test showed that the e-module developed was able to fill in the deficiencies found in textbooks that were usually used by students.

The e-module developed also included critical thinking skills training. The topic of environmental change was chosen because it was in accordance with the PBL model combined with Socratic Dialogue and could train students' critical thinking. The topic of environmental change contains environmental problems that are close to students' lives (Pauzi & Windiaryani, 2021);(Mafarja et al., 2022), so it is in accordance with the PBL model combined with Socratic Dialogue, where students are required to produce various solutions to problems that are often encountered in real life by using prior knowledge and new information obtained from various resources (Aslan, 2021; Suwono et al., 2021).

Environmental change problems are complex because one problem can be caused by many causal factors. In addition, environmental changes can occur as the result of the interaction of various ecosystem components, which causes ecosystem imbalance (Barry, 2021). Ascher

(2018) states that environmental problems are complex problems and usually have more than one way to find a solution. Environmental change problems are real-life problems that must be solved by applying several concepts and principles (Priyadi & Suyanto, 2019). These characteristics make the topic of environmental change very suitable for training students' critical thinking skills.

The e-module, developed in the form of a flipbook, had an attractive appearance. Sari et al., (2023) stated that flipbooks have more attractive features compared to printed books because they have hypermedia characteristics. Mutiara and Emilia (2022) stated that flipbooks have a more interactive nature because they are not only limited to text but can also contain images, videos, audio, and links. The results of research by Febriyanti et al. (2021) state that attractive learning media designs can increase students' learning motivation. Research by Alhamad and Agha (2023) states that increasing student learning motivation in mobile learning can promote the acquisition and retention of knowledge compared to traditional learning.

The feasibility test results showed that the e-module was easy to access and easy to use by students. This was an important assessment aspect because previous studies showed that barriers to implementing mobile learning include internet connectivity problems, software-related barriers, and skills in using technology (Hoang et al., 2023; Mgeni et al., 2024; Nikolopoulou, 2022; Nikolopoulou et al., 2023). Different barriers may prevent students from utilizing mobile devices for learning activities, even though they have a positive view of mobile learning. Flipbooks were chosen because they are easy for students to access and can be accessed online or offline using a smartphone or laptop (Mutiara & Emilia, 2022; Sumarmi et al., 2021). Apart from that, at the beginning of the e-module, there was a user guide that explained the components and steps for

using the e-module. The explanation was equipped with a screenshot of the e-module so that it was easier for students to understand it.

The implication of this research was the availability of teaching materials that suit students' needs and could train students' critical thinking skills. The e-module had gone through the feasibility test stage, so it was suitable for use in the classroom. However, further research is needed to test the effectiveness of e-modules, especially their effectiveness in improving students' critical thinking skills.

### CONCLUSIONS AND SUGGESTIONS

The e-module based on PBL combined with Socratic dialogue has a very good level of feasibility and is suitable for application in the classroom. The results of the e-module validity test by material expert validators, learning media, and learning tools obtained a total average score of 92.67 and were included in the very good category. The results of the e-module practicality test by the teacher and a small group of students obtained a total average score of 92.66 and was included in the very good category. Given the high feasibility and suitability of the PBL-based e-module combined with Socratic dialogue for classroom application, it is recommended to expand its implementation to a larger scale within different educational settings. Future research could explore its long-term impact on student learning outcomes and engagement across diverse student populations. Additionally, the development of supplementary training programs for teachers on effectively integrating this e-module into their teaching practices could further enhance its effectiveness. Continuous evaluation and iterative improvement of the e-module based on feedback from broader and more varied users would ensure its sustained relevance and effectiveness.

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