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Development of Contextual E-Module in Science (Physics) Learning to Improve Students' Critical Thinking Skills

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Abstract: This research is a type of research and development (R&D) using the 4D model: define, design, develop, and disseminate. The goal of this research and development is to find out the content validity, practitioners' responses, and the effectiveness of using a contextual e-module in science (physics) learning to improve students' critical thinking skills. The content validity of the e-module was evaluated by 3 experts. Its practicality was evaluated by 10 science teachers who teach physics. The e-module was tested on 45 eighth-grade students at SMP Katolik Sudiang, where the researcher teaches. The instruments used in this study included a validation sheet for the e-module, a validation sheet for the practitioners' response questionnaire, and a critical thinking test validation sheet. Each instrument was validated by experts. The practitioners' questionnaire and the critical thinking test were also used in the study. The results showed that the contextual e-module in science (physics) learning was valid according to the experts, very practical according to the practitioners' responses, and effective in improving students' critical thinking skills, with an N-Gain percentage of 60.85%. Based on the results, the developed e-module is considered valid, very practical, and effective in improving students' critical thinking skills.

Keywords: Contextual; Critical thinking; Electronic module

Introduction

Education today focuses on developing skills and competencies, which is known as 21st-century learning. This learning is marked by fast technology development. The challenges of 21st-century learning make both teachers and students need to have and improve certain skills and knowledge during the learning process. In line with this progress, the Merdeka Curriculum in Indonesia now has many similarities and supports the goals and approaches of 21st-century learning. Both the Merdeka Curriculum and 21st-century learning focus on building relevant skills. One example is student-centered learning, using technology in the classroom, developing soft skills and character, flexibility and adaptability, and global citizenship. So, teachers must be able to use technology and new teaching methods to help students understand better, including improving critical thinking skills.

Critical thinking is a person's ability to make and gather evidence to draw and consider conclusions (Eggen & Kauchak, 2012). According to Ennis (1996), critical thinking is a very important process in daily life, which means making reasonable decisions about what to believe and what to do. Syamsinar et al. (2023) also say that critical thinking is the ability to think logically, analyze problems objectively, and evaluate information correctly. With critical thinking, we can get results that are accurate, factual, and reasonable. Every person needs to be able to tell the difference between facts and opinions and judge the truth of the evidence (Azizah & Winarti, 2020). Critical thinking helps a person manage and develop ideas in a logical and structured way, which supports the ability to innovate by creating new ideas,

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planning new things, and showing the results (Jahn & Kenner, 2018; Lombu'u, 2019; Wijaya, 2010). Students' thinking skills are developed with the help of teachers, who guide students to be active in the learning process (Hanani, 2020). With critical thinking skills, people can compete in the era of science and technology development (Mappalsey et al., 2021). Based on the opinions of these experts, the researcher summarizes four indicators of critical thinking: analyzing facts, formulating problems, clarifying logical arguments, and making conclusions.

One of the school subjects that helps develop critical thinking skills is science, especially physics. Science is basically a product, a process, and an application (Trianto, 2007). Science is the human effort to understand the universe through careful observation, using correct procedures, and explaining with logical, organized, and evidence-based reasoning to make the right conclusions (Inafah & Saputro, 2024). The characteristics of science learning, especially physics, are actually the same as other subjects. The difference is that in physics, the affective aspect (attitude and values) is more focused for development (Harefa, 2020). Physics learning is abstract, including concepts, theories, and natural laws or phenomena that must be understood. Because of this, it needs real experiences to help students learn better (Bahril et al., 2017). Science learning, especially physics, should help students understand concepts, do experiments, and improve thinking skills. But in reality, physics learning at school still mostly uses a one-way method and focuses only on giving formulas or concepts in written form. This causes students to have low critical thinking skills.

Based on the observation done at SMP Katolik Sudiang in grade VIII, it was found that in science learning, especially physics, most students are still at the stage of memorizing and do not really understand the concepts to solve problems. The data showed that only 28.98% of students were able to analyze, solve, and conclude problems. This means that students' critical thinking skills are still very low. One reason for this low critical thinking ability is the learning material used. The printed textbooks still mostly give information that is not contextual and do not include active interaction. As a result, students focus more on memorizing and do not explore how the concepts can be applied. Also, the textbooks do not provide enough questions or problems that ask students to analyze, evaluate, or solve problems, which are important skills in critical thinking. In addition, the use of technology such as e-modules has never been used in learning. Therefore, a solution is needed—not only to use technology in learning, but also to help improve students' critical thinking through contextual learning. Science learning, especially physics, should give direct experiences to students so they can connect them with physics concepts (Taufik et al., 2010).

Contextual learning is a holistic learning concept where the subject is connected to the surrounding environment or daily life situations. This creates meaningful learning and helps students gain knowledge and skills that they can use to solve real-life problems (Sulardi et al., 2015; Tari & Rosana, 2019). Learning that is connected to everyday life has been shown to be effective in helping students understand lessons more easily (Barrun et al., 2025; Getu et al., 2024). Physics phenomena are often found in real life, so students can more easily analyze, make problems, and answer questions (Wirdiyatusyifa et al., 2022). Through contextual learning, students can use everything around them in their learning environment to better understand the material or concept they learn. This makes them more motivated, increases participation, and builds teamwork and communication skills. Therefore, contextual learning can be an effective strategy to improve students' critical thinking skills.

Besides using the right approach, learning media also plays an important role in creating an effective learning process. In this digital era, electronic modules (e-modules) are an innovative alternative that is interesting and interactive. An e-module is a digital version of a printed book that contains well-organized knowledge in terms of language, content level, and broad explanation (Sukatin et al., 2023). E-modules are self-learning materials that give information in a digital format and are easy for users to use (Anggreni & Sari, 2022; Cynthia et al., 2023). E-modules include learning instructions, materials, example questions, evaluation, and assessment guides. These help students reach the learning goals (Yolanda, 2021). Compared to printed modules, e-modules have advantages like being interactive, easy to navigate, and containing pictures, audio, videos, and animations (Ramadayanty et al., 2021). The purpose of designing an e-module is to produce learning tools that increase students' motivation, interest, and ease in learning (Praherdhiono et al., 2021). Using interactive and flexible e-modules not only makes it easier to access learning materials but also gives students space to be active. Because of these characteristics, e-modules have the potential to be effective learning media to support the development of higher-order thinking skills, especially critical thinking.

Mariyanti (2022) stated in her research that using an e-module based on a contextual approach is quite effective in improving students' critical thinking skills, with an average N-gain score percentage of 58.68%. Based on the explanation above, it is clear that learning should focus more on connecting the material with students' real-life context so that it becomes more meaningful and relevant. It should also make use of technology and support the development of students' critical thinking skills. Therefore, the researcher sees the need to develop a contextual e-module in science (physics) learning to improve students' critical thinking skills.

Method

This research is a type of Research and Development (R&D) that aims to produce a contextual e-module in science (physics) learning to improve students' critical thinking skills. The development procedure follows the 4D model, which includes define, design, develop, and disseminate (Thiagarajan et al., 2015). The stages of the 4D development model can be seen in the following picture.

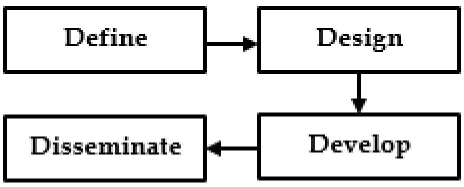

Figure 1. The stages of the 4D development model (Thiagarajan et al., 2015)

In the define stage, there are four types of analysis: initial needs analysis, student analysis, concept analysis, and learning objectives analysis.

Initial Needs Analysis

This analysis is done to find out the main problems in science learning, especially physics, at SMP Katolik Sudiang and to understand why it is important to develop relevant teaching materials. Based on classroom observations in Grade VIII, it was found that the learning process is still teacher-centered and mostly one-way. Students are usually passive during learning. They rarely ask questions and have difficulty connecting what they learn with real-life situations. Because of this, students have trouble understanding the material deeply and cannot relate physics concepts to everyday life. This also affects their critical thinking skills. One of the reasons is the use of printed textbooks as the main learning source. These books mostly explain concepts in long texts without giving students chances to explore. There are very few activities that challenge students, such as open-ended questions, case studies, or investigation-based tasks. The exercises also mostly focus on memorization and basic understanding, not on higher-order thinking skills like analyzing, evaluating, or building logical arguments. Besides that, the learning process does not yet use technology-based media like e-modules. In today's digital era, interactive learning media are very important to increase students' motivation, activeness, and critical thinking. Based on this condition, science (physics) learning at SMP Katolik Sudiang needs teaching materials that are interactive, technology-based, and contextual to improve students' critical thinking skills.

Student Analysis

Student analysis is done to find out how much ability the students have before making the e-module. The e-module will be made and designed to match the students' needs. Some things to consider to understand students' needs are general characteristics of the students, their cognitive ability, and learning style. Based on observation, most Grade 8 students are 13 to 14 years old. According to Jean Piaget's theory, children at this age are in the formal operational stage. This means they can think abstractly, use logic, and plan things. But in reality, most students have not reached this stage. They still find it hard to develop these skills. Students are not used to giving opinions and have difficulty processing information deeply, such as analyzing facts, making problems, clarifying logical arguments, and making conclusions. In terms of learning style, most students are kinesthetic. This means they understand the material better if it is given in a real-life context and involves hands-on activities. The results of the observation on students' learning styles are as follows.

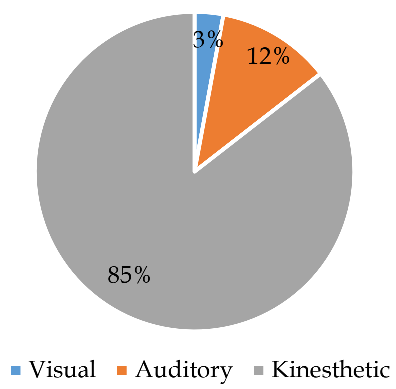

Figure 2. Learning styles of grade VIII students at SMP Katolik Sudiang

Based on the data from the diagram in Figure 2, it was found that most students have a tendency toward kinesthetic learning style (85%), followed by visual learning style (12%), and only a small number have auditory learning style (3%). Based on this analysis, students need learning materials that not only give information, but also help them interact actively and think critically through reflective questions, experiments, or problem-based activities.

Concept Analysis

Concept analysis aims to map and decide the main parts of the science (physics) material to be taught. The material to be analyzed is the concept of work and energy. Through concept analysis, the researcher can explore the material deeper, identify how the concept can be used in real life because students are usually more interested in material that connects with their daily experience, and decide the scope and learning goals. The chosen material will be presented through student learning activities in the e-module. By doing the analysis well, students can understand the connection between theory and practice by linking the concepts to real examples or physics phenomena around them. So, the development of the contextual e-module will be more effective in reaching the learning goals. It is also expected to improve students' critical thinking skills through activities in the e-module that test the principles of work and energy.

Learning Objectives Analysis

Learning objectives analysis is done by making learning goals for each learning activity based on the learning achievement (CP) set by the government and the learning objectives flow (ATP) found in the Merdeka Curriculum. The learning objectives that have been made will be used as a guide in designing and developing the product, which is a contextual e-module on the topic of work and energy, to improve students' critical thinking skills.

The design stage includes activities to plan the e-module product that will be created, focusing on the learning process to reach the expected goals. The steps in this stage include: preparing the research instruments, preparing the material, and designing the e-module. In designing the e-module, Canva application is used. The e-module is developed by integrating material that fits with real-life situations so it becomes relevant to the students' daily lives.

The development stage includes product validation to find out whether the developed product is suitable or not, by giving validation sheets to validators or expert teams, as well as conducting limited and field trials. The trial design used is "One Group Pre-Test and Post-Test Design". In this design, the trial is done two times, before the experiment (O_1), called the pre-test, and after the experiment (O_2), called the post-test. This trial design is described as follows (Sujadi, 2002; Sugiyono, 2013).

O_1 X O_2

Figure 3. Research trial design

Explanation:

X : treatment (independent variable)
O_1 : pre-test score (initial test before treatment)
O_2 : post-test score (final test after treatment)

The disseminate stage aims to analyze the results of the product trial in the field and to make improvements if there are suggestions or feedback from practitioners. The improved or revised product, in this case the e-module, will be given to the teacher as a way of distributing it to the school and will be published in a journal for wider reach.

Data Analysis

Data Analysis of Validation Results

The analysis used to find out the level of relevance by experts used the content validity coefficient (Aiken's V). Aiken's V formula is used to calculate the content validity coefficient based on the expert's rating of each item (Azwar, 2012).

$$V = \frac{\sum s}{n\,(c-1)} \quad (1)$$

Explanation:

V : index of expert agreement on item validity
S : s = r - l0
O_2 : post-test score (final test after treatment)
S : the difference between the score given by each expert and the lowest score in the rating scale
I_0 : score given by the rater (expert)
n : number of experts
c : the highest score in the rating scale

The Aiken test requirement, after calculation, is that if V ≥ 0.4, then the expert agreement index is considered valid.

Practicality Analysis

The practitioners' assessment of the e-module was carried out using a questionnaire filled out by MGMP IPA teachers, with a rating scale from 1 to 4. The coding rules for the responses are clearly explained based on the criteria in Table 1 below (Sugiyono, 2018).

Table 1. Coding of practitioner response

Category	Positive Statement Score	Negative Statement Score
Strongly Agree	4	1
Agree	3	2
Disagree	2	3
Strongly Disagree	1	4

The steps of the analysis are calculating the ideal score statement or item, calculating the total score for each statement or item and calculating the percentage of the total score for each item using the formula.

$$\text{Percentage} = \frac{\text{Total score of each item}}{\text{Total ideal (maximum) score}} \times 100\% \quad (2)$$

The percentage of practitioner responses for each statement will be analyzed using the scoring criteria in Table 2 below (Sahida, 2018).

Table 2. Practitioner score criteria

Percentage (%)	Category
76 < × ≤ 100	Very Practical
56 < × ≤ 75	Practical
26 < × ≤ 50	Less Practical
0 < × ≤ 25	Not Practical

Effectiveness Analysis

The effectiveness analysis aims to process and analyze the data from students' critical thinking skills tests on the pretest and posttest to show the improvement in students' critical thinking skills after using the contextual e-module, before and after the learning process. According to Sundayana (2014), the N-gain (normalized gain) can be calculated using the following formula.

$$\text{Normalized Gain} = \frac{X_{\text{Posttest}} - X_{\text{Pretest}}}{X_{\text{Max}} - X_{\text{Pretest}}} \quad (3)$$

Explanation:

G : Normalized gain score
$X_{pretest}$: Pretest score (initial test)
$X_{posttest}$: Posttest score (final test)
X_{max} : Maximum score

The criteria for normalized gain can be seen in Table 3 below (Sundayana, 2014).

Table 3. Normalized gain criteria

Normalized Gain Score	Category
g > 0.7	High
0.3 ≤ g ≤ 0.7	Medium
g < 0.3	Low

The effectiveness of using the e-module is based on the interpretation of the N-gain score obtained, which is then converted into a percentage (%) as shown in Table 4 below (Puspita & Setyaningtyas, 2022).

Table 4. Interpretation categories of N-gain score effectiveness

Interval (%)	Category
g ≤ 55	Not Effective
g ≥ 56	Effective

Result and Discussion

Development of Contextual E-Module in Science (Physics) Learning to Improve Students' Critical Thinking Skills

The main focus of this research is to develop a contextual e-module in science (physics) learning that is suitable to use in the classroom to improve students' critical thinking skills. The research process includes systematic steps, starting from identifying the needs, designing the e-module, and continuing to the development stage. This development includes validation from experts for the e-module and for test and non-test instruments. The following explains the development of the e-module and the trial results in Grade VIII of SMP Katolik Sudiang to see its implementation and effectiveness.

The Results of Developing a Contextual E-Module in Science (Physics) Learning

The development in this research is a contextual e-module focused on the topic of work and energy. This e-module is designed as an interactive learning material to help improve students' critical thinking skills through contextual content and activities that stimulate the critical thinking process. The e-module developed is made as a flipbook that can be used by students independently or as a support in the learning process. It can be opened using electronic devices such as laptops, tablets, or mobile phones. According to Hartanto et al. (2020), a digital module in the form of a flipbook is made so it does not look stiff like a module in PDF or DJVU format.

Before the e-module was developed, it was first analyzed based on students' learning needs, the characteristics of the material, and the principles of developing an interactive e-module. The content was arranged step by step, starting from mapping the material, formulating learning objectives based on learning outcomes, developing learning activities, and inserting critical thinking skill indicators. Each part of the e-module was designed to be integrated and coherent, taking into account the students' cognitive development level. The e-module includes symbols that help users, such as icons for the main menu, next, and previous.

The development of the e-module went through a validation stage by experts to ensure that the product has good quality and matches the learning and research goals. The validation was done to check the e-module's quality from several aspects, such as content, presentation, graphics, language, and its connection to the development of students' critical thinking skills. The analysis results from the validation data, based on agreement from three experts using Aiken's V index, are shown in Table 5 below.

Table 5. Content validation test of the contextual e-module in science physics learning

Aspect	Total Validity Item Score	V	Category
Content	14.20	0.79	Valid
Presentation	6.22	0.78	Valid
Graphic	5.78	0.83	Valid
Language	7.33	0.81	Valid

Table 5 shows that all aspects of the assessment are in the valid category. This means that the developed e-module has fully met the content feasibility standards in terms of content, presentation, graphics, and language. Therefore, this e-module is considered suitable to be used in the learning process.

This analysis is in line with the research conducted by Rizki et al. (2022), which stated that a contextual teaching and learning-based e-module on energy sources was declared valid by experts. Furthermore, the research by Lestari et al. (2022) on the development of e-module teaching materials integrated with the contextual teaching and learning approach on the topic of material elasticity also met the criteria of being valid for use in learning.

Although this research and development did not mention it in the research objectives, the researcher also did validation for the questionnaire instrument and the critical thinking test instrument as part of the development process. Therefore, here are the validation results: The practitioner response questionnaire was validated by three experts to make sure that each question met quality standards in content, structure, and language. Based on the validity test using Aiken's V index, the results are: for content, the average validity score (V) was 0.83; for structure, the score was 0.81; and for language, the score was also 0.81. So, in general, the practitioner response questionnaire is valid and suitable to use without revision; and the critical thinking test instrument was made in the form of 16 essay questions on the topic of work and energy. It included 8 pretest questions and 8 posttest questions. This test was validated by three experts to make sure that every question could really measure critical thinking skills correctly and match the students' characteristics. Based on the validity analysis using Aiken's V index, the results for each critical thinking indicator used in this research are: for the indicator "analyzing facts," the average validity score (V) was 0.79 for the pretest and 0.81 for the posttest. For the indicator "formulating problems," the average V score was 0.79 for both pretest and posttest. For the indicator "clarifying logical arguments," the average V score was 0.78 (pretest) and 0.82 (posttest). For the indicator "drawing conclusions," the average V score was 0.83 (pretest) and 0.78 (posttest). So, in general, based on these results, the critical thinking test instrument is valid and suitable to use without revision.

Practitioners' Responses to the Contextual E-Module in Science (Physics) Learning

This assessment was carried out by 10 science teachers who are members of the MGMP IPA group. The practitioners were asked to evaluate the e-module after reading and reviewing its contents through a provided e-module link. They gave their responses by filling out a questionnaire using a Google Form link, which was chosen to make it easier for them to assess. The questionnaire consisted of 26 questions covering four indicators: appearance, material presentation, media/e-module operation, and media usefulness. The results of the practitioner's response analysis to the developed e-module can be seen in Table 6 below.

Table 6. Practitioners' responses to the contextual e-module in science (physics) learning

Indicator	Average Score	Percentage (%)	Category
Appearance	3.82	95.45	Very practical
Material Presentation	3.76	94.00	Very practical
Media Operation	3.70	92.50	Very practical
Media Usefulness	3.80	95.00	Very practical

Table 6 shows that the practitioner gave a positive response to the developed product. The practitioner stated that the e-module has met good criteria in terms of appearance, material presentation, operation, and usefulness for students' needs. Therefore, the e-module is considered very practical to use in learning.

The result of this analysis is in line with the research by Sari (2022) and Salassa et al. (2023), which stated that the development of a physics e-module based on contextual teaching and learning in the topic of straight motion was practical to use. Similarly, the research by Rizki et al. (2022) stated that the contextual teaching and learning-based e-module on the topic of energy sources received positive responses, meaning it was considered very appropriate or practical by educators.

The practitioners said that this contextual e-module is quite flexible to use both online and offline. The learning activities inside it are also considered to encourage students to be more active and help them practice critical thinking. Some teachers gave comments that the student activities are not only for checking basic understanding, but also help students analyze facts, make problems, clarify logical arguments, and make conclusions. This is in line with the research by Hartanto et al. (2020), which said that through the contextual approach, students are given chances to act actively in finding answers to problems they face and try to examine, search, and make logical, critical, analytical, and systematic conclusions by themselves. Similarly, according to Toheri et al. (2020), through contextual learning, students have very good abilities in identifying and formulating problems, as well as correctly answering the problem statements and providing accurate calculations.

The Effectiveness of the Contextual E-Module in Science (Physics) Learning

The effectiveness of the e-module developed to improve students' critical thinking skills was tested through its implementation at SMP Katolik Sudiang, involving 45 eighth-grade students as respondents. The evaluation was conducted using a test instrument in the form of essay questions for both pretest and posttest, each consisting of 8 questions that had been previously developed and validated. These questions were designed to measure 4 indicators of critical thinking skills: analyzing facts, formulating problems, clarifying logical arguments, and drawing conclusions based on the results they obtained. The questions do not just ask about the material again, but are made more challenging so that students can think more deeply about real-life situations, solve problems, and give explanations using logic and evidence based on theory. The descriptive analysis results of the critical thinking skills test are presented in Table 7 below.

Table 7. Descriptive scores of students' critical thinking skills

Parameter	Critical Thinking Skills	
	Pretest	Posttest
Number of Respondents	45	45
Maximum Ideal Score	112	112
Minimum Ideal Score	0	0
Maximum Empirical Score	73	109
Minimum Empirical Score	16	52
Average Score	48.93	86.20

Table 7 shows that there is an increase in the average score of students' critical thinking test before and after the use of the contextual e-module in science (physics) learning. The average pretest score of the students was 48.93, with the highest score among 45 students being 73 and the lowest score being 16. Meanwhile, the average posttest score was 86.20, with the highest score being 109 and the lowest score being 52. The results of the analysis of students' critical thinking test before using the developed e-module are fully shown in Table 8 below.

Table 8. Percentage of students' critical thinking pretest scores

Range	Category	Frequency	Percentage (%)
$90 < X \leq 112$	Very Good	0	0.00
$68 < X \leq 89$	Good	7	15.55
$46 < X \leq 67$	Fair	21	46.67
$23 < X \leq 45$	Poor	16	35.56
$X \leq 22$	Very poor	1	2.22

Table 8 shows that most of the students' pretest scores are in the medium and low categories, with almost the same number. Only a few are in the good and very low categories, and no one reached the very good category. Therefore, in general, the percentage of students' pretest scores is in the medium to low category.

Critical thinking skills were then measured on the same respondents after the implementation of the developed e-module for five meetings. The results of the analysis of students' critical thinking test after the implementation of the developed e-module on the topic of work and energy are shown in Table 9 below.

Table 9. Percentage of students' critical thinking posttest scores

Range	Category	Frequency	Percentage (%)
$90 < X \leq 112$	Very Good	20	44.44
$68 < X \leq 89$	Good	19	42.22
$46 < X \leq 67$	Fair	6	13.33
$23 < X \leq 45$	Poor	0	0.00
$X \leq 22$	Very poor	0	0.00

Table 9 shows that most of the students' posttest scores are in the very good and good categories. Only a few are in the medium category, and no students are in the low or very low categories. Therefore, in general, the students' posttest scores increased. To get a more detailed picture, Table 10 and Table 11 show the students' pretest and posttest critical thinking scores based on each indicator.

Table 10. Students' pretest critical thinking scores based on indicators

Indicator	Ideal Score	Total Score	Percentage (%)
Analyzing Facts	1080	837	77.50
Formulating Problems	1080	715	66.20
Clarifying Logical Arguments	1800	398	22.11
Drawing Conclusions	1080	252	23.33

Table 10 shows the pretest results of students' critical thinking skills analyzed based on four indicators. The total score was obtained by adding all the scores from 45 students, and the percentage was calculated by dividing the total score by the ideal score, then multiplying by 100%. The result shows that the indicator analyzing facts had the highest percentage, followed by formulating problems, while the lowest percentages were in clarifying logical arguments and drawing conclusions. This result shows that before using the e-module, most students were already able to analyze facts and formulate problems, but still had difficulties in clarifying logical arguments and drawing conclusions from the questions.

Table 11. Students' posttest critical thinking scores based on indicators

Indicator	Ideal Score	Total Score	Percentage (%)
Analyzing Facts	1080	1026	95
Formulating Problems	1080	977	90.46
Clarifying Logical Arguments	1800	1228	68.22
Drawing Conclusions	1080	648	60

Table 11 shows the posttest results of students' critical thinking skills. The indicator analyzing facts had the highest percentage, followed by formulating problems. Although clarifying logical arguments and drawing conclusions were still the lowest, both showed a significant improvement compared to the pretest. Therefore, it can be concluded that learning using the developed e-module was able to improve all four indicators of students' critical thinking skills. The results of the analysis of the improvement in students' critical thinking skills based on the critical thinking indicators used in this study can be seen in Table 12 below.

Table 12. Analysis of students' critical thinking improvement by each indicator

Indicator	Average Pretest Score	Average Posttest Score	Percentage of Improvement (%)
Analyzing Facts	2.33	2.85	17.50
Formulating Problems	1.99	2.71	24.26
Clarifying Logical Arguments	1.11	3.41	46.11
Drawing Conclusions	0.70	1.81	36.67

Table 12 presents the comparison of the average pretest and posttest scores of students for each critical thinking indicator, along with the percentage of improvement. The average pretest and posttest scores were calculated by dividing the total scores of all students on each indicator by the number of questions (8 questions) and the number of students (45 students). The percentage of improvement was calculated from the difference between the posttest and pretest percentages based on the ideal score for each indicator in Tables 10 and 11. The differences in the improvement percentage for each indicator occurred because students' initial abilities during the pretest were not the same. The indicator analyzing facts showed the lowest improvement because from the beginning, most students were already able to answer questions correctly in this indicator. This means their ability to analyze facts was already quite good in the pretest, so there was not much room for improvement after using the e-module. On the other hand, the indicator clarifying logical arguments showed the highest improvement because students' pretest scores in this indicator were very low. However, after using the e-module, students began to answer the questions correctly on this indicator. This caused a high improvement percentage. In addition, the improvement in each indicator was also supported by the e-module's attractive design, systematic content structure, and presentation of learning activities based on real-world problems. The e-module also included clear instructions related to critical thinking indicators that students had to complete, such as analyzing facts in a given problem, formulating problems based on topics they wanted to explore further, clarifying logical arguments by answering questions correctly, and drawing conclusions based on the questions and their formulated problem statements.

Next, the effectiveness of using the contextual e-module in science (physics) learning is categorized based on the interpretation of gain score effectiveness in percentage (%). The analysis results of the N-Gain score can be seen in Table 13 below.

Table 13. Percentage of N-gain score effectiveness in critical thinking skills

Percentage (%)	Category	Frequency	Percentage (%)
g ≤ 55	Not Effective	9	20.00
g ≥ 56	Effective	36	80.00
Total		45	100.00

Based on Table 13, it can be seen that 9 students are still in the 'not effective' category with a percentage of 20.00%, and 36 students are in the 'effective' category with a percentage of 80.00%. The effectiveness of the e-module is categorized based on criteria adapted from Hake (Puspita & Setyaningtyas, 2022), where an average N-gain score of ≥ 56% is considered effective. From these percentages, it can be concluded that the developed product, with an average N-gain score of 60.85%, is effective in improving the critical thinking skills of the students at SMP Katolik Sudiang, especially in Grade VIII.

This is in line with the research by Mariyanti (2022) on the development of a science e-module, which found that using a contextual-based e-module is considered quite effective in improving students' critical thinking skills, with an average N-gain percentage score of 58.68%. The same goes for the research by Pestiya (2023) about developing a case-based contextual e-module to improve critical thinking skills, which showed an N-gain score in the medium category, meaning it was effective in improving students' critical thinking skills.

Conclusion

Based on the results of the research and development that have been carried out, the following conclusions can be drawn: The developed e-module is declared valid by experts based on assessments of content, presentation, graphics, and language aspects. This result shows that the e-module is suitable for use; Responses from practitioners show that the e-module is considered very practical because it is easy to use, visually appealing, contains material that is easy to understand, and provides direct benefits in supporting the learning process; The e-module has been proven effective in improving the critical thinking skills of Grade VIII students at SMP Katolik Sudiang. Based on the analysis of critical thinking test results, the N-gain score obtained was 60.85%. Referring to the effectiveness category, this score falls into the effective category (effective ≥ 56%). Therefore, the developed e-module can be used to support learning that aims to improve students' critical thinking skills.

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Conflict of Interest

The author declares no conflict of interest.

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