Development of STEM

by Yuberti Dkk.

Development of STEM-integrated physics e-module to train critical thinking skills: The perspective of preservice teachers

Development of STEM-integrated physics e-module to train critical thinking skills: The perspective of preservice teachers

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Abstract. The 21st-industrial revolution has become a hot topic to be discussed, including in the field of education. A country must be able to compete globally from the aspects of modern science and technology, one of which is through education. Education requires learning materials as a reference in the 21st-century. The purpose of this study was to develop learning media in the form of electronic modules for students on critical-thinking skills. The method used was Research and Development (R&D) with 26 students as the subjects. The research began by analyzing the needs of the physics education students of UIN Raden Intan Lampung. The results showed that the STEM-integrated physics E-Module needed to be equipped with quizzes and questions to train students' critical-thinking skills. This research has only reached the product design stage, not yet the content and product validation stage by experts.
Keywords: Critical Thinking, Physics E-Module, STEM Approach

1. Introduction

One of the important skills that students must master in the 21st-century is critical thinking [1]. In general, the teaching and learning conditions of higher education institutions in Indonesia have not changed significantly in terms of academic behavior [2]. Critical thinking is included in cognitive strategies with a series of methods used to solve problems effectively [3-5]. Students who have critical thinking skills will reason logically with complex understanding [6]. Reliable critical thinkers have the ability to (1) find problems and formulate questions accurately and clearly; (2) present relevant information with abstract thinking and interpret it effectively; (3) generate logical conclusions and test them against certain standard criteria; (4) generate practical alternative thoughts according to needs by assuming and implying; and (5) communicate effectively with others to find solutions to problems [7]. Higher education challenges the teaching of critical thinking through the STEM approach which focuses on memorizing critical information [8].

The science, technology, engineering, and mathematics (STEM) approach will remain a critical need in terms of retention, recruitment, and reform, especially in education [9]. The spatial rationalization of entries, performance, and persistence are the main factors of the STEM approach discipline [10]. Education with the STEM approach contains components which cover the problem-solving, critical thinking skills, analytical, and communication as a pedagogical strategy [11]. In particular, the application of the STEM approach in education is applied in the learning experience process [12]. The STEM approach discipline is expected to increase equality in higher education [13]. Learning through

the STEM approach is very important because it can train students to integrate every aspect at once [14,15]. It emphasizes the inter-disciplinary field of content [16]. The STEM approach can evaluate learning media applied as a strategy in education [17].

Learning innovation by optimally utilizing technology is needed, especially in the industrial revolution era 4.0 [18]. The application of technology-based learning media can improve the quality of learning [19,20]. Technology-based learning media can be in the form of systematically structured teaching materials presented in electronic format, namely the Physics E-Module which contains animation, audio, and video so that users can be more interactive in using the Physics E-Module [21,22]. Learning with the Physics E-Module can be accessed anywhere because it is more flexible [23,24].

Based on the previous research, the learning process has not used the STEM-integrated learning media on the thermodynamic course. It is necessary to develop a physics e-module integrated with the STEM approach [25]. Although other studies have discussed the STEM-integrated electronic modules, they were not focused on critical-thinking skills [26]. Therefore, research on the development of the STEM-integrated physics e-module on critical thinking skills needs to be developed for students.

Research Method

The purpose of this research was to develop a learning media in the form of electronic modules for students on critical thinking skills. This study employed the Research and Development (R&D) method [27,28]. This research and development design used was the 4-D model which consisted of Define, Design, Development, and Disseminate stages [29].

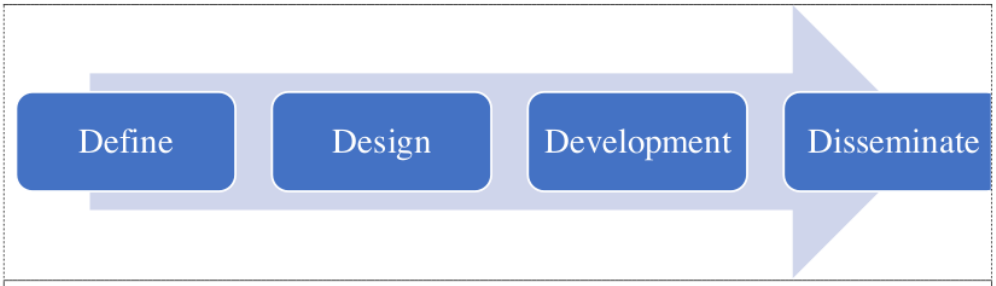


Figure 1. The 4D Development Stages

However, this study only presents the results up to the Define and Design stages. The research was started by distributing questionnaires to analyze student needs, products, and preliminary studies. This research was conducted in September 2020. The research sample was 26 students of the Physics Education Department of UIN Raden Intan Lampung. The data collection had been carried out online using Google Form. The instrument used was a questionnaire instrument with the Guttman's scale. The instrument had been distributed using WhatsApp social media. Furthermore, the data were collected and analyzed using percentage techniques. Students' interpretation of the thermodynamics course can be seen in table 1.

Table 1. Student Interpretation of Thermodynamics Course

No	Question	Category (%)	
		Yes	No
1.	Do you like Thermodynamics lectures?	92.3%	7.7%
2.	Is the Thermodynamics course a subject with difficult to understand materials?	61.5%	38.5%

No	Question	Category (%)	
		Yes	No
3.	Do you have learning materials for the Thermodynamics course?	76.9%	23.1%
4.	Are the learning materials you used enough for you to understand the course?	26.9%	73.1%
5.	Do you need additional study materials to support learning in this course?	100%	0%

Table 1 shows that students need additional learning materials to support learning in the Thermodynamics course. It can be seen from the percentage that some students consider the Thermodynamics course is difficult to understand the course.

The following are the responses of questionnaires for students regarding their needs on the STEM-integrated E-module. The questionnaire contained questions with predetermined categories to analyze students' needs for the content of the STEM-integrated physics E-module.

Table 2. The Students' Responses toward the STEM-Integrated Physics E-Module

No	Questions	%	Response
1.	Have you ever used E-module in studying the Thermodynamics course?	53.8%	Never
2.	If not, do you think that E-module is required in the Thermodynamics course?	69.2%	Required
3.	What additional content do you expect the E-module to contain?	34.6%	Elaboration of the Equations
4.	Are you interested in using the E-Module for the Thermodynamics course?	34.6%	Interested
5.	Statement (1) difficult to understand learning materials and (2) courses that do not have teaching materials. In your opinion, what are the criteria for learning materials that require an E-module?	46.2%	Statements 1 & 2

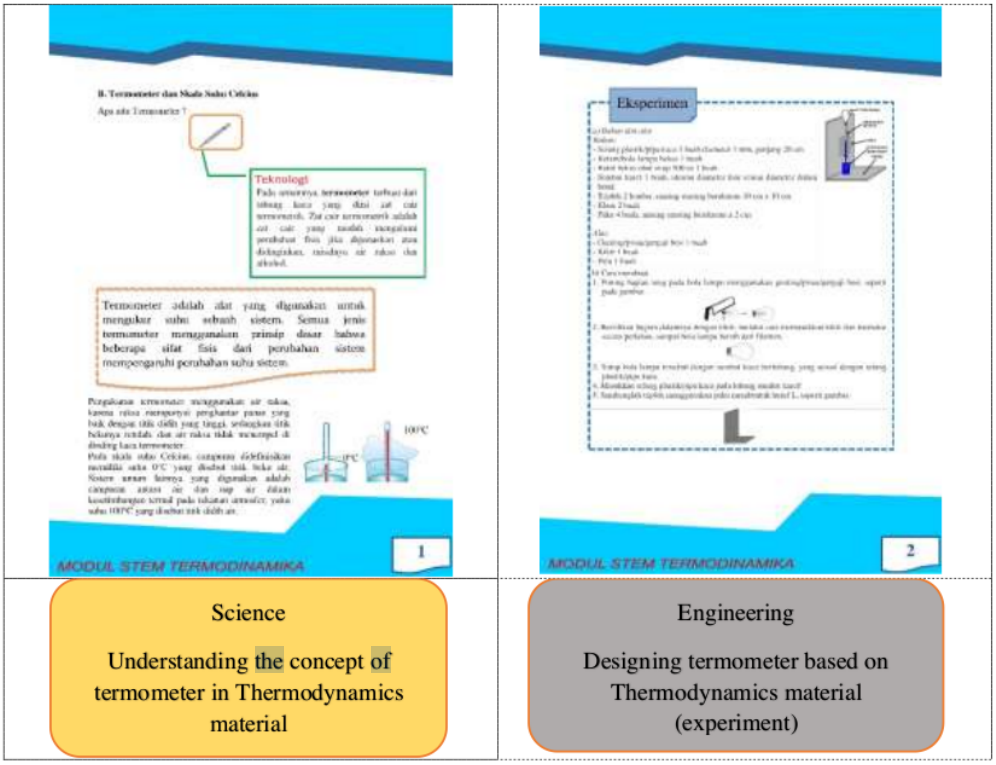
Based on Table 2, most students have never used an E-module in the Thermodynamics course. The students expressed their support for the development of the physics E-module. The students prefer the E-module to contain formula elaboration because some students think that the Thermodynamics course is difficult to understand. Also, the students need a physics E-module to study the Thermodynamics course because they have never used physics E-Module in the Thermodynamics course. The students expect that the contents of the physics E-module to contain a formula description

3. Results and Discussion

STEM-integrated physics E-module is indispensable for students. Technology-based learning media make learning more interesting. It can describe abstract material through factual animation [30]. Physics E-module supports interactive learning because it contains images, animation, audio, and video so that users can self-evaluate the competency and the evaluation results independently.

The STEM-integrated E-module can support students to think critically. Critical thinking skills are needed in analyzing and solving problems in everyday life [31]. Each individual must have critical thinking skills, digital literacy knowledge and skills, information literacy, media literacy, and information and communication technology skills [32]. These abilities are shown by students in the suitability of learning styles so that self-confidence, creativity, and critical thinking will arise [33].

Therefore, to support students' critical thinking skills, the STEM approach is packaged in the Physics E-Module so that it can achieve learning objectives. The following is the design of the STEM-integrated physics E-module.



Science	Engineering
Understanding the concept of termometer in Thermodynamics material	Designing termometer based on Thermodynamics material (experiment)

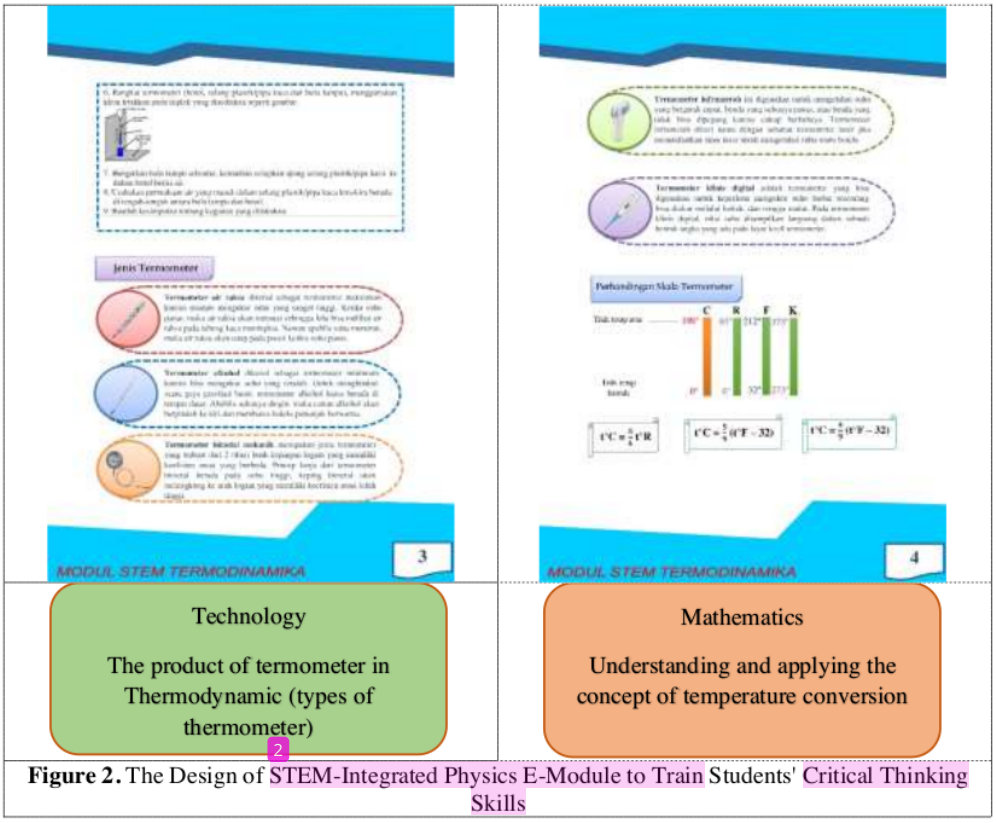


Figure 2. The Design of STEM-Integrated Physics E-Module to Train Students' Critical Thinking Skills

Based on the results of the needs analysis questionnaire, the content of the STEM-integrated physics E-module contains the temperature discussion which is one of the materials in the Thermodynamics course. The students are expected to analyze the data, images, and numbers contained in the E-module.

The STEM-integrated physics E-module is accompanied by animation, pictures, experiments, videos, and sample questions. The weakness of the STEM-integrated physics E-module is that the contents and products have not been validated by experts. However, the advantage of this product is that it contains quizzes and questions that can train students' critical thinking skills.

4. Conclusion

Based on the results of research and discussion, it can be concluded that students strongly support the development of a STEM-integrated physics E-module to help them understand and analyze the material contained in the Thermodynamics course. The STEM-integrated physics E-module can support students' critical thinking skills to compete in the industrial revolution 4.0. The students can carry out self-evaluation and be able to follow up on the results of self-evaluation. The quizzes contained in the E-module can foster students' critical-thinking skills.

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