The Effectiveness of STEM-Based High School Biology E-Module on Respiratory System Material to Improve Student Learning Outcomes and Creative Thinking

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ABSTRACT: One of the factors for improving the quality of education in schools is teaching materials. Based on the results of observations at SMAN 1 Sitiung that students have not used e-modules but use electronic teaching materials in the form of pdf files downloaded from the internet and only in the form of writing and a few pictures. Based on the results of the questionnaire, it is known that students have difficulty understanding the concept of the respiratory system material. This causes low student learning outcomes. Based on the results of the creative thinking questionnaire, it was found thatstudents' creative thinking ability is still low with an average score of 33.8, so it is included in the less creative category.So it takes teaching materials that can help in visualizing the subject matter.This type of research is Plomp model development research which consists of three stages, namely the initial investigation stage, the development or prototyping stage, and the assessment stage. The research subjects were class XI students at SMAN 1 Sitiung for the 2022-2023 academic year. Effectiveness test data were obtained from multiple choice question sheets for assessing cognitive competence, observation sheets for assessing affective competence and psychomotor competence, and essay question sheets for assessing students' creative thinking skills. The effectiveness test results from the cognitive, affective, and psychomotor aspects of students show that STEM-based e-modules are very effective and the value of creative thinking skills is obtained on average81.22% (very creative).

KEYWORDS: E-Module, STEM, Learning Outcomes, Creative Thinking

INTRODUCTION

E-moduleis a teaching material packaged digitally. E-module can help teachers facilitate students in learning(Asrial, 2020). Diantari (2018) states that e-modules are digital learning media that are arranged systematically so that students can learn independently and solve existing problems. It can be concluded that e-modules are digital teaching materials that are systematically arranged and presented in electronic form. E-module can increase students' interest and motivation in learning.

E-modulehas an important role in the learning process that can assist teachers in explaining subject matter. The advantage of emodule compared to other print media is that it is interactive, e-module can be accessed via mobile phones, laptops or computers. So that the e-module can be used as one of the best alternatives to increase the understanding of students, and can improve the learning outcomes of these students (Pramana, 2020).

The software used in making the e-module is Adobe Flash Professional CS6. Adobe flash professional CS6 is one of the applications found on computers to develop multimedia-based learning media. Adobe flash professional CS6 is capable of creating and processing text and objects with three-dimensional effects(Simanullang & Manullang, 2022). The advantage of Adobe Flash Professional CS6 is that it has many features so that it can connect images, sounds and animations simultaneously. In addition, this software also has high-extension features, so that media can be stored on mobile phones to make it more practical (Rezeki, 2018). With the help of this application, e-modules can be made more interesting and there are animations related to the material so that students can interact directly and can help students to better understand the material.

Based on the results of observations made in July 2022, students have not used e-modules but have used electronic teaching materials in the form of pdf files downloaded from the internet and only in the form of writing and a few pictures. In addition, the teaching materials used by students during the learning process are only in the form of textbooks and learning support books (student worksheets) and are still very limited, causing a lack of learning resources for students and teaching material sources for teachers. Therefore, with such a learning process it results in students only getting material from the teacher (only as recipients of information) which can result in relatively low student learning outcomes.

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Table 1. Daily test scores of SMAN 1 Sitiung students

No	Class	Respiratory System Average Score
1	XI MIPA 1	58.30
2	XI MIPA 2	57,52
3	XI MIPA 3	61.30
	Average	59.04

In addition, based on the results of interviews conducted with Mrs. Satria Dewita, S.Pd. in July 2022, who was one of the Biology class XI MIPA teachers at SMAN 1 Sitiung, it was found that the teacher still applied conventional learning and the learning process was still teacher-centered using the lecture learning method. This results in a lack of student activity in the learning process, such as a lack of students asking questions, a lack of responsibility in doing assignments and exercises, and a lack of students in understanding concepts.

Based on the results of the researcher's analysis of the problems of teaching materials and analysis of students' needs in studying biology, which had been filled in by 62 students, several problems were found regarding the electronic teaching materials used, namely as follows. First, biological materials in the digestive system and respiratory system experience difficulty with a percentage of 73%. Second, the electronic teaching materials that have been used have not been fully implementedhave pictures that support the theoretical basis of the material being taught.The results of the questionnaire show that only 42% of the pictures in electronic teaching materials support the theory and the pictures are not clear and not interesting enough. Third, the language used is not easy to understand. It was revealed in the student statements that only 34% of students answered that the language used in electronic teaching materials was easy to understand. Fourth, according to students, electronic teaching materials are less attractive, because 15% of students say that electronic teaching materials are less attractive with color combinations. It was also revealed that 23% of students during the learning process had not participated actively.

According to Vembriarto (1985) that the learning materials contained in the module are self-instructional so that high learning activity can occur and can increase students' creative thinking. Creative thinking skills are very necessaryowned by every student to be able to create and update various innovative new breakthroughs, and be able to solve learning problems as well as in everyday life quickly and precisely. One of the biology subject matter that can require students to think creatively is the digestive system material. In this material, there are many students who experience difficulties in working on questions related to problem solving. This is provenBased on the results of a questionnaire about creative thinking for students, it was found that students' creative thinking ability was still low with an average value of 33.8, so it was included in the less creative category.

To overcome these problems, it is necessary to develop biology e-modules for class XI SMA with a STEM-based approach.STEM is an acronym for Science Technology Engineering Mathematics which means an integrated learning approach that connects real-world applications with classroom learning which covers four disciplines, namely natural sciences (science), technology, engineering results, and mathematics.(Gustiani, Widodo, & Suwarma, 2017).

Based on the problems that have been raised, a research was conducted on the Effectiveness of Science Technology Engineering and Mathematics (STEM)-Based Biology E-Module Assisted by the Adobe Flash CS6 Application to Improve Learning Outcomes and Creative Thinking of Students at SMAN 1 Sitiung.

METHODOLOGY

This type of research is development research or called Research and Development (R&D). This study aims to determine the effectiveness of e-module biology based on science technology engineering and mathematics (STEM) assisted by the Adobe Flash CS6 application to improve learning outcomes and creative thinking of students at SMAN 1 Sitiung. This research began in the even semester of January-June at SMAN 1 Sitiung for the 2022/2023 academic year. The research was conducted at the Faculty of Mathematics and Natural Sciences (FMIPA) Padang State University (UNP) and SMAN 1 Sitiung. The subjects of this study were 33 class X students of SMAN 1 Sitiung, three lecturers from the Department of Biology FMIPA UNP and one Biology teacher at SMAN 1 Sitiung. The object of this research is a STEM-based biology E-module using the Plomp model.(Plomp & Nieveen, 2013).

The instruments used to collect data in this study were questions and observation sheets. In the learning outcomes, the instruments used were affective (attitude) observation sheets, psychomotor (skill) observation sheets and test assessment sheets for cognitive (knowledge) learning outcomes. While on creative thinking skills using essay questions.

Analysis of data on the effectiveness of STEM-based e-modules seen from the competence of knowledge (cognitive), attitudes (affective) and skills (psychomotor) of student learning outcomes.

a. Cognitive Aspect
To determine the learning completeness of students can be done by using the following formula:

$$KB = \frac{T}{Tt} \times 100\%$$

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Information:

KB = Mastery learning

Q = The number of scores obtained by students

Tt = Sum of total scores

Table 2. Cognitive Aspect Assessment Criteria

Quality Score	Quality Value	Category
81–100	A	Very good
66–80	B	Good
56–65	C	Enough
46 – 55	D	Not enough
≤ 45	E	Bad

b. Affective Aspect

Affective competency data analysis uses the following formula:

$$NP = \frac{Skor\ yang\ diperoleh\ peserta\ didik}{Skor\ maksimum} \times 100\%$$

Information:

NP = Expected percent value

Table 3. Criteria for evaluating affective aspects

Percentage Range (%)	Criteria	Effectiveness Category
1 – 20	Very Not Good	Very Ineffective
21–40	Not good	Ineffective
41–60	Currently	Effective enough
61–80	Good	Effective
81–100	Very good	Very effective

c. Psychomotor Aspect

The formula used in determining the assessment of learning outcomes in the psychomotor domain is as follows:

$$NP = \frac{Jumlah\ skor\ yang\ diperoleh\ peserta\ didik}{Jumlah\ skor\ maksimum} \times 100\%$$

Table 4. Criteria for evaluating psychomotor aspects

Percentage Range (%)	Criteria	Effectiveness Category
1 – 20	Very Not Good	Very Ineffective
21–40	Not good	Ineffective
41–60	Currently	Effective enough
61–80	Good	Effective
81–100	Very good	Very effective

d. Creative Thinking

Assessment of creative thinking skills uses a question sheet in the form of five essay questions. Calculating the value of an essay question uses the following formula

$$Value = \frac{Jumlah\ skor\ yang\ diperoleh\ peserta\ didik}{Jumlah\ skor\ maksimum} \times 100\%$$

Table 5. Criteria for Assessment of Creative Thinking Skills

The Value of Creative Thinking	Criteria
0-20	Not creative
21-40	Less creative
41-60	Pretty creative
61-80	Creative
81-100	Very creative

Source: (Ekawati, 2011)

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RESULTS AND DISCUSSION

Testing the effectiveness of STEM-based e-modules was carried out in two classes, namely, the experimental class and the control class. The results of the effectiveness test are used as a guide in determining the effectiveness of the developed STEM-based emodule.

A. Cognitive Competency Assessment

Cognitive competency assessment can be obtained through a final test in the form of multiple choice/objective questions given to students in the experimental class and control class. Work on the final test questions is carried out at the end of the learning meeting.

Table 6. Average Cognitive Competency Results

No	Class	Min value	Maximum Value	Amount	Average
1	Experiment	70	95	2675	83.59
2	Control	65	90	2380	79,33

Data Table 6. shows that the average value of cognitive competence in the experimental class is higher than the control class. The experimental class is a class that is given treatment in the form of using STEM-based e-modules, while the control class is a class without the use of STEM-based e-modules. The average value of the experimental class was 83.59 using STEM-based e-modules, while the average value of the control class was 79.33 not using STEM-based e-modules.

B. Affective Competency Assessment

The assessment of affective competence was carried out by observers by assessing and observing the activities of students both in the experimental class and in the control class during the learning process.

Table 7. Average Affective Competency Results

No	Class	Amount	Average	Criteria
1	Experiment	2695.83	84,24	Very good
2	Control	2416,67	80.56	Good

Table 7 data shows that the average value of the affective competence of the experimental class and the control class is different. It is known that the average value of the experimental class is 84.24, while the average value of the control class is 80.56. It can be concluded that the affective competence of students in the experimental class using STEM-based e-modules is better than the control class.

C. Psychomotor Competency Assessment

Psychomotor competency assessment was carried out by observers by filling out questionnaires observing the activities of students both in the experimental class and in the control class during the learning process.

Table 8. Average Psychomotor Competency Results

No	Class	Amount	Average	Criteria
1	Experiment	2594,44	81.08	Very good
2	Control	2322,22	77,41	Good

Table 8 shows that the average value of the psychomotor competence of students in the experimental class and the control class is different. The result of the average value of the experimental class was 81.08 while the average value of the control class was 77.41. It can be concluded that the psychomotor competence of students in the experimental class who used STEM-based e-modules was better than the control class who did not use STEM-based e-modules.

D. Creative Thinking Competency Assessment

The value of creative thinking skills is obtained through the implementation of the final test in the form of essay questions given to students in the experimental class and control class.

Table 9. Average Results for Creative Thinking Skills

No	Class	Min value	Maximum Value	Amount	Average
1	Experiment	70	95	2599	81,22
2	Control	70	90	2278	75,17

Based on Table 9, it was found that the average value of the experimental class' creative thinking was higher than the average value of the control class. The experimental class was given treatment using STEM-based e-modules, while the control class did not use STEM-based e-modules. The average value of the experimental class is 80.5 in the creative category, and the average value of the control class is 75.93 in the creative category.

Based on the results of the research above, the overall value of the resultsthe results of the effectiveness test from the cognitive, affective, and psychomotor aspects of the students showed that it was very effective and the value of creative thinking skills was obtainedvery creative. The development of STEM-based E-modules carried out by previous researchers only focused on animal waste material (Umbara, 2022).

CONCLUSION

Based on the results of the research and discussion that have been described, it can be concluded thatthe results of the effectiveness test of the cognitive, affective, and psychomotor aspects of the students show that the STEM-based e-module is very effective and the value of creative thinking skills is obtained on average81.22% (very creative).

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