# Effect of The STEM Integrated Physics E-Modules to Improve Critical Thinking Ability

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**ABSTRACT**

*Life in this era of globalization requires many changes and developments from previous life. The methods and models used by teachers in the learning process also affect students' critical thinking skills. students' critical thinking, namely the discovery learning model with the STEM approach. The use of this model can change teacher centered learning to student centered. The teacher does not yet have access to references to the STEM learning approach which is accompanied by guidelines for use and the tools needed. Easy, namely less than 50%. The solution that can be done is to change the teaching materials used, namely can use STEM-integrated e-modules. The experimental class was given treatment in the form of STEM integrated e-modules, while the control class was not given treatment. After conducting the research it turned out that students' critical thinking abilities as seen from each student's answer from the two sample classes had different averages in common, namely the normality test, test homogeneity, two-mean similarity test From the analysis results obtained, namely the value of th is in the H0 resistance area so that it can be said that H1 is accepted at a significant level of 0.05. The results of the statistical analysis of the data show that th> tt is 5.897> 2.00, so it can be concluded that there are differences in students' critical thinking skills in the aspect of knowledge using e-modules and not using e-modules.*

## I. INTRODUCTION

Education in the era of globalization is developing very rapidly. Life in this era of globalization requires many changes and developments from previous life . The increasingly fierce competition requires high quality human resources. One way to improve the quality of human resources is through education.

Education is something that is important and must be given to citizens in order to increase the quality and quantity of knowledge and to improve brain function so that they can think and reason. Education is a conscious and planned effort to create a learning atmosphere and learning process so that students actively develop their potential to have religious spiritual strength, self-control, personality, intelligence, noble character and skills needed by themselves, society, nation and state.

The government's efforts to improve education are by changing the curriculum in each period. Curriculum is the most important aspect in education so that the goals of education are achieved. The KTSP curriculum emphasizes cognitive aspects, while K-13 focuses more on improving the quality of education by balancing hard skills and soft skills through attitudes, skills and knowledge [1].

Academic engagement with the curriculum does not only emphasize aspects of knowledge, but also emphasizes the four criteria for skills known as 4C skills, namely critical thinking, creative thinking, communication, and collaboration. . One of the most important skills in education is the ability to think critically

The importance of the ability to think critically is needed so that you are not far behind with the times. If this ability is mastered, it is expected to create quality human resources with high competitiveness at this time and be able to compete in the world of work in a healthy manner. A reliable critical thinker will have the ability

to find problems and formulate questions precisely and clearly, convey relevant information with logical thinking, valid conclusions and be able to implement them practically[2].

The teacher's efforts to improve students' critical thinking abilities are by choosing the right learning model. Teachers can choose several models in the learning process according to the learning objectives to be achieved. The learning model is a systematic procedure or pattern that is used as a guide in the learning process, this learning model refers to the learning approach that will be used including methods, strategies, objectives and learning steps[3]. The learning model that can improve students' critical thinking skills is the discovery learning model with the STEM approach. The use of this model can change teacher-centered learning to become student-centered [4].

Teachers do not yet have access to references to the STEM learning approach accompanied by guidelines for use and the tools needed[5]. Previous research showed that 21% of students have the ability to think critically in the medium category, 64% of students in the low category, and 15% of students in the very low category[6]. Students' critical thinking skills on the topic of sound and light waves are still relatively low, which is less than 50%[7]. Therefore, teaching materials are needed that can increase students' learning motivation so they can think critically and logically.

Teaching materials are all forms of materials used to help teachers carry out learning activities[8]. The teaching materials consist of written and unwritten materials. Written materials such as modules, student worksheets, handouts, books, brochures, wallcharts, leaflets, while non-written materials such as VCDs, cassettes, radio, interactive CDs, videos/films, and the internet[9]. Teaching materials are one of the important factors for the effectiveness of a learning process.

E-module is one of the teaching materials that is very important in the learning process. E-modules can make it easier for students to learn independently, and assist students in understanding material concepts[10]. The e-module used was made by a Research Team written by Asrizal and Naurah, in 2022. The E-module contains video, audio, material and practice questions so it is hoped that the learning atmosphere will be fun[11]. The learning process that utilizes e-modules will make it easier for students to access them anywhere and anytime. The e-module used needs to be conducted an experiment to see whether the e-module has an effect on students' critical thinking skills . One of them is by using integrated STEM (Science, Technology, Engineering, and Mathematics) e-modules that link the fields of science, technology, engineering, and mathematics, so that students are given a holistic understanding of the interrelationships of fields of science through learning experiences in this globalization era[12]. STEM-based learning can train students to apply their knowledge in making designs as a way of solving problems related to the environment by utilizing technology[13].

The STEM integrated e-module aims to determine the effect of the e-module on to critical thinking skills . E-modules can make it easier for students to learn material with the help of sample questions and practice questions. So, the title of this research is "The Influence of STEM Integrated Physics E-Module to Improve Critical Thinking Ability of Class XI Students of  Senior High School"

## II. METHOD

The type of research used is experimental or quantitative research. According to[14], said that this design has a control group, but it does not fully function to control external variables that affect the implementation of the experiment. This opinion is reinforced by[15] that this design is also influenced by other variables and not solely by treatment.  This study aims to investigate the effect of STEM integrated e-module on the critical thinking skills of class XI students of Senior High School The population in this study were MIPA class XI students for the 2022/2023 school year.

Table 1. Posttest Only Design

| Group | Treatment | Posttest |
|---|---|---|
| Experiment | X | $O_1$ |
| Control | - | $O_2$ |

[14]

Information:

X = Treatment given to the experimental class, namely the application of STEM integrated e-modules

$O_1$ = Posttest given to the experimental class

O $_2$ = Posttest given to the control class

The research conducted was limited to the cognitive aspect, by providing written test questions at the end of the study in the form of essay questions. The questions used contain indicators of critical thinking. This question was given to the two classes that were used as samples, namely the control class and the experimental class. This written test has been tested and data analysis obtained 16 questions that can be given to both sample classes. Before being given the final test both classes were given a grid of questions.

Statistical analysis used to determine the final test questions taken from test questions, there are four stages, namely testing the validity of the questions, reliability, level of difficulty, and different power of questions that have been tested in classes outside the sample class.

Final data analysis was carried out with the aim of testing whether the working hypothesis put forward in this study was accepted or rejected . From this research the data processing technique is seen from the aspect of knowledge . Knowledge data analysis begins with a test of the similarity of the two means. There are several conditions that must be met in its use, namely the data is normally distributed and homogeneous. If the sample from the population is normally distributed and homogeneous, then the appropriate statistic to use is the t test. If the sample is normally distributed but not homogeneous, then the t' test statistic is more appropriate to use. Meanwhile, if the sample is not normally distributed and does not have a homogeneous variant, then the hypothesis test used is the u test.

## III. RESULTS AND DISCUSSION

The data from the research results were taken from the learning outcomes or posttest carried out at the end of the study. The test is in the form of a written test with 16 essay questions. *Posttest* questions are designed to refer to indicators of critical thinking. Before using the questions have been tested so that the questions are suitable for *posttest* . Descriptive data can be seen in Table 2.

Table 2. Results of Data Analysis in the Sample Class

| No. | Statistical Parameters | | Class | |
|---|---|---|---|---|
| | | | Experiment | Control |
| | | | Descriptive statistics | |
| 1 | a. | N | 30 | 32 |
| | b. | Means | 71.04167 | 57.41935 |
| | c. | S | 4.67 | 11.72 |
| | d. | S $^2$ | 21.88 | 137.35 |
| | | | Normality test | |
| 2. | a. | $\alpha$ | 0.05 | 0.05 |
| | b. | L $_0$ | 0.154557 | 0.132447 |
| | c. | L $_t$ | 0.161 | 0.159 |
| | d. | Information | Normal | Normal |
| | | | Homogeneity Test | |
| 3 | a. | $\alpha$ | 0.05 | 0.05 |
| | b. | F $_h$ | 0.159289 | |
| | c. | Ft | 0.541081 | |
| | d. | Information | Homogeneous | |
| | | | Comparison Test of Two Averages | |
| 4 | a. | $\alpha$ | 0.05 | 0.05 |
| | a. | t $_h$ | 3,21 | |
| | b. | t $_t$ | 2.00 | |
| | c. | Information | There is a difference | |

The results of the descriptive statistical analysis in Table 2 show the difference in the value of learning outcomes in the knowledge aspects of students in the control class and the experimental class using STEM integrated e-modules and using existing teaching materials in schools on their critical thinking abilities. The average value of the knowledge of the experimental class is higher than the average value of the control class. The average difference between the experimental class and the control class is 13.63 . This shows a significant difference between the two sample classes which are assessed from the aspect of knowledge and critical thinking skills.

The knowledge test questions are made in accordance with the indicators of critical thinking from theory [16], namely there are 5 indicators, namely: the ability to identify problems (Interpretation), the ability to analyze

arguments in other forms with the same meaning (Analysis), the ability to assess the credibility of claims and the strength or weakness of an argument (Evaluation), the ability to draw conclusions (Inference), and the ability to explain something in detail (Explanation).

The effect of STEM-integrated e-modules on the two sample classes can be determined by testing the hypothesis on the knowledge aspects of the students by testing the hypotheses on the aspects of the students' knowledge by conducting an average comparison test. A comparison test of two means can be carried out after the data is normally distributed and homogeneous. The results of the statistical tests carried out are:

1. Normality test

The normality test is used to see whether the two sample classes are normally distributed or not. The normality test results that have been carried out show that the $L_{0\,value}$ is smaller than the $L_{t\,value}$ at a significant level of 0.05 for $n_1 = 30$ and $n_2 = 32$ as written in Table 2. In the table it is found that the normality test results $L_0$ in class experiment is 0.154 while the value of $L_0$ for the control class is 0.132. The sample will be normally distributed if the price is $L_0 \leq L_t$ at a significant level of 0.05 . The value of Lt at a significant level of 0.05 for n = 30 is 0.161 while for n = 32 it is 0.159. So it can be concluded that the data obtained by the value of $L_0 \leq L_t$ so that both sample class data are normally distributed. The results of the normality test for the two sample classes can be seen in the table below.

Table 3. Sample Class Normality Test Results

| Class | N | $\alpha$ | $L_o$ | $L_t$ | Information |
|---|---|---|---|---|---|
| Experiment | 30 | 0.05 | 0.1545 | 0.161 | Normal |
| Control | 32 | 0.05 | 0.1324 | 0.1559 | Normal |

2. Homogeneity Test

The homogeneity test aims to determine whether the two sample classes have a homogeneous variance or not. Data is declared to have a homogeneous variance if the value of $F_h$ is in the area of rejection $H_0$. The table below shows the results of $F_h$ for the sample class obtained at 0.159. From the statistical analysis, the $F_t$ value is 1.834. The two sample classes will have a homogeneous variance if the value of $F_h < F_t$ is 0.159 <1.834. This shows that the two sample classes have a homogeneous variance. The results of the homogeneity test of the two sample classes can be seen in the following table.

Table 4. Results of the homogeneity test of the two sample classes

| Class | N | $S^2$ | $\alpha$ | $F_h$ | $F_t$ | Information |
|---|---|---|---|---|---|---|
| Experiment | 30 | 118.05 | 0.05 | 1.1526 | 1.8349 | Homogeneous |
| Control | 30 | 141.77 | 0.05 | | | |

3. Hypothesis testing

Hypothesis testing is used to determine whether the hypothesis is accepted or rejected. The hypothesis test used is the comparison test of the two averages. The data obtained is normally distributed and has a homogeneous variance. If the data is normally distributed and has a homogeneous variance, then the t test can be used to test the hypothesis.

The table below shows the results of the t test for the knowledge aspect. The value obtained was obtained from the student's score in answering the final question ( *posttest* ) with the results of statistical analysis of $t_h = 5.987$ and the $t_{t\,value}$ for dk = $(n_1 + n_2)$ -2 of $t_t = 2.00$ . The value of $t_h$ is in the area of rejection of $H_0$ so that it can be said that $H_1$ is accepted at a significant level of 0.05 . The results of the statistical analysis of the data show that $t_h > t_t$ is 5.897> 2.00 . It can be concluded that there are differences in learning outcomes in the aspect of knowledge using e-modules and not using e-modules in class XI students of Senior High School.

The results of this study were to see the use of STEM integrated e-modules affecting students' critical thinking skills. Based on the data analysis that has been done, the average score of students is obtained from the aspect of knowledge from the results of *the posttest* which contains indicators of critical thinking, carried out at the end of the study.

The use of STEM integrated e-modules has an effect on student knowledge. The average value of knowledge before being given treatment was in the sufficient category, but after being given treatment in the form of STEM integrated e-modules the average value of students increased to be good. After statistical tests were carried out, namely the two average similarity test, it was found that the use of integrated STEM e-modules

had a significant effect on the critical thinking skills of class XI high school students. In line with research[17], student learning outcomes have increased due to the use of e-modules in the learning process. Student learning outcomes are seen from the value of the pretest and *posttest* .

Student knowledge increases due to the use of e-modules. E-modules are teaching materials that effectively increase student understanding[18]. STEM integration does not only focus on content but also incorporates problem-solving skills and educational-based instruction[19]. Integrating STEM in the learning process can increase students' understanding of a material.

Providing e-modules in the learning process increases students' curiosity. STEM science integrated e-modules provide a good scientific process experience, where material exposure is linked to developing technologies[20]. E-modules are also integrated with technology and engineering components. Both of these components focus on project-based learning.

STEM integrated e-modules are electronic teaching materials equipped with videos, animations, images, text, graphics, and their combinations[21]. The e-module is equipped with a Virtual Lab link in the form of Phet Colorado which students can directly access online to carry out individual practicums. Virtual Lab Practicum increases students' high curiosity[20]. PheT is a simulation that can be used for individual learning purposes. The simulation is designed interactively so that users can carry out practicum directly[22].

The practicum is carried out in groups by students in a computer room connected to the internet, this makes it easy for students to do practicum without preparing the tools and materials first. When the virtual practicum is carried out guided by the STEM integrated e-module, students' critical thinking skills increase. However, when the *virtual lab practicum* is carried out with LKPD taken from the STEM integrated e-module that has been printed so that students can easily read the procedure and fill in the data needed during the practicum. This is because students experience difficulties in using the application.

This research has been carried out as well as possible, but there are still obstacles in conducting research. The first obstacle is the limited hours of lessons when doing the test questions. The solution to overcome this obstacle is to ask permission from the teacher of the next subject to add hours of physics lessons that day.

The second obstacle is the limited hours of study because in the month of Ramadan students do not study as usual, so the teacher pursues the material that must be taught until the last Basic Competence. In the matter of sound and light waves which should have met 10 times, it was shortened to 6 JP. The solution to overcome this obstacle is to teach the important points in the material so that the learning objectives are achieved. Another solution, it is hoped that other researchers will conduct research to see the effect of integrated STEM e-modules according to the number of study hours in the syllabus.

## IV. CONCLUSION

Based on the data that has been analyzed it can be concluded. After analyzing the data, it was concluded that the STEM integrated e-module on sound waves and light waves has a significant influence on students' knowledge seen from their learning outcomes. The STEM integrated e-module has a significant influence on students' critical thinking skills as seen from students' answers to each question. Based on the conclusions, it is hoped that the STEM integrated e-module can be used as a source of independent learning by students in achieving learning goals so that meaningful learning is realized and the formation of students who are able to compete with current advances in x-security and technology.

## ACKNOWLEDGMENT

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