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The Effectiveness of an E-Module Based on Socio-Scientific Issues to Improve Critical Thinking

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Abstract

Technology in the era of the fourth industrial revolution is a trend that cannot be avoided and teachers are required to integrate the learning process with existing technology. However, this has not been implemented in many schools so students tend to be passive during learning. In learning, technology integration plays a role in increasing student motivation. Through a socio-scientific issues approach with problem-based learning syntax, students can develop problem-solving skills that are relevant to the real world. This research aims to measurement an e-module based on Socio-Scientific Issues with a Problem-Based Learning (PBL) model on the ecosystem concept to improve critical thinking. The type of research chosen is the research design used a pretest-posttest control group design. Based on the research results, the effectiveness test, it can be seen that the SSI-based e-module can improve students' critical thinking skills, especially in the aspects of concluding as well as conjecture and integration where the N-Gain value is >0.7 in the high category.

How to Cite

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INTRODUCTION

Technology in the era of the fourth industrial revolution is an unavoidable trend. Modern technology and interconnected networks are applied in various industries, including education as part of the fourth industrial revolution (Cynthia et al., 2023). Education 4.0 aims to inspire learners to discover the sources of their knowledge and skills in addition to imparting knowledge and skills (Retnaningsih, 2019). Wijayanti and Isnawati (2023) explained that in facing this phenomenon, teachers are required to integrate the learning process with existing technology, so teachers must adapt and master technology.

Ecosystem Material in Biology Education can be applied through learning in the environment . Environmental learning requires an aspect of contextuality because environmental issues are related to real life and do not only rely on knowledge, but also the environment requires attitudes and skills to solve existing environmental problems (Subiantoro et al., 2013). Zuchdi et al. (2014) added that learning will be more meaningful if it is done by involving the problems of environmental conditions around students. Environmental learning that involves real environmental problems will make students develop more critical thinking attitudes and increase values, positive attitudes, and knowledge. The purpose of this is to empower them in dealing with various environmental problems and ultimately foster awareness of the importance of protecting the environment.

The results of observations conducted at SMAN 1 Palimanan showed that the learning has not integrated existing technology. In addition, digital-based teaching materials that raise environmental issues have not been used. Ongoing learning emphasizes teaching and dissemination of materials, but has not given priority to the process of knowledge reconstruction. Environmental learning does not directly involve students in dealing with various environmental issues that are happening and only relies on memorizing concepts based on the material provided, even though the location of SMA Negeri 1 Palimanan is not too far from the factory area and is located on the main Pantura road which causes a lot of air pollution which allows it to be related to environmental learning material, so that learning is more meaningful.

Learning is done with group discussions and presentations. Each group was assigned to create a PowerPoint with different materials. During the lesson, learners are immediately given the opportunity for a question and answer session without any introduction to the basic material from the teacher or the presenting group. This often results in a lack of initiative from learners to experiment with different ways of thinking to develop their understanding. During direct observation, learners tend to be passive and only a few ask questions without any reciprocity so the discussion is only one-way. Without reference to reading materials or notes, learners also have difficulty developing critical thinking skills and expressing ideas independently. These findings highlight that the current learning approach has not provided an optimal learning experience for learners and as a result their ability to think critically is still limited. Therefore, a strategy is needed to overcome these problems, one of which is to develop a teaching material that can train student's ability to think critically, one of which is an e-module.

Teaching materials are needed to train student's ability to think critically, one of them is an electronic module (Naj'iyah et al., 2020). E-modules are electronic teaching materials resulting from the development of technology and information, this development aims to assist the learning process at school so that students can learn independently with guidance from teachers at school or independently at home (Darmayasa et al., 2018; Yuningtyas et al., 2023). The learning approach that can be integrated with e-modules is the Socio-Scientific Issues (SSI) approach because in Indonesia it is still relatively rare. This SSI approach seeks to increase the critical thinking skills mastered by students. Learning that can be oriented to teach students with environmental issues that exist around them is one of them is SSI learning. These environmental issues such as the issue of environmental pollution due to waste and forest and land fires (Nazilah et al., 2018; Sari, et al., 2021).

According to Sadler et al. (2016), SSI involves scientific or science products and processes that have the potential to generate controversy and social debate. SSI involves problems, issues, news, or information found around society and encourages learners to debate and solve problems. This is to previous research by Sholehah et al. (2022) that learning SSI-based ecosystem material has an effect in improving critical thinking skills compared to ordinary learning applied by teachers.

The application of SSI in learning can be done by integrating SSI with certain learning models, one of which is the problem-based learning (PBL) model. Problem-Based Learning (PBL) is a learning model that presents various

ill- structured problem situations to learners that can serve as an intermediary for the process of investigation and inquiry (Arends, 2008). Learners are expected to correlate the subject matter with facts in the surrounding environment. The PBL model is very suitable for delivering material related to environmental issues where problem-solving can use the Socio-Scientific Issue (SSI) approach.

Based on relevant research conducted by Nissa et al. (2023) the results of his research prove that student's critical thinking skills increase due to the influence of using Socio-Scientific Issues (SSI)-based e-modules on the theme of food loss and food waste. The novelty of this research lies in the theme and development model. The study used food loss and food waste material to measure the improvement of critical thinking skills, while this study raised the SSI theme on the concept of ecosystems that link environmental issues around Cirebon to measure the improvement of critical thinking skills. In addition, the e-module research is packaged in the form of an Android application. The superior content contained in the e-module to be developed is that the e-module can be accessed on various devices such as smartphones and PCs that can be accessed offline and online. The e-module is also equipped with quizzes on each sub-chapter. In addition to quizzes, e-modules are equipped with learning activity sheets in each sub-chapter along with evaluation sheets made using liveworksheet so that students can answer directly on the sheet.

METHOD

The type of research chosen is the research design used a pretest-posttest control group design. This design consists of an experimental group (which applies SSI-based e-modules) and a control group (which does not apply SSI-based e-modules). The sample selection was carried out by purposive sampling method based on the duration of each lesson hour in each class. The samples used were students of class X SMA Negeri 1 Palimanan, namely X-7 and X-8 as the control class, X-9 and X-12 as the experimental class. Each sample member was given a pre-test and post-test consisting of multiple-choice questions and description questions. The results of the test were then used as a measure of effectiveness in measuring student's critical thinking skills and environmental awareness.

The instruments used to measure critical thinking variables are 10 multiple-choice questions and 5 description questions, while the environmental care attitude instrument is by distributing questionnaires arranged on a Likert scale. Both questions and questionnaires were tested for normality, homogeneity, t-test, and N- Gain test. In addition, the e-module practicalization test was carried out by teachers and students by distributing questionnaires.

RESULT AND DISCUSSION

Characteristics of SSI-based E-Modules

The cover page contains the title of the e-module. The e-module title uses Bobby Jones Soft, handyman and Scripter font types. The cover is designed with a blue background with pictures related to environmental problems presented in the e-module such as waste pollution and air pollution due to factory smoke. In addition, here is a picture of students throwing garbage which indicates an attitude of environmental care. On the cover page there is a "start" button to open the e-module page. The cover e-module can be seen in Figure 1.

Figure 1. Cover of the SSI-based E-Module

One of the excellent features of the developed e-module is the navigation button that functions to make it easier for users to operate the e-module and to make it more interactive. The main menu of the e-module contains instructions for use, learning outcomes, concept maps, materials, evaluations, reference lists, glossaries, and developer profiles. Each menu is facilitated with navigation buttons, making it easier for users to go to the intended e-module page. The main menu display on the e-module can be seen in Figure 2.

Figure 2. Main Menu of SSI-Based E-Module

Researchers carry out needs analysis activities that aim to analyze problems. The first analysis is curriculum analysis by conducting interviews with 2 junior high school teachers and 1 MtsN teacher adjusted to the curriculum used in schools. Curriculum analysis was carried out using the interview method. According to the results of the interview, SMP IT Bina Amal Semarang and MTsN Semarang use a curriculum that is adapted to the learning guidelines that apply to the Merdeka Curriculum for classes VII and the 2013 Curriculum for classes VIII and IX. From the results of the interview activities in the needs analysis, the researcher prepared the final product in the form of "AKM Questions to Measure Students' Scientific Literacy and Numeracy Abilities". The SSI-based e-module presents various examples of environmental issues that occur around Cirebon, which can be seen in Figure 3.

Figure 3. Material Page Presenting Environmental Issues Around Cirebon

One of the socio-scientific issues discussed in the e-module is accumulation of rubbish that occurs around Kesenden Beach Cirebon and shown in Figure 3. Apart from that, the material page is equipped with navigation buttons such as the next button to go to the next page, previous to go to the previous page, help which contains instructions for using the e-module and the main menu. The template used as a background also contains biotic and abiotic components as components of the ecosystem.

Another excellent feature contained in the e-module is the quiz. The quiz is designed in a gameshow format using Wordwall. The faster the learners answer, the greater the bonus score they get. Learners are given time to answer each question for 2 minutes and the questions are arranged randomly. After finishing answering the questions, learners can see the scoreboard. The quiz display can be seen in Figure 4.

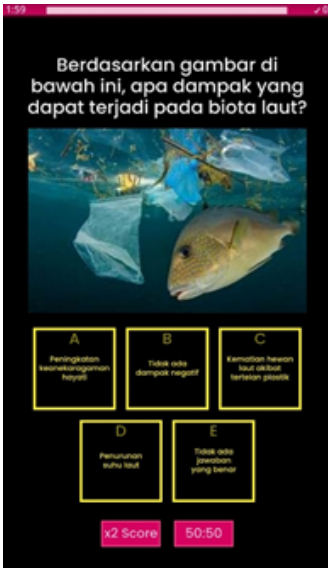

Figure 4. Display of E-Module Quiz Designed with Gameshow Format

Effectiveness of SSI-Based E-Modules

The effectiveness test was carried out to see how effective the SSI-based e-module with the PBL model on the ecosystem concept was in improving critical thinking skills. E-modules were distributed to the experimental class to study independently. During learning in the control class and experimental class the teacher reviews the material in general and relates it to environmental issues that occur around the school and Cirebon regarding the causes, impacts, and efforts or solutions to overcome the impact of the problems that occur. The learning process is carried out using the Problem-Based Learning method which con-

sists of an introductory stage, followed by core activities, and ending with a closing stage.

According to Minarti et al. (2023), PBL involves a series of steps in core learning that focuses on problem-solving. The stages are as follows: 1) problem identification, namely students are introduced to real problems that are difficult and relevant to the subjects being studied, which is the starting point for implementing PBL; 2) research and analysis, at this stage students carry out independent studies to understand problems, collect data and analyze related variables; 3) cooperation, students work together to share information, discuss and create new solutions collaboratively; 4) problem-solving, students formulate and apply solutions resulting from critical thinking about the situations encountered; 5) reflection, namely the phase where students reflect on their learning, evaluate the advantages and disadvantages of the solutions found, and ask new questions to deepen their understanding.

The effectiveness test was carried out by looking at the comparison between the pre-test and post-test scores of the experimental class using the Paired Sample t-Test with the help of SPSS 23. The effectiveness test of the SSI-based e-module with the PBL model on the ecosystem concept began by carrying out a descriptive analysis first. The results of descriptive analysis on the critical thinking variable can be seen in Table 1.

Table 1. Recapitulation of Descriptive Analysis

Class		Min. Value	Max. Value	Mean
X-7 (Control 1)	Pretest	25	95	58.88
	Posttest	45	100	71.67
X-8 (Control 2)	Pretest	40	90	70.33
	Posttest	65	100	77.83
X-9 (Experiment 1)	Pretest	25	95	67.71
	Posttest	45	100	81.77
X-12 (Experiment 2)	Pretest	35	80	38.77
	Posttest	40	100	70.61

Based on Table 1 regarding the recapitulation of the results of descriptive analysis on critical thinking variables in the pretest class X-7 (control class) minimum value of 25, maximum value of 95 and average value of 58.88 then after learning there was an increase in learning outcomes which can be seen from the posttest score, namely the minimum value of 45, the maximum value of 100 and the average value of 71.67. In the X-8 pretest (control class) a minimum score of 40 was obtained, a maximum score of 90 with an average value of 70.33 and in the posttest results there was an increase, namely a minimum score of 65, a maximum value of 100 and an average value of 77.83. In the X-9 pretest (experimental class) a minimum score of 25 was obtained, a maximum score of 95 with an average score of 67.71 and in the posttest results there was an increase, namely a minimum value of 45, a maximum value of 100 and an average value of 81.77. In the X-12 pretest (experimental class) a minimum score of 35 was obtained, a maximum score of 80 with an average score of 38.77 and in the posttest results there was an increase, namely a minimum score of 40, a maximum value of 100 and an average score of 70.61. Based on the results of the pretest and posttest in both the control class and the experimental class, both experienced an increase but a significant increase occurred in the experimental class which can be seen from the difference in the results of the pretest and posttest scores. The next step is followed by an equivalence test in the form of a normality test and a homogeneity test.

Table 2. Recapitulation of Normality Test

Class		Sig.	Information
X-7 (Control 1)	Pretest	0.07	Normally distributed
	Posttest	0.2	Normally distributed
X-8 (Control 2)	Pretest	0.06	Normally distributed
	Posttest	0.08	Normally distributed
X-9 (Experiment 1)	Pretest	0.05	Normally distributed
	Posttest	0.07	Normally distributed
X-12 (Experiment 2)	Pretest	0.2	Normally distributed
	Posttest	0.2	Normally distributed

Table 2 shows the normality test calculation data on the critical thinking variable using SPSS 23. The results of the sig value for both the pretest and posttest in the control class and experimental class are >0.05 which indicates that the data is normally distributed.

Table 3. Recapitulation of Homogeneity Test

Variable	Sig.	Information
X-7 (Control)	0.13	Homogeneous
X-8 (Control)	0.33	Homogeneous
X-9 (Experiment)	0.73	Homogeneous
X-12 (Experiment)	0.11	Homogeneous

Based on Table 3 it can be seen that the sig value in class X-7 as a control class is 0.13 which means homogeneous data, class X-8 as the second control class is 0.33 so the data is said to be homogeneous. In addition, class X-9 as an experimental class obtained a sig value of 0.73 and class X-12 as the second experimental class of 0.11 so it can be said that both experimental classes also have homogeneous data. The data is said to be homogeneous if the sig value > 0.05.

t-Test

After the data is said to be normally distributed and homogeneous, the next step is the Paired t-test to determine the level of effectiveness of the SSI-based e-module after being implemented in the experimental class, which will then be compared with the control class which only uses regular printed books. The results of the t-test on the critical thinking variable can be seen in Table 4.

The t-test results obtained in all classes were, namely both the control class and the experimental class, showed a value of 0.00 < 0.05, which means there was a significant incease between the pretest and posttest results.

Table 4. Recapitulation of t-test

Variable	Sig.	Information
X-7 (Control)	0.00	Significant
X-8 (Control)	0.00	Significant
X-9 (Experiment)	0.00	Significant
X-12 (Experiment)	0.00	Significant

N-Gain Test

After the t-test, the next step is to calculate the N-Gain score to determine the increase in learning outcomes in the control class and experimental class. The red line in Figure 6 shows the increase in the N-Gain score in the medium category. Based on this figure, it can be seen that in the experimental class, namely class X-9 and X-12, the N-Gain value for each indicator is more than >0.3, while in the control class, namely class The integration value of N-Gain is <0.3 which means it is in the low category. Apart from that, in control class 2, namely X-8, the advanced clarification indicator determines the conclusion that the N-Gain value is <3 in the low category. The results of the N-Gain score analysis show that for each indicator, the experimental class has a higher N-gain value than the control class, so it can be said that the use of SSI-based e-modules with the PBL model on the ecosystem concept can improve critical thinking abilities learners. The complete N-Gain calculation results can be seen in Figure 5.

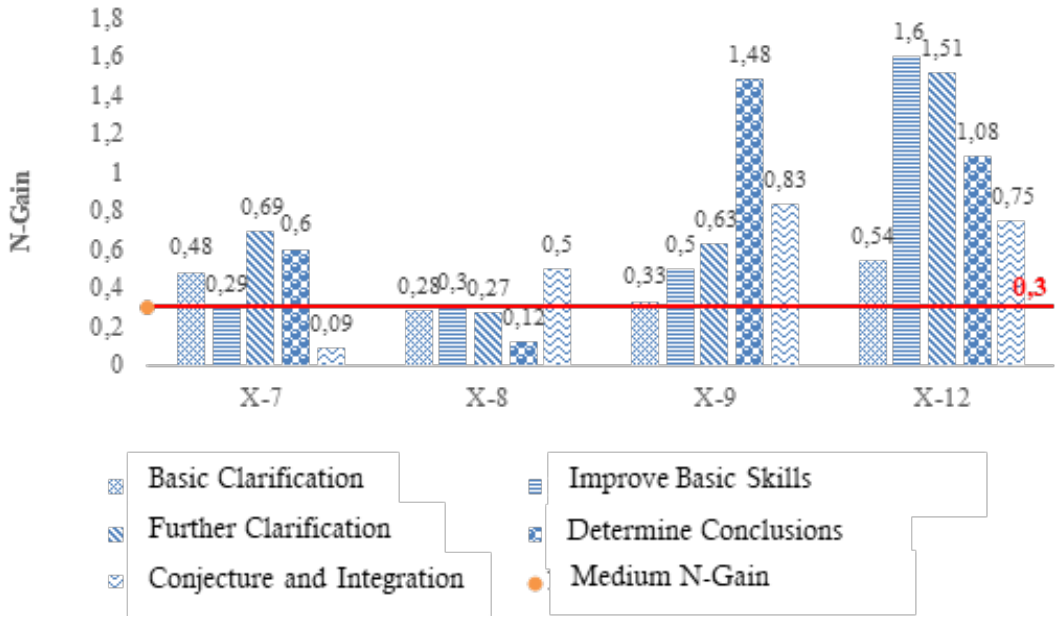

Figure 5. N-Gain Value For Each Indicator Critical Thinking

The e-module content is structured based on tasks that require students to analyze data and solve problems to develop their critical thinking skills. According to Wijayanti's research (2019) critical thinking skills are the ability to extract information from difficulties clearly, logically, and concisely. Based on the data that has been described, it can be concluded that the use of SSI-based e-modules with the PBL model on the ecosystem concept is feasible and effective for use in the learning process and can improve the critical thinking skills of the class. This is by the statement from (Retnaningsih, 2019), that students who use critical thinking are better able to make decisions and draw conclusions from various information and points of view (Rizaldi & Mawardi, 2021).

Based on the data that has been described, it can be concluded that the use of SSI-based e-modules with the PBL model on the ecosystem concept is feasible and effective for use in the learning process and can improve the critical thinking abilities of class X students in ecosystem material. This proves that SSI-based learning media will easily foster critical thinking about the concepts or material presented. Seamolec (2013) explained that the function of e-modules in the learning process is as a medium that can increase learning productivity and as a tool to help teachers make learning time more effective and efficient. This is in line with research conducted by Aprilia (2021) which states that a learning model based on contextual problems in the environment can improve student's critical thinking abilities. Rosyidah & Subekti (2023) added that in learning Socio-scientific Issues (SSI), critical thinking plays an important role in describing and identifying aspects of science. Critical thinking skills will help critically examine information based on various sources used to explain socio-scientific problems, including SSI information that needs to be clarified.

Muzijah et al. (2020) state that inquiry-based teaching materials can improve student's critical thinking abilities. This activity takes the form of the syntax of the inquiry learning model, namely solving problems, formulating hypotheses, collecting data, testing hypotheses, and concluding. Students are presented with problems related to the material. Through this activity students gain knowledge about the material being taught. Besides that Anjarsari et al. (2023) add that activity in inquiry syntax can improve student's critical thinking abilities. This study's findings are consistent with prior studies showing that problem-based learning can enhance critical thinking abilities (Adhelacahya et al, 2023).Student's critical thinking abilities on basic clarification indicators show that students can provide opinions from cases or information that occurs in ecosystem material. This is possible for several reasons, namely (1) because students can understand the explanations contained in inquiry-based e-modules, (2) by studying the literature contained in the e-modules provided, this allows students to express their thoughts in answering problems. given from various points of view, (3) the inquiry process contained in the e-module shows that the learning provided can train students in giving arguments.

CONCLUSION

E-modules that integrate socio-scientific issues with problem-based learning models are effective to improve critical thinking. The results of the e-module effectiveness test in the experimental class obtained significant results compared to the control class to improve critical thinking, especially in the indicators of concluding as well as conjecture and integration.

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