



Developing E-Modules Based of SSI the Theme of Biodiversity to Enhance Students' Critical Thinking Skills Abilities

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Abstract: Critical thinking skills are one of the important skills to be applied in science learning. Critical thinking skills refer to students abilities to analyze complex issues, investigate questions that lack clear answers, evaluate various perspectives from information sources, and draw accurate conclusions. Several previous studies have shown that students' critical thinking skills in Indonesia are still relatively low and need to be improved. One approach is to use e-modules based SSI (socio scientific issues on the topic of biodiversity). E-modules are electronic teaching materials containing learning materials that students can use independently. Socio-scientific issues are social problems related to science. Biodiversity is one of the topics taught in junior high school science. E-modules based SSI on the theme biodiversity is an electronic module that presents social science issues related to the theme of biodiversity which is able to train students' critical thinking skills. This study aims are (1) to determine eligibility of e-modules based SSI on the topic biodiversity for improving the students critical thinking skills and to determine; (2) to determine the level of practicality of the e-modules based SSI on the topic biodiversity for improving the students critical thinking skills; and (3) to determine the effectiveness of e-modules based SSI on the topic biodiversity for improving the students critical thinking skills. The research employed a development method using the ADDIE development model are Analysis, Design, Development, Implementation, and Evaluation. The developed e-modules has been validated by experts and field testing in junior high school students in Magelang city. Based on the validator's assessment, the total score from four validator was 15.71 with an average score of 3.92, indicating that the developed e-module based SSI is good and suitable for use in science learning. Then, from the results of the student response questionnaire, the overall average score for the material, language, presentation, and graphics aspects was 4.133 with a good category, so that e-module based SSI is suitable for use in science learning. Based on the result of the paired sample t-test with a Sig. $0.000 < 0.05$ and an N-gain value of 0.34, categorized as currently, so that the e-module is effective in improving critical thinking skills. The conclusion of this study is that the developing e-module is suitable, deemed practical, effective for use science learning in junior high school.

Keywords: Biodiversity; Critical thinking skills; E-module; SSI

Introduction

Critical thinking skills include other higher order thinking skills can have a positive impact such as engaging students into open mindness, critical thinker,

always evaluating incoming information, and always being skeptical (Costa, 1988; Erickson et al., 2017; Jhonson, 2002). Critical thinking skills and scientific attitudes are essential components that need to be mastered by students (Fitriani et al., 2020). Critical

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thinking skills are one of the important skills to be applied in science learning, because they can support quality learning activities (Pujiasih, 2020).

Critical thinking skills refer to students' abilities to analyze complex issues, investigate questions that do not have clear answers, evaluate various perspectives on information sources, and draw accurate conclusions (Ennis, 2018). Critical thinking skills can solve problems logically, provide clear answers to questions, and come to reasoned conclusions about what to do or believe; critical thinking abilities are necessary (Hidayati et al., 2021). Critical thinking skills are one of the skills needed by individuals to overcome various problems they face, both in social and individual life (Riezandi et al., 2022). Beside that critical thinking can make students intelligent in thinking about the environment around them (Arifah et al., 2021; Doyan et al., 2022; Kartini et al., 2019).

Based on the research results of Kamsinah et al. (2020) stated that critical thinking skills in science learning are still very low. One of the causes is that learning activities do not provide facilities for students to develop critical thinking skills. One way that can be done to improve students' critical thinking skills is learning by using e-module based of SSI (socio scientific issues). Modules are teaching materials that contain learning materials that students can use independently (Daryanto, 2013). There are two types of modules commonly used in learning, namely printed modules and electronic modules (e-modules).

The difference between the two modules lies in their physical presentation. Where printed modules require paper in their presentation, while electronic modules require technological devices to run them, so that they can increase the effectiveness and efficiency of the module as a learning medium (Putri et al., 2023). Socio scientific issues are social problems that are related to science, namely connecting social events in the surrounding environment with scientific concepts (Alfiriani et al., 2017).

Socio scientific issues include social problems that are currently in the spotlight of society and challenges in the realm of scientific knowledge (Maulidiawati et al., 2023). SSI are social issues that reap pros and cons and are related to science, which by applying them in learning can trigger students to be active in conducting discussions (Rahayu, 2019). Where socio scientific issues related to the theme of biodiversity include climate change and environmental sustainability, so that they can encourage students to think critically in analyzing the impacts of various human actions (Subiantoro et al., 2013). Biodiversity in junior high school science learning is one of the materials that has an important part in the junior high school science curriculum.

The biodiversity in Indonesia has so many types of plants along with a very broad ecosystem, making this position very important and strategic as a center of world biodiversity. This is proven by a number of 29.375 species of vascular plants or about 7.7% of the world's species population and animal biodiversity including 670 species of mammals or about 10.5% of the world's species population, 4.782 species of fish or about 1.2% of the world's species population, 1.711 species of birds or about 15.5% of the world's population, 755 species of reptiles or about 6.7% of the world's population, and 365 species of amphibians or about 4.6% of the world's population (Hartanto et al., 2025; Kusumasari et al., 2024).

This biodiversity can provide versatile benefits as well as vital and strategic benefits, as basic capital in national development and is the lungs of the world that are absolutely needed now and the future (Anggraini, 2018). On the other hand, with the changing function of forests as fields, gardens or residences, it also reduces the amount of biodiversity in Indonesia. In line with the research of Laksono et al. (2022), it shows that the development of SSI-based teaching materials can improve Higher Order Thinking Skills (HOTS). In this study, one of the high-level abilities measured is critical thinking skills.

Method

The method in this research is development research referring to ADDIE (Analyze, Design, Develop, Implementation, Evaluation) development model. The ADDIE development model is appropriate to use because it represents the development stages systematically and can produce an effective and efficient product (Pribadi, 2016).

Development Stage

The details of the development stages are as follows:

Analyze

At this stage, an initial research study is carried out which includes identifying problems in the field, literature studies, and initial surveys.

Design

At this stage, the e-module is designed, including the preparation of an outline and the determination of the e-module's structure. The selection of an e-module outline is based on several factors, including learning objectives, student characteristics, and the nature of the material. The designed outline is as follows: (a) Cover: Contains the title and author; (b) Foreword: Contains thanks to God, a brief explanation of the purpose and

content of the work, thanks to those who helped, and a request for criticism and suggestions; (c) Table of Contents; (d) List of Figures; (e) Module Usage Instructions: Instructions for students on how to use the module; (f) Learning Steps in Student Activities: Contains procedures for using the module; (g) Mind Map: Contains concepts connected by lines or arrows to show relationships between ideas; (h) Materials: Contains material on biodiversity, student activities (observing and analyzing videos related to the material, analyzing SSI-based cases related to the material); (i) Self-Evaluation: Contains practice questions related to the material (Widoyoko, 2016); (j) Bibliography: Includes complete information about reference sources, such as author's name, year of publication, title, city, and publisher. The e-module's structure includes: General Information and Core Components.

Develop

At this stage, reference studies related to the material to be developed, e-module draft writing, editing, and revisions were conducted. During the editing stage, the developed e-module was assessed by expert validators, and then revisions were made based on input and suggestions from the validators. Four validators assessed the e-module: three science lecturers and one junior high school science teacher. The three science lecturers are indeed experts in the field of science, with a Bachelor's and Master's degree in Science Education, while the science teacher is a junior high school science teacher with a Bachelor's degree in Biology Education, Master's degree in Science Education, and PPG in Science Education.

Implementation

The developed e-module was implemented on a limited basis in the two schools used as research samples: SMP Negeri 11 Magelang and SMP Negeri 13 Magelang. During the implementation phase, a pretest was conducted before students began learning using the e-module to measure their initial critical thinking skills. A posttest was then conducted at the end of the lesson or after students had learned to use the e-module. The implementation time for the e-module was carried out in 5 meetings, with the details of the first meeting starting with a pretest, then learning with the e-module until the 4th meeting, then at the 5th meeting a posttest was carried out.

Evaluation

Evaluation is carried out at all stages of e-module development (Analyze, Design, Develop, Implementation, and Evaluation).

Research Subject

The subjects of this study were students from public junior high schools in Magelang City, Central Java, as the location for the limited trial. The sample used was students from SMP N 11 Magelang and SMP N 13 Magelang. The sampling technique used purposive sampling, namely a sampling technique based on certain criteria. The criteria used are that students from both schools have the same initial level of ability.

Research Instrument

The research instruments used were tests and questionnaires. The test instrument consisted of descriptive questions to measure students' critical thinking skills, while the questionnaire instrument consisted of an expert validation sheet to assess the suitability of the module and a student response questionnaire to measure the practicality of the developed module.

Data Analysis Techniques

The data analysis techniques used include:

E-Module Feasibility Analysis

Data from the validator's assessment of the e-module was analyzed using power analysis techniques by converting the qualitative data into a five-point scale as follows: tabulate the obtained data and calculate the average score using the formula:

$$\bar{X} = \frac{\sum x}{n} \tag{1}$$

Description:

\bar{X} = average score for each sub-component

$\sum X$ = total score for each sub-component

n = number of assessors

The average score obtained is then converted into qualitative data on a five-point scale. The e-module is considered suitable for use if the minimum score obtained is sufficient. The following assessment criteria according to the conversion are presented in Table 1.

Table 1. Conversion of Actual Scores to a Five-Point Scale

Score Range	Score	Category
$x > X + 1.8 \text{ sbi}$	A	Very Good
$X + 0.6 \text{ sbi} < x \leq X + 1.8 \text{ sbi}$	B	Good
$X - 0.6 \text{ sbi} < x \leq X + 0.6 \text{ sbi}$	C	Fairly Good
$X - 1.8 \text{ sbi} < x \leq X - 0.6 \text{ sbi}$	D	Not Good
$x \leq X - 1.8 \text{ sbi}$	E	Very Bad

Description:

x = actual score (score achieved)

X = ideal average = $\frac{1}{2}$ (ideal maximum score + ideal minimum score)
 s_{bi} = ideal standard deviation = $\frac{1}{6}$ (ideal maximum score - ideal minimum score)

Testing the Validity of the Expert Validation Sheet Questionnaire Results

Test the validity of the expert validation sheet questionnaire results using Aiken's V (Azwar, 2012).

$$V = \frac{\sum(r_i - l_o)}{n(c-1)} \tag{2}$$

Description:

r = number given by the assessor
 l_o = lowest validation assessment number
 n = number of experts/practitioners conducting the assessment
 c = highest validation assessment number
 i = integer from 1, 2, 3 to n

The V range obtained is between 0 and 1.00. An item is declared valid if it has a V value of more than or equal to 0.05 (Hake, 1999).

Validity Test of Critical Thinking Question Instruments

Testing the validity of questions is the process of testing question instruments to determine the validity of pretest and posttest questions and to determine the ability of questions to evaluate what should be evaluated (Khairiati, 2022).

Testing the Effectiveness of E-Modules in Improving Students' Critical Thinking Skills

Normality Test

To determine whether the data obtained is normally distributed, this normality test uses student test results. The normality test was conducted using SPSS using the Kolmogorov-Smirnov test. The normality test was conducted using SPSS software. The margin of error in this study was 5%, or $\alpha = 0.05$. The basis for making decisions in this normality test is as follows: (a) If the significance value is >0.05 , the data can be declared normally distributed. (b) If the significance value is <0.05 , the data can be declared non-normally distributed.

Homogeneity Test

A homogeneity test was conducted as a prerequisite for the difference test. The data in this analysis consisted of pre-test and post-test results. The purpose of this homogeneity test was to determine whether the pre-test and post-test data had equal variances. The homogeneity test method used was Levene's test. The homogeneity test was conducted using SPSS software. The degree of error in this analysis

was 5%, or $\alpha = 0.05$. Therefore, the basis for decision-making can be stated as follows: (a) If the significance value is > 0.05 , the data can be declared homogeneous. (b) If the significance value is < 0.05 , the data can be declared inhomogeneous.

Paired Sample T-test

To determine the effectiveness of e-module use on students' critical thinking skills, a paired sample t-test data analysis was used. The paired sample t-test is a parametric test to determine the difference in means between two paired samples (Sugiyono, 2019). Decision-making in the paired t-test is based on the results of the significance test. If the significance value is <0.05 , H_a is accepted and H_o is rejected. Conversely, if the significance value is >0.05 , H_a is rejected and H_o is accepted.

N-Gain Test

The effectiveness of the e-modules was determined based on students' pretest and posttest scores during a limited-scale trial. The pretest and posttest data were then analyzed to determine the significance of the improvements using the N-Gain formula.

$$N - gain = \frac{posttest\ score - pretest\ score}{maximum\ score - minimum\ score} \tag{3}$$

Next, the calculation results are classified according to the N-Gain category in the following table.

Table 2. N-Gain Category Classification (Archambault, 2008)

N-Gain Score	Category
$G \geq 0.70$	High
$0.30 \leq G < 0.70$	Medium
$G < 0.30$	Low

Practicality Test for E-Module Use

Data from the results of filling in the student response questionnaire to the e-module were analyzed using power analysis techniques, converting the qualitative data into a five-point scale as follows: tabulate the data obtained and calculate the average score using the formula:

$$\bar{X} = \frac{\sum x}{n} \tag{4}$$

Description:

X = average score for each sub-component
 $\sum X$ = total score for each sub-component
 n = number of assessors

The average score obtained is then converted into qualitative data on a five-point scale. The e-module is

considered suitable for use if the minimum score obtained is sufficient. The following assessment criteria according to the conversion are presented in Table 3.

Table 3. Conversion of Actual Scores to a Five-Point Scale

Score Range	Score	Category
$x > X + 1.8 \text{ sbi}$	A	Very Good
$X + 0.6 \text{ sbi} < x \leq X + 1.8 \text{ sbi}$	B	Good
$X - 0.6 \text{ sbi} < x \leq X + 0.6 \text{ sbi}$	C	Fairly Good
$X - 1.8 \text{ sbi} < x \leq X - 0.6 \text{ sbi}$	D	Not Good
$x \leq X - 1.8 \text{ sbi}$	E	Very Bad

Description:

x = actual score (score achieved)

X = ideal average = $\frac{1}{2}$ (ideal maximum score + ideal minimum score)

sbi = ideal standard deviation = $\frac{1}{6}$ (ideal maximum score - ideal minimum score)

Result and Discussion

Based on the research results, data was obtained from the validity test results for the content of the critical thinking ability instrument as shown in Table 4.

Table 4. Results of the Content Validity Test of the Critical Thinking Ability Question Instrument for Students

Number of Question	Number of Validator	Average Value of V Count	Significan-ce Level	Value of V Table	Category
7	4	0.85	5%	0.76	Valid

Based on the validator's assessment of the material and media, the developed e-module was declared suitable for use in research. The validators in this study were three science lecturers and one junior high school

science teacher. Validation was conducted to determine the quality of the developed e-module before its use in research. The results of the validator's assessment of the e-module can be seen in Table 5.

Table 5. Validator Assessment Results

Aspect	Score			
	Validator I	Validator II	Validator III	Validator IV
Content Suitability	48	49	38	41
Linguistic Suitability	31	34	32	29
Presentation Suitability	18	20	20	20
Graphic Suitability	41	42	33	38
Total Score	138	145	123	128
Average Score	4.18	4.39	3.27	3.87
Assessment Criteria	Very Good	Very Good	Good	Good

Based on the data in Table 5, it can be concluded that the total score from the four validators was 15.71, with an average score of 3.92, thus declaring the e-module good or feasible. After the e-module was validated and revised, a limited trial was conducted on students of SMP Negeri 11 Magelang and SMP Negeri 13 Magelang. Furthermore, the e-module was also tested

for its practicality. The practicality of the e-module was tested using a student response questionnaire. Students' assessments of the e-module included aspects of material, language, presentation, and graphics. The results of the student response questionnaire analysis of the e-module are presented in Table 6.

Table 6. Results of the Practicality Analysis of the E-module

Aspect	Item	Average Score Per Item	Description
Material	Item 1	4.083	Good
	Item 2	4.41	Very Good
	Item 3	3.75	Good
	Item 4	4.375	Very Good
	Item 5	3.875	Good
Language	Item 8	4.25	Very Good
	Item 9	4.208	Good
	Item 10	4	Good
Presentation	Item 7	4.333	Very Good
Graphics	Item 6	4.041	Good
Average			4.133
Description			Good

Based on Table 6, it can be concluded that the overall average score for the material, language, presentation, and graphics aspects was 4.133, categorized as good. This indicates that the e-module is suitable for use in science learning.

The next data analysis was to test the effectiveness of the e-module in improving students' critical thinking skills using paired sample t-test dan N-Gain. Before

conducting the paired sample t-test and N-gain test, normality and homogeneity tests were conducted. Based on the results of the normality and homogeneity tests, it was shown that the data were normally distributed with score 0.13 and homogeneous with score 0.86, so that the paired sample t-test and N-gain could be conducted. The results of the paired sample t-test can be seen in Table 7.

Table 7. Results of the Paired Sample T-test

	Mean	Std Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1 Pretest - Posttest	-	5.73773	.79568	-	-	-	51	.000
	21.50000			23.09739	19.90261	27.021		

Table 7 shows that the paired sample t-test results show a Sig. value of $0.000 < 0.05$, meaning there is a significant difference between the pretest and posttest data. Next, an N-gain test was conducted. The results of the N-gain test can be seen in Table 8.

Table 8. Results of the N-Gain Test of Students' Critical Thinking Skills

N-Gain Score	Category
$0.30 \leq 0.34 < 0.70$	Currently

Based on the data in the table above, it is known that the N-gain value is 0.34 in the medium category, meaning that the e-module developed can improve students' critical thinking skills. This is also in line with the research results of Utami et al. (2023) which states that learning using SSI-based e-modules can improve students' critical thinking skills in the high category with an average N-Gain score of critical thinking skills of 0.78. The difference in N-gain values from the research conducted with other studies reflects the complexity of implementing the SSI approach and is influenced by various contextual factors.

Based on the results of the paired sample t-test and N-gain test, it was found that the developed SSI-based e-module was effective in improving students' critical thinking skills. This is in line with research by Suastrawan et al. (2021), which demonstrated that improving students' critical thinking skills can be influenced by the implementation of a science e-module using the Process Oriented Guided Inquiry Learning (POGIL) model based on social science issues or SSI. Furthermore, each component of the learning activity in the SSI-based e-module on biodiversity can train students' critical thinking skills and make learning more meaningful by presenting scientific issues related to the material being discussed. This aligns with the research findings of Taufik et al. (2023), which revealed that the presence of a Socio-Scientific Issues (SSI) context in science learning is more meaningful because the material being studied is discussed simultaneously with

issues in everyday life (Febriana et al., 2023). Teaching material based SSI using dilemmatic social issues related to science, including images, materials, and learning activities, can make the learning environment more engaging for students (Akram et al., 2023; Ma'rufah et al., 2021). In addition, the uses of a socio-scientific issues approach as a learning stage and teaching material framework makes it easy for students to understand the teaching material, can improve students' argumentation skills and ability to think critically in dealing with related issues (Pratiwi et al., 2021; Putriana, 2020; Rostikawati et al., 2016). In addition, in research conducted by Sismawarni et al. (2020), it was revealed that the use of a socio-scientific issue-based approach in science learning can stimulate students to think critically, because they are faced with social problems related to science, such as environmental and health issues. Rubini et al. (2019) research result show that the module is very effective to use as a supporting material in order to enhance critical thinking skills, based on the students' response, the media was very helpful to student to learn science as well as to enhance the skill in how to practice IT.

Conclusion

Based on the results and discussion, it can be concluded that: The SSI-based e-module on the theme of biodiversity is suitable for use in science learning. This is demonstrated by the validator score of 3.92, categorized as valid or feasible. The SSI-based e-module on the theme of biodiversity is deemed practical to use. Based on the practicality questionnaire analysis data, it scored 4.133, categorized as good. The SSI-based e-module on the theme of biodiversity is deemed effective in improving students' critical thinking skills. This is evidenced by the paired sample t-test with a Sig. $0.000 < 0.05$ and an N-gain value of 0.34, categorized as currently.

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Author Contributions

Nuryunita Dewantari and Laura Ardiyani Rohmah Cahyani: writing-original draft preparation, result, discussion, methodology, conclusion, review, and editing; Zuida Ratih Hendrastuti and Nurul Rahmawati: analysis, review and editing.

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Conflicts of Interest

The author declares that there is no conflict of interest regarding the publication of this article.

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