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How does the SETS Model Work Through E-Modules to Enhance Students' Critical Thinking Skills? Effectiveness Level of Instructional Materials

Septania Pratiwi[1*], Jaridatul Muniroh[1], Zuhdan Kun Prasetyo[1], Jumadi Jumadi[1], Insih Wilujeng[1]

[1]Department of Science Education, Faculty of Mathematics and Natural Sciences, Yogyakarta State University, Indonesia.

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Corresponding Author:
Septania Pratiwi
septaniapratiwi.2021@student.uny.ac.id

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Abstract: Critical thinking skills are 21st century skills that can be improved through the use of appropriate learning models and supported by the prior knowledge that students already have. One of the learning models that can improve critical thinking skills is the SET learning model through the Science E-Module. The purpose of this study was to show the effectiveness of the application of SETS-based e-modules in Natural Science (IPA) subjects with the topic of waves and sound to improve students' critical thinking skills. This study used a quantitative descriptive design with one-group pretest-posttest technique. The sample consisted of 29 students from class VIII.C who were selected through cluster sampling. Data were analyzed using the normalized N-gain method and paired sample t-test. The results showed that the average N-gain of students' critical thinking skills after implementing learning through SETS-based science e-modules on wave and sound material was 0.4, including in the medium category. The average critical thinking skills of students after the intervention (72) were significantly higher than before the intervention (51). In addition, students' response to the SETS-based science e-module on wave and sound material resulted in a score of 90.4% which showed very good criteria. Therefore, it can be concluded that the implementation of SETS-based science on wave and sound materials can improve students' critical thinking skills.

Keywords: Critical thinking skills; SETS model; Science e-module.

Introduction

Education is one of the widely discussed topics across different segments of society, from the general public to the government. In general, the quality of education is considered the most important factor in learning (Rohman et al., 2018). Furthermore, education fundamentally concerns the intelligence of the nation, which is one of the objectives outlined in the opening of the 1945 Constitution. The intelligence of the nation can be realized through the advancement of human resources (HR) in the field of education. There are many challenges that society must face in the field of education, such as the rapid development of science and technology, which easily permeates all aspects of life. Currently, there is no human activity that is not related to technology, especially in the realm of education.

The main factors that contribute to a nation's competitiveness are innovation and technological proficiency. Students are not only provided with the necessary tools to foster creativity and innovation; educators are also expected to have higher levels of creativity and innovation in their teaching practices. For instance, by developing instructional media that create a comfortable learning environment for students and promote independent learning, educators can broaden students' perspectives. The role of media is pivotal within the realm of education, functioning as a vital

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channel for communication between instructors and learners (Dwi Nurfarida et al., 2021). By leveraging current technological advancements, learning resources are not limited to internet-based sources alone.

The 21st century is characterized by globalization, which brings about transformations in various facets of life due to technological advancements (Khasanah & Herina, 2019). The demands of the world on the education system are to better prepare students for the competencies of the 21st century, enabling them to face the increasingly complex challenges of the present and future. These competencies encompass knowledge, skills, and other attributes that assist students in reaching their full potential (Mardhiyah et al., 2021). Therefore, the learning system in the 21st century is no longer teacher-centered but student-centered. The aim is to provide students with skills in critical thinking and learning proficiency in the 21st century.

"The 4C Skills," formulated by the Framework Partnership of 21st Century Skills, include: (1) Communication, this skills involve the ability to convey ideas and information effectively through a variety of communication channels and styles; (2) Collaboration, this skills emphasize the importance of working together in a team, sharing knowledge and contributing to the group; (3) Critical Thinking and Problem Solving, this skill involves the ability to analyze information in depth, evaluate different arguments and evidence, and develop sound judgment; and (4) Creative and Innovative Thinking, this skills involve the ability to think outside the box, develop new ideas, and create innovative solutions (Makaramani, 2015; Cynthia et al., 2023).

Muhali (2019) explain that to face learning in the 21st century, individuals must possess critical thinking skills, digital literacy knowledge and abilities, information literacy, media literacy, and mastery of information and communication technology. As per the findings of Facione et al. (1996), having a critical thinking disposition involves possessing a persistent internal drive to engage with challenges and arrive at decisions. This concept aligns with the assertion by Facione & Giancarlo (2013) that individuals demonstrating a robust inclination for critical thinking possess a steady internal motivation to tackle issues and make decisions by applying critical thinking skills.

Critical thinking skills, also known as critical thinking, are among the competencies specified in the 2013 curriculum that students need to acquire in order to effectively tackle various challenges in the 21st century (Putri et al., 2023). Critical thinking plays a crucial role in the field of education and is a primary goal in learning, as it enables students to not only master the content of each subject but also apply it in everyday life. However, despite the advancement of education, it does not necessarily mean that the science proficiency of Indonesia ranks high globally. Based on the results of the 2015 PISA report, Indonesia's science proficiency ranked 69th out of 76 countries (Kemendikbud, 2016). According to Purwanto in (Fitriani & Sari, 2019), low science proficiency is influenced by two factors: internal factors, including students' cognitive abilities, and external factors, such as limited resources for students due to Indonesia's vast territory, which includes areas that are difficult to access.

Additional discoveries made by Lombardi & Mednick et al. (2022) indicate that during the educational journey, learners do not receive adequate support in comprehending, analyzing, and engaging in thoughtful contemplation of information, as educators themselves possess insufficiencies in terms of their expertise, educational background, and preparation for nurturing students' abilities in critical thinking. Moreover, students have not fully acquired proficiency in activities such as scrutinizing, engaging in complex problem-solving, and demonstrating sound decision-making skills (Zulyusri et al., 2023).

Learning resources refer to the tools and equipment directly used and support the educational process, including the use of instructional materials. Students' critical thinking abilities in learning can be influenced by instructional materials, as materials that fail to engage students actively in the learning process can result in limited development of critical thinking skills (Triandini & Wayan Gunada, 2021).

Ministerial Regulation Number 81A of 2013 concerning the implementation of the curriculum signifies a shift from a teacher-centered learning approach to a student-centered approach, where the teacher assumes the role of a facilitator. The previous one-way pattern of interaction between teachers and students has transformed into interactive learning involving the teacher, students, community, natural environment, and other sources or media. However, in its implementation at schools, teachers have not been able to fully utilize this approach effectively, and the instructional media used are still limited. Therefore, a new innovation in instructional media is needed at present. One way to address this is for teachers to leverage technology in science education, such as creating electronic modules or e-modules.

E-modules refer to self-contained educational resources delivered in digital form, designed to enhance user accessibility and convenience. These digital modules are a product of ICT-driven advancements and present distinct benefits when compared to traditional print-based materials. E-modules possess the capability to infuse the learning experience with greater engagement and interactivity (Andriani, 2021). They

excel in capturing historical narratives via multimedia elements like images and videos, thus stimulating a dee per understanding. Furthermore, these modules foster active student participation through interactive components, contributing to the refinement of auditory acumen and facilitating improved comprehension of the presented content (Cynthia et al., 2023).

In the development of electronic modules, an integrated learning model needs to be employed to provide a more focused, structured, and systematic approach. An appropriate approach for the topic of waves and sound is the Science, Environment, Technology, and Society (SETS) based learning model. SETS learning is an effective approach for exploring the interconnections between science, environment, technology, society, and critical thinking skills (Ningsih et al., 2020). The characteristics of the Science, Environment, Technology, and Society (SETS) approach in science education include the following: (a) aims to provide contextual science learning; (b) guides students to utilize scientific concepts in technology for the benefit of society; (c) encourages students to think about various possible consequences that occur during the transfer of scientific concepts to technological forms; (d) prompts students to explain the relationship between the elements of science concepts, particularly waves and sound, with the SETS elements that influence various interrelationships among those elements (Fatimah & Serevina, 2020).

Based on the results of observations made while studying science, it was found that teaching materials were still focused on science books from the government, learning models were less diverse and student responses were sometimes monotonous. On the other hand, the researcher also interviewed with one of the science teachers at the school, the result was that teaching materials at school were still lacking and not yet integrated with models because most of them only relied on books from the government, using the same methods and models such as lectures and discovery learning to make students' abilities students' cognitive abilities in terms of critical thinking skills are still low. This is known from the lack of students' ability to distinguish vibrations and waves and their relationship with sound.

Based on this statement, efforts are needed to improve student's critical thinking skills by developing teaching materials based on the SETS model. Khidayatullah & Yelianti (2019) revealed that modules can improve critical thinking skills because students can learn independently which allows students to increase student activity according to their respective abilities and progress. One form of presenting learning materials in digital or electronic formats is e-modules. Electronic modules or commonly known as e-modules are displays of information or manuscripts in book format that are recorded electronically using data storage media and can be opened and read using a computer or an electronic book reader (e-modules viewer or e-book) (Latifah et al., 2020). Based on the explanation above, one of the efforts to improve student's critical thinking skills can be done by developing SETS-based Science e-modules.

Method

This type of research uses descriptive quantitative method with pre-experimental research design through one group pretest posttest research design. The population of this study was all class VIII at SMPN 2 Depok Yogyakarta. The sampling technique was carried out by cluster sampling and class VIII.C was obtained. The selected class is class VIII.C which consists of 29 students. The instrument used in this study was a student critical thinking skills test sheet, which consisted of 10 multiple-choice questions and a student response questionnaire.

The research sample will be given a pretest and posttest in the form of 10 multiple choice questions on wave and sound material based on four indicators of critical thinking skills according to Facione (2013), namely interpretation, analysis, evaluation, and inference (Desty Sugiharti et al., 2019). The pretest will be given before the class carries out learning activities that aim to find out whether there are differences in the initial ability of critical thinking of students in learning ipa, followed by learning activities according to using teaching materials e-modules based on the SETS model and at the end of learning given a posttest to determine the increase in critical thinking skills of students. Data collection techniques were in the form of test methods and questionnaire methods, while data analysis techniques were in the form of data analysis on the results of critical thinking skills tests and student response questionnaires. The research design can be seen in Table 1.

Table 1. One group pretest-posttest design

Pretest	Treatment	Postest
O_1	X	O_2

The SETS-based science e-module assessment was obtained based on improving students' critical thinking skills and student response questionnaires which were then analyzed. Analysis of critical thinking test data is obtained by using the formula.

$$Obtained\ value = \frac{score\ obtained}{maximum\ score}\ x\ 100\% \quad (1)$$

Which is then interpreted based on the scale according to Riduwan (2013). Students are declared to have the ability to think critically if they reach a percentage of 51% -100% while increasing critical thinking skills is obtained by the following equation 2.

$$N - gain = \frac{S_{Post} - S_{Pre}}{S_{Gmax} - S_{Pre}} \; x \; 100\% \quad (2)$$

Table 2. Criteria for Obtaining N-gain Scores

N-gain	Criteria
g > 0.7	High
0.3 ≤ g ≤ 0.7	Medium
g < 0.3	Low

Source: Riduwan & Akdon, 2013.

The significance of the improvement in students' critical thinking skills is determined through a one-tailed hypothesis test using a paired sample t-test, which is calculated using Ms. Office Excel for iOS. The hypothesis being tested is stated as follows:

H_0: There is no significant difference in students' critical thinking skills after using the SETS-based e-module on waves and sound compared to before the intervention.
H_a: There is a significant increase in students' critical thinking skills after using the SETS-based e-module on waves and sound compared to before the intervention.

Result and Discussion

These results were obtained after conducting research, where the experimental class was given treatment, namely by applying the SETS-modeled science e-module to see how the level of critical thinking skills of class VIII students, especially in science subjects at SMPN 2 Depok.

Students' critical thinking skills in science learning can be seen from the application of the SETS model in teaching materials in the form of e-modules. In the application of the SETS model, it provides a stimulus and several applications and problems that must be solved by students through the steps of the SETS model based on the wave and sound material that students are studying in class VIII which can be seen in Figure 1.

Figure 1. Problem in SETS Model according to syntax

After providing problems or phenomena that must be solved by students, the solution of each answer to students in the form of student answer sheets is a form of critical thinking skills. Critical thinking skills can be seen from how students convey ideas to solve a problem from the given phenomenon, namely designing a seismograph device in a simple way, can be seen in Figure 2.

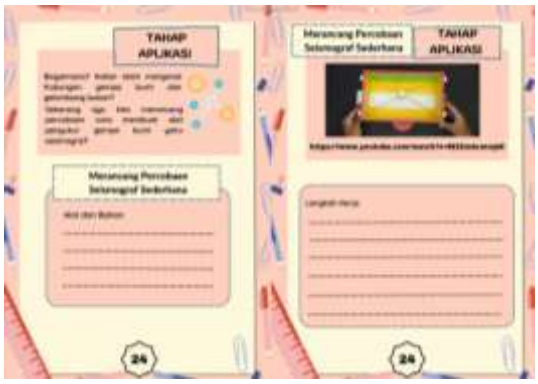

Figure 2. Assignment to design a simple seismograph device to see students' critical problem-solving skills.

After students fill in the answer sheet, each student then takes a pre-test given by the teacher consisting of 10 questions about waves and sound. The results of the pre-test were statistically analyzed to see a comparison of the level of students' critical thinking skills.

The process of forming critical thinking skills must be facilitated by meaningful learning. Such learning can improve students' abilities in basic understanding and thinking skills, including the ability to analyze, evaluate, and problem-solve (Fatimahwati, et al., 2021). With the use of teaching materials in the form of e-modules which are used as a substitute for printed books and modules without limiting their function as a source of information (Az Zahro et al., 2022). The use of e-modules can also be used outside and inside the classroom. Students can learn materials and theories outside the classroom and practice them in the classroom under the

guidance of the teacher (Herala et al., 2015; Kusumawati, 2021).

Research result

A total of 29 students participated in both the pretest and posttest. The posttest was conducted after the students completed the learning process with the SETS-based e-module in the topic of waves and sound. The posttest questions had the same content as the pretest and the students were given 10 minutes to answer them. The pretest and posttest consisted of 10 multiple-choice questions that assessed critical thinking skills.

The assessed critical thinking skills included interpretation, analysis, evaluation, drawing conclusion s, and explanation, using the SETS-based e-module in the topic of waves and sound. Table 3 presents a summary of the results of the pretest and posttest on students' critical thinking skills in class VIII.C of SMP Negeri 2 Depok, Yogyakarta.

Table 3. The results of the pretest and posttest on students' critical thinking skills

Roll Number	Pre	Post	N-Gain	Criteria
Student 1	60	70	0.3	Medium
Student 2	40	50	0.2	Low
Student 3	40	70	0.5	Medium
Student 4	60	80	0.5	Medium
Student 5	50	70	0.4	Medium
Student 6	50	80	0.6	Medium
Student 7	40	70	0.5	Medium
Student 8	60	80	0.5	Medium
Student 9	40	70	0.5	Medium
Student 10	50	70	0.4	Medium
Student 11	40	70	0.5	Medium
Student 12	70	80	0.3	Medium
Student 13	60	70	0.3	Medium
Student 14	50	80	0.6	Medium
Student 15	40	70	0.5	Medium
Student 16	40	50	0.2	Low
Student 17	60	70	0.3	Medium
Student 18	40	70	0.5	Medium
Student 19	60	70	0.3	Medium
Student 20	20	70	0.6	Medium
Student 21	40	60	0.3	Medium
Student 22	60	80	0.5	Medium
Student 23	70	90	0.7	Medium
Student 24	50	70	0.4	Medium
Student 25	60	90	0.8	High
Student 26	40	70	0.5	Medium
Student 27	70	80	0.3	Medium
Student 28	70	70	0.4	Medium
Student 29	50	80	0.6	Medium
Average	51	72	0.4	Medium

Based on the results from Table 3, there is an improvement in students' critical thinking skills as seen from the N-Gain scores of each student. Generally, it can be observed that 2 students achieved low gains, 26 students achieved moderate gains, and 1 student achieved high gains.

Regarding the data on critical thinking skills, the average score of students' critical thinking skills before implementing the SETS-based e-module in the topic of waves and sound was 51, with a minimum score of 20 and a maximum score of 70. The average score of critical thinking skills after being taught using the SETS-based e-module in the topic of waves and sound was 72, with a minimum score of 50 and a maximum score of 90. This is followed by a one-tailed hypothesis test using the paired sample t-test calculated using Ms. Office Excel for iOS. Further details can be found in Table 4.

Table 4. Data analysis results of the pretest and posttest for class VIII.C

	PRETEST	POSTEST
Mean	51.03	71.72
Variance	152.46	100.49
Observations	29	29
Pearson Correlation	0.5	
Hypothesized Mean Difference	0	
df	28	
t Stat	-9.84	
P(T<=t) one-tail	7×10^{-11}	
t Critical one-tail	1.7	
P(T<=t) two-tail	14×10^{-11}	
t Critical two-tail	2.04	

From the statistical analysis results in Table 4, it is obtained that the significance between pretest and posttest is 14×10^{-11}, which is smaller than 0.05. According to the decision of the hypothesis, H_0 is rejected and H_a is accepted. Therefore, it can be concluded that the implementation of SETS-based e-module in the topic of waves and sound is effective in improving students' critical thinking skills.

The high, medium, and low N-Gain scores were obtained based on the pretest and posttest scores. The average N-Gain score obtained is 0.4, which falls into the moderate category. The improvement category based on N-Gain scores indicates that the SETS-based e-module in the topic of waves and sound is moderately effective, as there are no scores that fall into the high or low criteria. When considering the N-Gain for each aspect of critical thinking skills, the following data is obtained.

Based on the table 5, the N-Gain scores are the same for the four aspects, namely interpretation, analysis, evaluation, and drawing conclusions, with a value of 0.6. The highest N-Gain score is observed in the aspect of explanation, although all five aspects fall within the moderate category.

Table 5. Achievement of Each Aspect of Critical Thinking Skills

Observed aspect	Achievement percentage		Gain	Criteria
	Pre-Test	Post-Test		
Interpret	61	85	0.6	Medium
Analyze	48	77	0.6	Medium
Evaluate	52	81	0.6	Medium
Draw a conclusion	42	79	0.6	Medium
Explanation	63	89	0.7	Medium

Discussion

The differences in scores may be due to the individual results obtained by the students. There are three students who have not achieved the mastery level, namely student 2, student 16, and student 21. These three students obtained post-test scores below the IPA standard of 70. The lack of mastery in these students is attributed to their average critical thinking skill level of 69%, falling under the category of moderate critical thinking, resulting in posttest scores below the Minimum Competency Criteria (KKM). Students who lack critical thinking skills are unable to effectively organize evidence and problem-solving solutions, which can lead to lower scores (Nur et al., 2017).

Although both students fall within the same category based on their N-Gain scores, Student A has a higher gain score compared to Student H. Additionally, Student 25 shows the highest improvement from the pretest to the posttest, with a gain score of 30. The data obtained during this study is consistent with the perspective of Puspitasari et al (2020), which states that the development of e-modules can enhance critical thinking skills. E-modules offer several advantages that make students more responsible and allow them to improve their learning activities optimally based on their progress and acquired abilities during the learning process.

The elements influencing students' critical thinking orientations encompass the manner in which the instructional approach is employed and its effectiveness in enhancing critical thinking abilities. Consequently, a well-structured curriculum design that fosters the enhancement of students' critical thinking through a focus on problem-solving orientation becomes imperative (Syahfitri & Firman, 2022). This is also in line with research according to Yerimadesi et al., (2022) that the use of teaching materials in the form of e-modules with the SETS model has an impact in improving 21st century abilities such as students' critical and creative thinking skills, where students become more responsive and can work independently on tasks given by the teacher.

Furthermore, the student's response stating that "this SETS-based e-module on wave and sound topics makes it easier for me to engage in higher-order thinking (critical thinking) and the SETS model makes science learning more interesting" with a perfect score also supports this perspective. In addition to the improvement in critical thinking skills, the effectiveness was also assessed based on the results of the student response questionnaire. The following table presents the summarized data from the student response questionnaire.

Table 6. Summary of Student Questionnaire Response Data.

Rated aspect	Percentage (%)
Usage	100
Aesthetics	88
Appearance	85
Usefulness	92
Visual Communication	87
Overall values of student questionnaire responses.	90.4
Criteria	Very Good

Based on the table 6, it can be observed that there are 5 aspects evaluated to determine student responses. The results indicate that the aspect of aesthetics received the lowest percentage. This can be attributed to the differences in the appearance of the SETS-based e-module for the wave and sound material, including the layout of the student worksheets, which creates a less comfortable impression. On the other hand, the aspect of usefulness obtained the highest percentage, which is 100%.

This is because the SETS-based IPA e-module for the wave and sound material is easily understood by the students. However, it is important to note that accessing the e-module requires an internet-connected device. Overall, the results demonstrate that the developed SETS-based IPA e-module for the wave and sound material can be effectively used by students, offering innovative concepts that prevent boredom. The e-module includes images, animations, and instructional videos, enhancing the learning experience. This is in line with a study conducted by Diana (2019), which states that learning using e-modules is more effective compared to conventional learning methods. With e-modules, students can learn independently and be more actively engaged, leading to the development of strategies and skills that have a positive impact on improved student learning outcomes.

The SETS methodology represents Science, Environment, Technology, and Society, serving as an educational strategy that integrates environment, society, and technology into the learning process to

enhance its significance. The primary objective of the SETS approach is to enable students to uncover interconnected knowledge spanning across science, environment, technology, and society domains, as emphasized by Nikmah and Binadja (2013) in Warlinda et al., (2022). Through the implementation of the SETS methodology in education, it has the potential to foster the enhancement of students' scholastic skills, leading to better educational achievements (Akmalia, 2019; Fatimahwati et al., 2021). This, in turn, results in a discernible variation in the mean performance of the sampled classes.

Conclusion

The results of the research that have been described and explained above provide a conclusion that by applying teaching materials in the form of SETS-based ipa emodules have a significantly higher effect on the average test scores of critical thinking skills of class VIII.C students at SMP Negeri 2 Depok and the results of the questionnaire responses of interested students.

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Jaridatul Muniroh, data analysis and editing; Zuhdan Kun Prasetyo, review and investigation; Jumadi and Insih Wilujeng, validation and supervision.

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Conflicts of Interest
The authors declare no conflict of interest.

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