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THE EFFECT OF DISCOVERY LEARNING ASSISTED BY ELECTRONIC MODULES (E-MODULES) ON STUDENTS' CRITICAL THINKING SKILLS IN VIRUS TOPIC OF GRADE X AT SMA NEGERI 9 PEKANBARU

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ABSTRACT

Twenty-first century science learning requires students to possess critical thinking skills; however, in practice, students still experience difficulties in understanding complex biological concepts, particularly virus material, which is abstract and microscopic in nature. This condition has an impact on the low achievement of critical thinking indicators at SMA Negeri 9 Pekanbaru. This study aims to determine the effect of the Discovery Learning model assisted by electronic modules (e-modules) on students' critical thinking skills and to describe the improvement of critical thinking ability in each indicator. The research employed a quantitative method with a quasi-experimental design using a pretest–posttest control group design. The research sample consisted of two classes: class X.3 as the experimental group and class X.2 as the control group, each comprising 37 students. The experimental group implemented Discovery Learning assisted by e-modules, while the control group applied Discovery Learning without e-modules. Data were collected through pretests, posttests, and critical thinking observation sheets, and then analyzed using normality tests, homogeneity tests, t-tests, and N-Gain tests. The results showed that the average posttest score of the experimental group (84.46) was in the critical category and higher than that of the control group (69.17). The average N-Gain value of the experimental group was 71.3%, categorized as moderately effective, while the control group achieved 48.7%, categorized as less effective. Hypothesis testing indicated a significance value of 0.000 < 0.05, confirming that Discovery Learning assisted by e-modules has a significant effect and is more effective in improving students' critical thinking skills on virus material.

Keywords: E-Module; Critical thinking skills; Virus material; Biology learning.

INTRODUCTION

Twenty-first-century science education requires students not only to master factual knowledge but also to possess higher-order thinking skills, particularly critical thinking, as essential competencies to face the increasingly complex development of science and technology. In biology learning, this demand becomes more crucial because many topics are conceptual, abstract, and cannot be directly observed. One topic that is considered difficult by students is viruses, which have microscopic characteristics, involve complex biological processes, and are filled with scientific terminology that requires deep conceptual understanding. Virus material cannot be optimally understood if it is delivered solely through lecture-based methods or simple learning media without adequate visualization support (Saputra & Hidayat, 2021).

Various studies indicate that limitations in learning media and conventional instructional approaches cause students to experience difficulties in understanding viral structures, life cycles, and replication mechanisms (Rahmawati & Nugroho, 2023). This condition results in low student ability to analyze information, connect concepts, solve problems, and evaluate virus-related phenomena in everyday life. In fact, critical thinking is one of the main competencies in 21st-century skills, commonly referred to as the 4C concept: critical thinking, creativity, collaboration, and communication (Prayogi & Estetika, 2019). Critical thinking serves as a fundamental skill because it enables students to analyze facts, evaluate evidence, and draw logical and rational conclusions.

Critical thinking is defined as the ability to analyze situations based on data and evidence to produce appropriate decisions or conclusions (Agnafia, 2019). Angelo (1995) stated that indicators of critical thinking include the ability to analyze, synthesize, identify and solve problems, draw conclusions, and evaluate and make judgments. However, biology learning in schools is still dominated by teacher-centered approaches, causing students to be passive and accustomed to memorizing concepts without understanding their meaning and application. Consequently, these critical thinking indicators have not developed optimally, particularly in virus-related topics.

The urgency of this issue highlights the need for instructional innovation that actively involves students in discovering and constructing knowledge. One relevant learning model is Discovery Learning, which emphasizes concept discovery through stages of stimulation, problem statement, data collection, data processing, verification, and generalization. This model provides students with opportunities to explore problems, process information, and draw conclusions independently, thereby potentially enhancing critical thinking skills (Fadhilah & Surya, 2019). Nevertheless, the implementation of Discovery Learning requires appropriate instructional materials to ensure effective concept discovery, especially for abstract subject matter.

An electronic module (E-Module) is a digital teaching material that integrates text, images, animations, videos, and interactive questions, enabling clearer visualization of abstract concepts and increasing student engagement in learning. Previous studies have shown that E-Modules are effective in improving conceptual understanding and training students to analyze and evaluate information independently (Asrial, 2020; Anggara, 2021). In this study, the E-Module used was developed by Grace Immanuella (2024), which has been validated and designed in alignment with the Discovery Learning syntax, thus theoretically supporting the concept discovery process and the development of students' critical thinking skills.

Based on the theoretical review and empirical conditions, this study aims to examine the effect of implementing the Discovery Learning model assisted by an E-Module on students' critical thinking skills in virus material. The problem-solving strategy is carried out by applying the Discovery Learning model integrated with an E-Module as a visualization tool and discovery activity, followed by an analysis of its effect on the improvement of critical thinking skills based on the indicators of analyzing, synthesizing, identifying and solving problems, drawing conclusions, and evaluating and making judgments. Therefore, the hypothesis proposed in this study is that the implementation of the Discovery Learning model assisted by an E-Module has a significant effect on students' critical thinking skills in virus material.

RESEARCH METHODS

This study employed a quantitative approach using a quasi-experimental research design to determine the effect of the Discovery Learning model assisted by an electronic module (E-Module) on students' critical thinking skills. The research design used was a pretest–posttest control group design involving two groups, namely the experimental class and the control class. The experimental

class received Discovery Learning assisted by an E-Module, while the control class implemented Discovery Learning without an E-Module.

The research was conducted in the odd semester of the 2025 academic year at SMAN 9 Pekanbaru. The research population consisted of all Grade X students across five classes. Samples were selected randomly after conducting a homogeneity test, resulting in Class X.3 as the experimental class and Class X.2 as the control class. The object of this study was students' critical thinking skills, measured based on the indicators of analyzing, synthesizing, identifying and solving problems, drawing conclusions, and evaluating and making judgments. Data were collected through pretests and posttests using HOTS-based critical thinking test items, as well as classroom observations conducted during the learning process using observation sheets completed by two observers.

The research instruments included instructional devices such as the Learning Objective Flow, teaching modules, student worksheets (LKPD), and an E-Module developed by Grace Immanuella (2024) and adapted to the Discovery Learning syntax. Data analysis was carried out quantitatively using SPSS version 26 through normality tests, homogeneity tests, and Independent Samples T-Tests. The improvement in students' critical thinking skills was analyzed using N-Gain calculations to determine the effectiveness level of the learning process.

RESULTS AND DISCUSSION

Results

Results of Instrument Feasibility Test

In this study, the research instruments were first tested for feasibility through validity, reliability, difficulty level, and discrimination index tests. The instruments could only be used if they met the criteria of being valid, reliable, having a moderate to difficult level of difficulty, and possessing moderate to high discrimination power. The results of the instrument feasibility tests are presented in Table 1.

Table 1. Results of the Feasibility Test of the Critical Thinking Skills Test Instrument

Type of Test	Test Result
Validity Test	Valid
Reliability Test	Reliable
Difficulty Level Test	Moderate
Discrimination Index Test	High

The test results showed that the instrument consisting of 25 items was valid and reliable, with a reliability coefficient of 0.738. The difficulty level analysis indicated that 24 items were categorized as moderate, while 1 item was categorized as difficult. Furthermore, the discrimination index analysis showed that 6 items were classified as having moderate discrimination power, while 19 items had high discrimination power. Therefore, the tested instrument was deemed appropriate for use, as it met the criteria of validity, reliability, difficulty level, and discrimination power.

Students' Critical Thinking Skills Based on Pretest–Posttest

The pretest and posttest data on students' critical thinking skills in the control and experimental classes are presented in Table 2.

Table 2. Critical Thinking Skills of Control and Experimental Classes

Class	Pretest Mean	Category	Posttest Mean	Category
Experimental	40,33	Very Uncritical	84,46	Critical
Control	40,81	Very Uncritical	69,17	Moderately Critical

The results presented in Table 2 show that the average pretest score of critical thinking skills in the control class was 40.81, categorized as very uncritical, and increased to 69.17 in the posttest, categorized as moderately critical. In the experimental class, the average pretest score was 40.33, also categorized as very uncritical, while the posttest average increased to 84.46, categorized as critical. A comparison of the posttest mean scores indicates a substantial difference between the control and experimental classes, with the experimental class achieving a higher score.

Students' Critical Thinking Skills Based on Observation

Observations were conducted by two observers, namely a Grade X biology teacher and a biology education student who understood the learning process in both the control and experimental classes. The average percentage of observation results is presented in Table 3.

Table 3. Observation Results of Students' Critical Thinking Skills in Control and Experimental Classes

Class	Average (%)	Category
Experimental	69,78	Critical
Control	43,38	Moderately Critical

Based on the results in Table 3, the average critical thinking skills of students in the control class reached 43.38%, categorized as moderately critical, while the experimental class obtained an average of 69.78%, categorized as critical.

Normalized Gain (N-Gain) Analysis

The N-Gain value was used to determine the effectiveness of students' critical thinking skills improvement in the experimental and control classes. The results of the N-Gain score calculation showed that the average N-Gain score of the experimental class was 71.3%, categorized as fairly effective, with a minimum score of 46% and a maximum score of 93%. Meanwhile, the control class obtained an average N-Gain score of 48.7%, categorized as less effective, with a minimum score of 14% and a maximum score of 76%. These results indicate that the Discovery Learning model assisted by an E-Module had a positive effect on improving students' critical thinking skills in virus material.

Table 4. Results of N-Gain Analysis

	Class		Statistic	Std. Error
N_GainPersen	Experimental	Mean	71.30	2.063
		Minimum	46	
		Maximum	93	
	Control	Mean	48.71	2.421
		Minimum	14	
		Maximum	76	

Hypothesis Testing

Based on the prerequisite tests conducted on the pretest and posttest data of each class, the data were normally distributed and had homogeneous variances. Therefore, hypothesis testing was conducted using the Independent Samples T-Test with a significance level of < 0.05. If the significance value is < 0.05, the hypothesis is accepted. The results of the hypothesis test are presented in Table 5.

Table 5. Hypothesis Testing Results of Critical Thinking Skills

Independent Samples Test

		t-test for Equality of Means			
		T	Df	Sig. (2-tailed)	*Mean Difference*
Posttest	*Equal variances assumsed*	7.849	72	.000	13.405
	Equal variances not assumed	7.849	67.921	.000	13.405

The test results showed a significance value (2-tailed) of 0.000, which is less than 0.05, and a calculated t-value of 7.849, which is greater than the t-table value of 1.995. Thus, H_0 is rejected and H_1 is accepted. This means that the use of the Discovery Learning model assisted by an electronic module has a significant effect on the critical thinking skills of Grade X students at SMAN 9 Pekanbaru.

Discussion

Instrument Feasibility Test

The results of the instrument feasibility test indicate that the 25 test items met the criteria of validity, reliability, appropriate difficulty level, and good discriminating power. The instrument trial

results showed that all 25 items were declared valid. This indicates that the instrument fulfills validity requirements and that each item is capable of measuring indicators of critical thinking skills in accordance with the implementation of the Discovery Learning model assisted by an e-module. Valid instruments support discovery-based learning and enhance active student engagement (Aprillia & Mahanani, 2021:244), and enable accurate measurement of students' critical thinking skills on virus material (Nurjanah et al., 2019:199).

The valid instrument in this study reflects students' abilities to analyze, solve problems, draw conclusions, and evaluate complex virus concepts. Item validity contributes to improving the quality of evaluation in Discovery Learning assisted by e-modules, ensuring that the data obtained are relevant to the objectives of discovery-based learning integrated with digital media.

The reliability test results showed a coefficient value of 0.738, which falls into the high category based on Arikunto's criteria (2020:239). This value indicates that the instrument has good consistency in measuring students' critical thinking skills. A reliable instrument produces stable and trustworthy data (Hidayah & Ridlo, 2023:55–63), and a Cronbach's Alpha value above 0.738 reflects high internal consistency (Yulianti & Arrahim, 2024:20).

The difficulty level analysis showed that most items were in the moderate category, indicating a balanced composition of test items. A good test should have a proportional level of difficulty to objectively measure students' abilities (Nurpitasari, 2023:29), as items that are too easy do not stimulate critical thinking, while overly difficult items may reduce learning motivation (Agusta, 2022:50). In addition, the predominance of high discriminating power indicates that the items are able to effectively distinguish students' ability levels (Nurhalimah et al., 2022:34).

Indicators of Critical Thinking Skills

The results of the study show that students' critical thinking skills improved across all indicators after the implementation of the Discovery Learning model assisted by an Electronic Module (E-Module). Overall, the most significant improvement occurred in the experimental class compared to the control class.

Students' analytical skills in the experimental class increased compared to the control class. Through the application of Discovery Learning assisted by an E-Module, students were encouraged to compare, identify, and classify information related to viruses, viroids, prions, and bacteria, as well as analyze the impacts of the Covid-19 pandemic. Exploration activities involving visual materials, tables, and videos in the E-Module strengthened the stimulation, data collection, and data processing stages, enabling students to independently discover concepts. This finding is consistent with Nasution (2022), who stated that interactive E-Modules strengthen visual and comparative analysis processes. Thus, the integration of Discovery Learning and E-Modules effectively enhances students' analytical abilities.

Students' synthesis skills also showed significant improvement in the experimental class. Students were able to connect various concepts, such as the role of viruses in biotechnology, viral life cycles, and Covid-19 prevention strategies, into logical ideas and solutions. Through the stages of data collection, verification, and generalization, students became accustomed to integrating facts and concepts into new understanding. These results support the studies of Yuliani and Saraswati (2022) and Nurlaili et al. (2024), which state that Discovery Learning assisted by E-Modules can enhance synthesis skills through integrated information processing.

The ability to identify and solve problems in the experimental class developed better than in the control class. Students were able to identify problems related to the Covid-19 pandemic and apply virology concepts to determine appropriate solutions, such as vaccination, health education, and early detection. The problem statement and data collection stages in Discovery Learning encouraged systematic and evidence-based thinking. This finding aligns with Ismi et al. (2021) and Pramudita et al. (2021), who stated that Discovery Learning assisted by E-Modules effectively improves scientific and contextual problem-solving skills.

For the conclusion-drawing indicator, students in the experimental class demonstrated better inductive and deductive reasoning abilities. Students were able to draw conclusions based on data from the historical discovery of viruses and relate them to relevant scientific concepts. The verification and generalization stages trained students to formulate conclusions and generate alternative ideas logically. These results support the findings of Imtihana (2023) and Rahmawati et al. (2020) that

Discovery Learning effectively enhances evidence-based and scientific reasoning skills in drawing conclusions.

The final indicator, evaluating and assessing, also showed significant improvement in the experimental class. Students were able to express and defend their opinions and assess the impacts of the Covid-19 pandemic based on relevant and scientific criteria. Through the data processing and verification stages, students were trained to distinguish facts from opinions and objectively evaluate solutions. This finding is consistent with Imtihana & Utami (2023) and Noeryana & Mubarok (2022), who emphasized that Discovery Learning assisted by E-Modules effectively enhances students' evaluative and argumentative skills. Thus, the application of Discovery Learning assisted by E-Modules has a positive effect on all indicators of students' critical thinking skills.

Effect of the Discovery Learning Model Assisted by Electronic Modules on Critical Thinking Skills

The critical thinking skills examined include analyzing, synthesizing, identifying and solving problems, drawing conclusions, and evaluating and assessing. Hypothesis testing results showed a significance value of 0.000 < 0.05 and a t-value of 7.849 > t-table value of 1.995, indicating that H_0 was rejected and H_1 was accepted. This proves that the application of the Discovery Learning model assisted by electronic modules (E-Modules) has a significant effect on the critical thinking skills of grade X students at SMAN 9 Pekanbaru.

In the first meeting on the topic of virus characteristics and structure, the E-Module functioned as an initial stimulation medium through the presentation of land conversion images and videos on virus characteristics. The visual and interactive media in the E-Module stimulated students' curiosity and helped clarify abstract concepts, thereby training analytical skills. In addition, the E-Module supported students in formulating problems and initial hypotheses during the problem statement stage and assisted students in synthesizing information through E-Module-based worksheets (Asrial, 2020; Rahmawati et al., 2020).

During the data collection and data processing stages in the first meeting, the E-Module served as the primary learning resource for collecting and processing data. Students used the E-Module to explore relevant facts and theories, then discussed them in groups to solve given problems. This role of the E-Module helped students organize, compare, and connect information, thereby enhancing analytical, synthesis, and problem-solving skills (Chusni et al., 2020; Nurlaili et al., 2024). In the verification and generalization stages, the E-Module supported students in evaluating discussion results and drawing evidence-based conclusions (Meriyana et al., 2020; Imtihana, 2023).

In the second and third meetings, the E-Module contributed through interactive animations of viral replication (lytic and lysogenic cycles) and videos on the roles and impacts of viruses in life. Visual media in the E-Module helped students understand complex biological processes and connect concepts with real phenomena, thereby encouraging higher-order and evaluative thinking (Anggara, 2021).

The N-Gain test results also showed that the Discovery Learning model assisted by E-Modules was able to improve students' critical thinking skills more optimally than conventional learning. The average N-Gain of the experimental class reached 71.30% (moderate–high category), while the control class only reached 48.71% (moderate category). This finding indicates that learning emphasizing discovery and active exploration is effective in developing critical thinking skills, as critical thinking develops through active student involvement in analyzing and evaluating information (Agnafia, 2019).

The improvement in critical thinking skills in the experimental class occurred in the indicators of analyzing, synthesizing, and identifying and solving problems, because the Discovery Learning syntax encourages students to identify problems, process information, and construct concepts independently. This process aligns with Bruner's constructivist theory (2017), which states that knowledge becomes more meaningful when obtained through discovery. In addition, the E-Module functions as a digital teaching material presenting contextual problems and exploratory activities, thereby strengthening problem identification skills as a foundation of critical thinking in science learning (Anggara, 2021).

Furthermore, improvements in the indicators of drawing conclusions and evaluating were influenced by students' involvement in the verification and generalization stages, which train the ability to draw conclusions and assess the validity of concepts based on evidence. The E-Module

functions as scaffolding that helps students systematically reflect on and evaluate learning outcomes, allowing critical thinking processes to develop comprehensively (Asrial, 2020).

Overall, the integration of E-Modules into each stage of Discovery Learning makes students more active, reflective, and capable of independently managing information, resulting in a significant improvement in students' critical thinking skills (Kusumawati & Adawiyah, 2019).

CONCLUSIONS

Based on the research results, it can be concluded that learning using the Discovery Learning model assisted by E-Modules has a significant effect on the critical thinking skills of grade X students at SMAN 9 Pekanbaru. The average posttest score of the experimental class reached the "critical" category with a value of 84.46%, while the control class only reached 69.17%, which falls into the "fairly critical" category. Observation results also showed that the critical thinking skills of the experimental class were in the critical category (69.78%), while the control class was in the fairly critical category (43.38%). Based on the N-Gain test, the Discovery Learning model assisted by E-Modules was also proven to be more effective in improving students' critical thinking skills on virus material compared to the control class, with a higher N-Gain value in the experimental class (71.3%) categorized as moderately effective.

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