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Development of E-Module Based on Science Technology Society (STS) on Immune System Material In Improving Students' Critical Thinking Skills

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Abstract: This study aims to produce an e-module based on Science Technology Society (STS) on the immune system material that is effective in improving critical thinking skills of grade XI high school students. This type of research is Research and Development (R&D) with the ADDIE research model (Analysis, Design, Development, Implementation, and Evaluation). The sampling technique used in this study was cluster random sampling with a research design of non-equivalent pretest and posttest control group design. The e-module was assessed for its feasibility and practicality by experts and limited trials. The results of this study indicate that the e-module is declared feasible and the results of the limited test of the use of the e-module are declared practical. The results of the large-scale test show that in the experimental class by implementing the STS-based e-module there was an increase in critical thinking skills with an average posttest score of 81.53 with the results of the gain score test on the medium criteria. While the control class also experienced an increase in critical thinking with an average posttest score of 77.00 with the results of the gain score test on the low criteria.

Keywords: Critical thinking; e-module; Immune system; Science technology society

Introduction

Education is the main capital in facing the challenges of the 21st century (Yuliana et al., 2023). Currently, academic achievement of the students is no longer seen as the only factor determining their success in the future, but more to gain a competence in communicating by using second language and acquire basic skills such as collaboration, critical thinking, problem solving, creativity and research gathering. This reformation of education was considered firstly in the United States of America by the movement of the 21st century skills (Ratminingsih et al., 2021).

21st century skills or known as 4C include communication, collaboration, critical thinking and creativity. Critical thinking is often referred to as one of the important skills in 21st century education, in addition to other skills that have been explained (Zikrullah & Azhari, 2024).

Critical thinking skills are closely related to students' in-depth understanding of the content of the subject matter(Jamaludin et al., 2022). Guo in (Agnesa & Rahmadana, 2022) said that critical thinking is included in the high order thinking skills (HOTS) which focus on activities of interpreting, analyzing, evaluating, making conclusions and considerations based on evidence, conceptually, methodologically, or contextually. Ennis & Wijayanti argue in (Yulianti et al., 2022) that critical thinking is the ability to think rationally and reflectively so that one can decide what to do or believe. Critical thinking skills can also be interpreted as a person's reflective thinking process that focuses on decision making in solving problems in various situations in real life (Irwandi, 2020).

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However, critical thinking skills in Indonesia are still low as evidenced by the 2018 PISA study, in the field of science with a score of 396 and ranked 69 out of 77 countries. In addition, research in the city of Ambon explains that students' thinking skills in science learning are still low, namely 53.41 (Jamaludin et al., 2022). Then (Pujiastuti, 2023) conducted research on six high schools in Jombang Regency. The results of the study showed that students' critical thinking skills were still low, with an average score of 2.7 and a level of mastery of critical thinking skills of 54%. Nawawi et al., (2019) conducted research in four high schools in Palembang. From the four Palembang State High Schools, an overall average of 32.56% was obtained, which was still categorized as low. Another finding was reported by (Sugiharti & Gayatri., 2021) that students' critical thinking skills in biology subjects in three high schools in Surabaya City had only reached 51.85 in the low category.

Based on the needs analysis conducted by (Ayunda et al., 2024) in nine State Senior High Schools in Sleman Regency, one of which is State Senior High School 1 Depok, stated that one of the skills that has not been mastered by students is critical thinking skills. This is in line with previous research conducted by (Prasetya et al., 2024) where the results of observations of critical thinking skills tests of students at State Senior High School 1 Depok showed relatively low numbers. In addition, the average cognitive ability has not met the target, it can be sesen that only 50% of students passed the mid-semester exam. So in this study, State Senior High School 1 Depok was chosen as the research location.

Based on the results of observations and interviews with biology subject teachers, learning activities still look passive and only listen to lectures. Teachers have implemented student-centered learning methods, with discovery learning and project-based learning (PjBL) models, but their implementation has not been optimal. Therefore, teachers more often use lecture methods with the help of PowerPoint so that teachers still dominate the learning process in the classroom. Then, based on the results of interviews with biology teachers, they stated that they had never used electronic modules (e-modules) especially in biology subjects before.

E-modules are a transformation of teaching materials from printed to digital form (Purba, 2024). E-modules are a type of module that contains text, images, graphics, animations, and videos that can be accessed anywhere and anytime (Lastri, 2023). The advantage of e-modules is that they allow images, audio, video and animations to be displayed so that students' understanding becomes clearer. Several studies have also shown that e-modules have an effect on learning independence, increase learning motivation, improve the ability to master material, and improve learning outcomes (Rizka Chaerunisa et al., 2023). In addition, learning e-modules are easier to use and can support independent learning that can be adjusted to the comfort and needs of students. The existence of e-modules gives students the flexibility to learn independently without being bound by time and place (Maulana et al., 2022).

Observation results at State Senior High School 1 Depok show that the biology subject matter that is considered difficult by students is the immune system. This is due to the fairly broad and complex scope of the material. And the immune system material is the final competency material. For that, so that the material provided can still be conveyed well, teaching materials should be provided that not only facilitate students to learn independently outside of class hours, but are also relevant to environmental issues in society.

Science Technology Society (STS) is a learning approach that in its learning links science and technology with problems that exist in society (Ivayuni Listiani, 2019). In addition, STS can also hone students' abilities to explore how science and technology can contribute to people's lives and direct them to be able to develop their skills. STS is a approach that connects science, technology, and their benefits to society (Roswita et al., 2021). Mansour argues in (Rachmawati & Rohaeti., 2018) that STS emphasizes students to think critically about environmental and technological issues that cause a problem and are sought for solutions by students. The STS approach shows positive results, some of which are that it can improve learning outcomes, effectively improve high-level thinking skills, and increase students' awareness of the environment (Roswita et al., 2021).

Based on the background of the problem, the development of an STS-based e-module was carried out. This study aims to produce an e-module that is effective in improving the critical thinking skills of grade XI high school students, especially in the immune system material.

Method

This study uses a research and development method with the ADDIE model. The selection of the ADDIE model is based on its advantages, namely the evaluation at each stage so that it can reduce existing deficiencies and the hope is that it can produce valid, feasible, practical, effective products that can help overcome problems that arise (Puspasari, 2019). According to McGriff in (Rapma et al., 2024) this ADDIE model consists of stages namely analysis, design, development, implementation and evaluation which can be seen in Figure 1. This research was conducted in State Senior High School 1 Depok. The population in this study were class XI students in biology subjects.

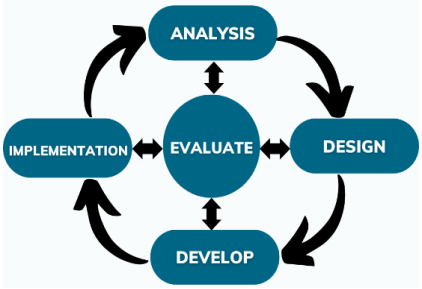

Figure 1. Stages of ADDIE model development

The first stage of analysis is. At this stage, an analysis is carried out on the situation and problems that occur during biology learning at SMA Negeri 1 Depok. This stage is carried out by collecting information at school through interviews, observations and questionnaires. The second stage is the product design stage by making a story board. The third stage is product development through the results of the analysis and planning concepts that have been determined previously. The next stage is the implementation stage. At this stage, the product that has been developed is implemented through a trial that aims to see the effectiveness of the product on students' critical thinking skills. The results of the trial are then explained to determine the increase in students' critical thinking skills.

Critical thinking skills analysis was conducted using the Normalized Gain Score (N-Gain). The use of the N-Gain score can describe how big the role of the STS-based e-module on the immune system material is in improving students' critical thinking skills. The following is the Normalized N-Gain Score, in Formula 1.

$$N - Gain = \frac{Posttest\ Score - Pretest\ Scor}{Maximum\ Score - Pretest\ Score} \quad (1)$$

(Ayunda et al., 2024)

The gain index values are then categorized using the criteria in Table 1.

Tabel 1. Index Score and Classification/effectiveness

Normalized Gain Index	Classification
g ≥ 0.70	High/very effective
0.30 ≤ (g) ≥ 0.70	Medium/effective
(g) < 0.30	Low/less effective

(Yustina, 2020)

And the final stage, namely the evaluation stage, is carried out to ensure that the learning objectives are achieved and the media and learning models used are appropriate.

Result and Discussion

This research is a type of research and development that produces an e-module based on STS that is feasible, practical and effective in improving critical thinking skills on the immune system material. The results of the research are revealed following the ADDIE development stages which include analysis, design, development, implementation, and evaluation as follows:

Analysis

Needs analysis was conducted through observation interviews with biology subject teachers and distribution of need assessment questionnaires to students so as to obtain the results needed to improve the success of biology learning in schools. Based on the results of observation interviews with biology subject teachers, previously teachers had never used e-module teaching materials, the delivery of materials in the classroom used a simple PowerPoint-assisted lecture method. Based on interviews with teachers, researchers also asked about biology materials that were difficult to teach in grade XI. One of the difficult materials is the immune system material.

Based on the results of the curriculum review and analysis conducted through observation and interview activities with teachers at SMA 1 Depok, it is known that the curriculum used in the school still uses the 2013 curriculum. The next step taken is the analysis of core competencies (KI) and basic competencies (KD) on the material studied, namely the immune system material. KI and KD refer to Permendikbud Number 37 of 2018, namely KD 3.14 Analyze the role of the immune system and immunization on physiological processes in the body; and KD 4.14 Conduct a campaign on the importance of community participation in programs and immunization and abnormalities in the immune system.

After conducting the KI and KD analysis, the next step is to analyze the characteristics of the students. At school, students are allowed to bring smartphones during learning; The school provides wifi in each class to support learning activities; Students said that biology is very interesting and fun to learn, but they find it difficult because there is too much material to memorize so they tend to get bored quickly. Quoting from Purwanto (Marwah., 2017) who explained, "memorizing or remembering is not the same as learning. Memorizing or remembering something does not guarantee that people have learned in the true sense. Because to know something is not enough just by memorizing, but with understanding"; furthermore, students stated that the concept of the immune system material that was most difficult for them to understand was the concept of antigens and antibodies. This was followed by the material on the mechanism of the immune system and disorders that occur in the immune system; As many as 56.06% of students stated that the teaching materials they used were quite helpful in understanding and

applying biology material; and the majority of students felt that electronic teaching materials that included a summary of the material with learning videos, learning activities that presented current issues would make them more interested in learning biology material.

Design

The design stage is the design of the e-module in the form of a storyboard that will later be made into a complete product. The process of compiling an e-module begins with the preparation of a framework for teaching materials, which includes the structure and content of the material to be delivered as well as evaluation tools.

Development

Development is the stage of product realization from the storyboard that has been designed at the design stage. At the development stage, the product's feasibility is assessed by media and material experts using a feasibility questionnaire. The following are the results of the product assessment based on media experts.

Table 1. Results of the Media Expert Feasibility Assessment

Aspect	Score	Category
E-module cover	23	Very Good
Fill in the e-module	26	Very Good
Appearance	22	Good

Based on the table above, it is known that the cover and content aspects of the e-module assessed by media experts show a very good category. While the presentation aspect shows a good category. It can be concluded that the e-module product with the STS approach is worthy of being tested in biology learning for immune system material.

Next, the product is assessed for its feasibility by material experts. The following are the results of the product assessment based on the assessment of material experts.

Table 2. Results of the Material Expert Feasibility Assessment

Aspect	Score	Category
Depth and breadth of material in accordance with competency	40	Very Good
Presentation of material	26	Very Good
Language	11	Very Good

Based on the data from the feasibility test results by the material expert, each aspect of the assessment is in the very good category. The evaluation results presented by the expert indicate that the e-module with the STS approach is feasible to be distributed and used by students in biology learning, especially the immune system material.

After the product has been assessed for its feasibility by media and material experts, the product is first tested on students to measure its level of practicality. The following are the results of the questionnaire assessment of the product's practicality by students.

Table 3. Results of the Product Practicality Assessment by Students

Aspect	Average	Category
Ease of understanding the material	15	Good
Ease of use	37.29	Very Good
attractive appearance	18.40	Very Good

Based on the results of the assessment of the practicality of the e-module by students, it shows that the e-module with the STS approach is categorized as practical for use.

Implementation

In the implementation stage, a large-scale test is conducted on products that have been deemed feasible and practical. This large-scale test aims to determine the effectiveness of the STS-based e-module that has been developed.

A large-scale test was conducted on grade XI MIPA students to observe whether e-modules can improve critical thinking skills on immune system material. This study used two test classes, namely one experimental class and one control class. The experimental class used a revised STS-based e-module, while the control class used commonly used learning resources. The number of students in each experimental and control class was 34 people. The purpose of this stage was to determine the effectiveness of e-modules in improving critical thinking skills of grade XI students of SMA Negeri 1 Depok.

The effectiveness assessment was conducted before the STS-based e-module was distributed with the aim of testing the effectiveness of the product that had been validated theoretically by implementing it in learning. The implementation was carried out using a quasi-experimental method with 2 classes, namely, 1 control class and 1 experimental class, where the control class carried out learning using commonly used teaching materials and the experimental class using STS-based e-modules. Students in both the experimental and control classes carried out pretests and posttests to measure critical thinking skills and see the differences between the two classes.

The measurement of the effectiveness of the STS-based e-module was carried out using previously validated critical thinking skills questions. The critical

thinking skills questions consisted of 10 descriptive questions. Students were given pretest and posttest questions to determine their initial and final abilities after studying the immune system material using the distributed e-module. Data on the differences in students' initial and final ability scores can be seen in Table 4.

Table 4. Results of Analysis of Critical Thinking Skills Data Description

Information	Eksperimen Class		Control Class	
	Pretest	Posttest	Pretest	Posttest
Sampel	34	34	34	34
Min	30	70	27	63
Max	65	90	65	90
Average	44.06	81.53	40.68	77.00

Based on the results of the data presentation in table 4, it can be seen that the posttest value of critical thinking skills of students in the experimental and control classes has increased. If reviewed again, the average value of the experimental class using the STS-based e-module is higher than the control class in accordance with the theory stated by Yazdani dalam (Rahayuni, 2016), which states that one of the outcomes of problem-based learning is to train students' critical thinking skills. For this reason, an analysis of the gain index value (n-gain) was then carried out. This n-gain analysis aims to determine how much the increase in value occurred in the experimental class and the control class towards their critical thinking skills, an analysis of the gain index value was carried out with the following results.

Table 5. Improving Critical Thinking Skills Based on Gain Score

Information	Critical Thinking Skills	
	Eksperimen Class	Control Class
Pretest	44.06	40.68
Posttest	81.53	77.00
N-Gain	0.67	0.50
N-gain Category	medium	Low
Effectiveness category	Quite Effective	Less Effective

The assessment results based on table 5 show an increase in the n-gain value of students' critical thinking skills in the experimental class and the control class. The experimental class obtained a gain index value of 0.67 (medium category), while the control class was 0.50 (low category). Although both classes are in different categories, the increase in value in the experimental class is higher than in the control class. This is possible because the experimental class uses an STS-based e-module while the control class uses commonly used modules and learning models.

STS has a positive influence on students' critical thinking skills. This is in accordance with research conducted by (Kassiavera, 2019) in his research revealed that the development of STS-based modules can improve critical thinking skills and learning motivation. In line with (Rachmawati & Rohaeti., 2018) that learning using the STS approach is better than using non-STS. Not only that, STS supports the achievement of 21st century skills. This is in line with Suarni et al., (2021) in their research that STS has advantages, including improving critical thinking skills, logical reasoning, and creative problem solving.

Yoruk, Morgil, & Secken in (Rachmawati & Rohaeti., 2018) revealed that STS learning can increase interaction in the learning process and create a student-centered learning environment. The STS learning model can activate students to think critically about existing issues or problems. Thus, students can search for information, analyze, identify, to be applied in solving these problems. Students are required to be able to solve problems or issues that develop in society. Students can investigate problems, interpret content related to the problem, analyze the causes and effects of the problem, spread the problem process, and conclude the results of the problem. Therefore, it can be said that critical thinking skills are important skills in problem solving (Lorencia & Jatmiko (2021).

STS has various characteristics compared to other learning approaches. These characteristics are in the domain of STS itself. First, in the aspect of the connection and application of learning materials, students can connect what they learn with everyday life phenomena. Second, students' creativity increases by asking more questions, indicating possible causes of observation results. Third, students' interest in science increases and their curiosity also increases, and science is seen as a tool for solving problems. So that in the process domain, students can be more active in seeking information that can be applied to solve problems they face in everyday life. Another characteristic lies in the beginning of learning (invitation phase), namely by presenting issues or problems that occur in society, both problems that are explored by students themselves and problems that are presented directly by the teacher (Marwah et al., 2017). In this study, the development of STS-based e-modules has proven effective in improving students' critical thinking skills in biology learning.

Evaluation

At this stage, a comprehensive evaluation of the e-module product was conducted after it was implemented on students. The final results of this study indicate that the e-module product can improve students' critical thinking skills. However, updates must still be made. This is because the material contained in

the e-module is related to the issue of autoimmune problems that continue to develop. The purpose of the update is to ensure that the e-module content remains relevant, accurate, and able to present the latest information.

Conclusion

Based on the results of the research that has been conducted, it can be concluded that the E-module with the STS approach to the immune system material is feasible based on the assessment of media and material experts. The E-module with the STS approach to the immune system material is declared practical based on the assessment of teachers and students. The STS approach E-module to the immune system material has proven effective in significantly improving the critical thinking skills of grade XI high school students.

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The author declares that he has no conflicts of interest.

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