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### Development of Interactive E-Modules for Differentiated Learning to Improve Critical Thinking Skills and Student Learning Outcomes on Body Defense System Materials

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#### Abstract

The results of the PISA study in 2015 show that the critical thinking ability of the majority of students in Indonesia is still low. The low critical thinking ability of students is an indicator that determines the quality of student learning outcomes. One of the reasons is that there are not many learning media that are able to facilitate the diversity of student learning that can be accessed by mobile. E-Modules that are made specifically for differentiated learning are media developed to answer these problems. The purpose of this study is to determine the characteristics, feasibility, and effectiveness of interactive e-modules in differentiated learning to improve students' critical thinking skills and learning outcomes. This study refers to the development research design of Borg and Gall which consists of 10 steps, but the researcher only conducts research up to the eighth step, namely Operational Field Testing. Data collection was carried out by interview, questionnaire and test methods (pretest and posttest). The data analysis techniques in this study are descriptive analysis, feasibility percentage analysis and N-Gain test. The e-module developed has a special characteristic, namely the existence of features that support differentiating content, processes and products based on visual and auditory learning styles. The results of the e-module feasibility test by validators of media experts and material experts, both received very feasible criteria with percentages of 99.3% and 93.4%. In the feasibility test by users, very feasible criteria were also obtained, both in the teacher's response and the student's response, with a percentage of 96% and 83.25%, respectively. In the N-Gain test, the results of the e-module were also found to be effective in improving students' critical thinking skills and learning outcomes, with an average class N-Gain score of 0.85. So the conclusion is that the interactive e-module on differentiated learning has proven to be feasible and effective in improving students' critical thinking skills and learning outcomes on the Body Defense System material.

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## INTRODUCTION

The scope of biology learning which is a branch of science learning is inseparable from mastering concepts, facts, principles, laws, scientific work and thinking skills, but also learning about the application of technology, the ability to think critically, obtain information, and work scientifically (Puspitasari, 2019). From this description, the suitable learning media for biology subjects are media that are able to move students to learn actively and independently, and are not teacher-centered. One of the learning media that can be used as an alternative to support students' independent learning activities is modules (Faradila & Aimah, 2018). Modules are learning media in the form of books that are arranged so that students are able to learn independently with or without direction from the teacher (Finnajah, 2016). However, modules have several disadvantages, namely expensive printing costs, and limited features.

One of the mobile learning media that can be accessed by all people is electronic modules or e-modules. E-modules are learning media that present learning materials independently and structured in the smallest learning units, with the aim of achieving specific learning outcomes and are presented in electronic form, containing elements such as animation, audio, and navigation that aim to increase user interactivity with the program. E-modules have many advantages, including being able to load various kinds of media directly, being easily accessible and interactive (Suarsana et al., 2013). In its development, there are many aspects that must be considered to make e-modules as one of the teaching materials whose substance is easily understood by students. This is because not all students can easily understand the material presented, given the different levels of student development. Teachers need to pay attention to the breadth and depth of the content of the material presented, because how well children understand it depends on their level of cognitive development (Astiti et al., 2021).

Critical thinking skills are one of the basic abilities that students should have in the 21st century. Critical thinking skills refer to a person's ability to consider alternative decision-making and problem solving, by analyzing situations, evaluating arguments, and drawing accurate conclusions (Wahyuni et al., 2022). In addition, critical thinking skills are also one of the indicators that have a correlation with student learning outcomes (Ramdani & Badriah, 2018). Student learning outcomes are one of the benchmarks that can be used as a reference to determine the extent of student understanding of a material. The results of the PISA study in 2015 showed that the critical thinking, logical and problem solving skills of the majority of students in Indonesia were still low. The PISA data in 2015 is in line with Agnafia's research (2018), which concluded that students' critical thinking skills in learning biology are still in the low category, seen from indicators including inference, analysis, explanation, self-regulation, evaluation and interpretation. One of the efforts to improve critical thinking skills and student learning outcomes is to apply differentiated learning, as research by Avandra & Desyandri (2022), which concluded that the application of differentiated learning proved to be able to improve students' critical thinking skills.

Differentiated learning is a learning approach that considers and accommodates differences between students transparently, while meeting students' learning needs. In differentiated learning, teachers must pay attention to content, methods, learning outcomes, and learning environments that are tailored to students' conditions. There are three differentiated learning strategies, which include content differentiation, process differentiation, and product differentiation (Maryam, 2021). Content differentiated learning contains the material that students will learn, which is adjusted to the interests and readiness level of students or adjusts the material content based on the learning style of each student. The process differentiated learning strategy contains ways to make learning meaningful and in line with the material they learn. Meanwhile, product differentiated learning contains the form of assessment or final assessment after completing a material or topic of discussion (Marlina et al., 2019).

From the results of interviews with biology teachers at SMA Negeri 5 Semarang, it was found that critical thinking skills and the use of digital module learning media were rarely used, especially in biology subjects. The learning media used are still limited to printed books, blackboards, YouTube videos and power points. Whereas in this era, the use of technology as a learning media is more diverse. In addition, gadgets

are currently one of the things that every student has, especially at SMA Negeri 5 Semarang. Therefore, teachers must take advantage of these opportunities to improve the quality of student learning (Sanjaya et al., 2022). In addition, the development of learning media whose content represents differentiated learning that makes students able to learn independently, involves students in every process, and integrates various readiness, interests and talents of students has never been done in biology subjects at SMA Negeri 5 Semarang.

Departing from these problems, it is deemed necessary to have a learning media that can be a solution to these problems. The solution that is trying to be realized is by developing learning media that supports differentiated learning in schools, which can improve students' critical thinking skills and improve student learning outcomes, and can be accessed by devices. The learning media that is in accordance with these problems is the e-module. The integration of the use of e-modules is done to provide a learning resource that facilitates the diversity of student learning types in a class. Therefore, it is necessary to develop an interactive e-module in differentiated learning to improve students' critical thinking skills and learning outcomes on the material of the Body Defense System.

## **RESEARCH METHOD**

The subjects in this study were media experts, material experts, students of class XI SMA Negeri 5 Semarang, and biology teachers. The type of research conducted is research and development (RnD) used. The product developed is a differentiated e-module on the material of the Body Defense System to improve critical thinking skills and student learning outcomes. This research design refers to the design of Borg and Gall which consists of ten steps, including 1) research and information collecting (2) planning, (3) develop preliminary form of product; (4) preliminary field testing, (5) main product revision; (6) main field testing; (7) operational product revision; (8) operational field testing; (9) final product revision; (10) dissemination and implementation. Of the ten steps, researchers only conducted research until step number eight, namely Operational Field Testing. The data analysis techniques in this study were descriptive analysis, feasibility percentage analysis and N-Gain test.

## **RESULT AND DISCUSSION**

The purpose of this study was to determine the characteristics, feasibility, and effectiveness of interactive e-modules in differentiated learning to improve students' critical thinking skills and learning outcomes.

### **Characteristics of Differentiated E-Modules**

Interactive e-modules in differentiated learning have characteristics that distinguish them from e-modules in general. Differentiated e-modules have teaching materials that facilitate visual and auditory learning styles, on differentiated content, process and product. The features developed also adjust to the type of differentiated learning. The features include Visual Auditory Zone, Flash Comprehension, Muna-Fact and Enrichment Zone. Visual Auditory Zone is a feature that contains learning materials in the form of videos. This zone is made as a form of representation of process differentiation. Process differentiation is a form of differentiation that emphasizes the differences in the way students get information or how the learning process (Andini, 2016). In this e-module, reading text, images and audio visual zones are provided, so that learners can choose the most preferred features themselves. The second feature is the quick understanding feature. In this feature, a brief summary or mind map of the material is presented which can make it easier for students to remember the material in the sub-chapter. The next feature is the Muna-Fact feature. This feature stands for Immun-Fact, which contains interesting facts about immunity. The second and third features are additional features that aim to complement the e-module, so that the material obtained by students is easier to understand and has a wider scope of knowledge.

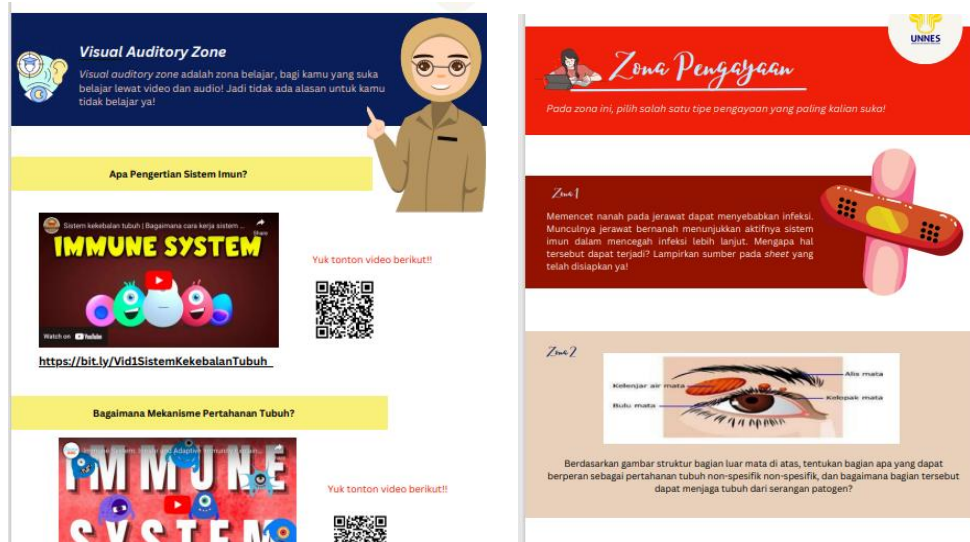


Figure 1. Visual Auditory Zone and Enrichment Zone features

The next characteristic is enrichment questions that are created by adjusting the learning style and interests of students. Enrichment questions here are included in the enrichment zone feature. Enrichment is useful as an instrument to assess students' abilities after studying the e-module on each topic. Each enrichment question has several different zones/types of questions. With several types of questions, students can freely choose one type of question that best suits their interests and learning styles. This enrichment zone is a representation of product differentiation. Product differentiation is evidence of learner achievement of what has been understood and learned (Andini, 2016). The selection of zones/types of questions makes learners free to express evidence of their learning outcomes. That way, learners can get better results because they work according to their own interests.

### Feasibility of E-Modules

Table 1. Media Expert Validator Results

Number	Assessment Indicator	Score
1	Size of e-module	10
2	E-module cover design (cover)	45
3	Design of e-module content	94
	Score obtained	149
	Maximum Score	150
	Percentage ( $\frac{\text{Total score obtained}}{\text{Total maximum score}} \times 100\%$ )	99,33%
	Eligibility criteria	Very feasible

Table 2. Material Expert Validator Results

Number	Assessment Indicator	Score
1	Content eligibility aspect	70
2	Presentation feasibility aspect	41
3	Aspects of linguistic feasibility	52
	Score obtained	163
	Maximum Score	175
	Percentage ( $\frac{\text{Total score obtained}}{\text{Total maximum score}} \times 100\%$ )	93,14%
	Eligibility criteria	Very feasible

Data from the e-module media feasibility test results get a percentage value of 99.33%, which indicates that the e-module is very feasible to use in learning the material of the Body Defense System. While

the data from the feasibility test results of the e-module material get a percentage value of 93.14%, which shows that the e-module is very feasible to use in learning the material of the Body Defense System.

The high percentage of media expert validation results is because almost all indicators assessed have been declared good. In the media aspect, only the indicator 'Design of e-module content' received an imperfect score, which was 19 out of a total score of 20. In this indicator, the point that did not get a perfect score was the point 'creative and dynamic'. This is because the e-module with the magazine theme is not the first time it has been developed, so in the future the creativity of its development can still be improved. The results of the material expert feasibility test are also high. This is because the material content contained in the e-module is complete and fulfills the learning outcomes of Phase F. In addition, the e-module also reflects the existence of novelty by displaying differentiated aspects and features and supports student achievement in improving critical thinking skills. From the description and results of the e-module feasibility validation instrument by media experts and material experts, the differentiated e-module developed is declared very feasible to use as a biology learning media on the material of the Body Defense System. The results of this study are in line with the results of previous research which states that differentiated e-modules are feasible in terms of media and material to be used as learning media in the classroom (Sanjaya et al., 2023).

The e-modules that have been tested for feasibility by experts were then tested for feasibility by users, namely by 10 students of class XII MIPA 4 SMA Negeri 5 Semarang and 1 biology teacher. The table of results of students' responses and teacher responses can be seen in tables 3 and 4.

Table 3. Results of Learner Responses

Percentage (%)	Criteria	Number of Students
81 < score ≤ 100	Very Feasible	6
61 < score ≤ 80	Feasible	4
41 < score ≤ 60	Feasible enough	-
21 < score ≤ 40	Less feasible	-
0 < score ≤ 20	Not feasible	-

Table 4. Teacher Response Results

Number	Assessment Indicator	Score
1	Material	39
2	Media	47
3	Language	10
	Score obtained	96
	Maximum Score	100
	Percentage ( $\frac{\text{Total score obtained}}{\text{Total maximum score}} \times 100\%$ )	96 %
	Eligibility criteria	Very Feasible

From table 3, the results of the responses of XII MIPA 4 students of SMA Negeri 5 Semarang to the differentiated e-module of the Body Defense System material developed, obtained 6 students with very feasible criteria and 4 students with feasible criteria. While the data from the response of biology teachers get a percentage value of 96%, which indicates that the e-module is very feasible to use in learning the material of the Body Defense System. The high percentage score obtained in the teacher's response, because the differentiated e-module developed is able to facilitate student diversity and can be accessed on one platform also makes it easier for teachers to carry out differentiated learning activities. This is in line with the results of the teacher questionnaire which all indicators (material, media and language indicators) get feasible and very feasible criteria. Similar to the teacher's response, the student's response also received a high score. This is because the e-module has an attractive appearance, is easily accessible, and has features that adjust students' learning styles.

Based on the results of teacher and student responses, the developed differentiated e-module is declared very feasible to use as a biology learning media on the material of the Body Defense System. The

results of this study are in line with the results of previous research which states that differentiated e-modules are suitable for use as learning media in the classroom (Sanjaya et al., 2023).

### Effectiveness of E-Modules in Improving Critical Thinking Skills and Student Learning Outcomes

After testing the students, each item was analyzed to find differences in students' critical thinking skills before and after the use of differentiated e-modules. The subjects of this effectiveness test were 91 students from classes XI-3, XI-4 and XI-5 of SMA Negeri 5 Semarang. Analysis of differences in students' critical thinking skills on each indicator before and after the use of differentiated e-modules is presented in Figure 2..

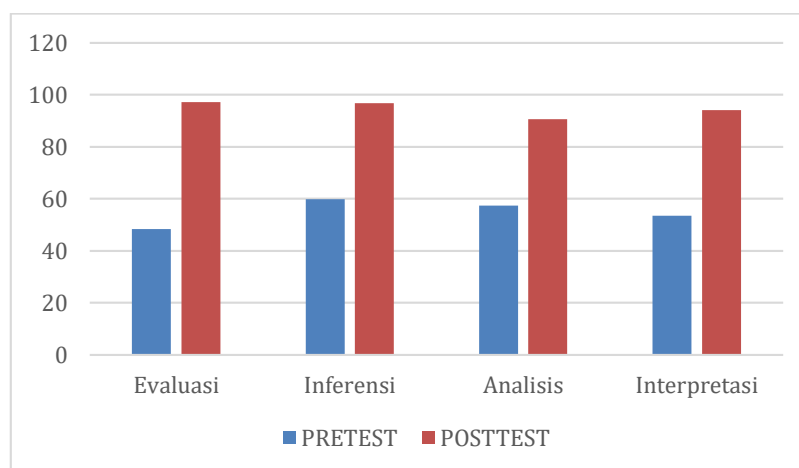


Figure 2. Graph of Improvement in Critical Thinking Ability

The increase in critical thinking skills per indicator can be seen from the difference in graphs between pretest and posttest. The pretest results on the first critical thinking indicator item, namely Evaluation, showed 48.3% of a total of 91 students answered correctly. After giving the differentiated e-module, the posttest results increased to 97.2% of students answered correctly. In the second indicator item, namely Inference, 59.8% of students answered correctly in the pretest question and increased to 96.8% of students answered correctly in the posttest question. In the third indicator item, namely Analysis, 57.5% of students answered correctly on the pretest question and increased to 90.6% of students answered correctly on the posttest question. In the fourth indicator item, namely Interpretation, 53.6% of students answered correctly on the pretest question and increased to 94.1% of students answered correctly on the posttest question. Analysis of the improvement of students' critical thinking skills in addition to being calculated per-indicator, is also calculated as a whole using the N-Gain test. The combined N-Gain test results from 91 students from classes XI-3, XI-4 and XI-5 get an average of 0.85, so it is in the high category.

Critical thinking skills are one of the basic abilities that students should have in the 21st century. Critical thinking skills refer to a person's ability to consider alternative decision-making and problem solving, by analyzing situations, evaluating arguments, and drawing accurate conclusions (Wahyuni et al., 2022). According to Karim & Normaya (2015), there are four aspects of critical thinking, which include Interpretation, Analysis, Evaluation and Inference. From the results of the research that has been done, it is found that there is an increase in students' critical thinking skills. The results of the N-Gain test of 91 students from classes XI-3, XI-4 and XI-5, obtained an average N-Gain score of 0.85. From the average value that gets a score above 0.75, it can be seen that there is an increase in critical thinking skills in the high category in all test classes. The use of differentiated e-modules on the material of the Body Defense System with the implementation of process, content and product differentiation is proven to be able to improve students' critical thinking skills. This is in line with Avandra & Desyandri's research (2022), which states that the

implementation of differentiated learning can improve students' critical thinking skills because students can learn according to their readiness, interests and learning styles. Another study also stated the same thing, that differentiated learning was able to improve students' critical thinking skills from pre-cycle to the last cycle (Seno & Utami, 2023). Before participating in learning using differentiated e-modules on the material of the Body Defense System, the indicators of students' critical thinking skills were lower than after learning using e-modules. There are four critical thinking indicators tested in this study, including Evaluation, Inference, Analysis and Interpretation (Karim & Normaya, 2015).

From the pretest and posttest results, the four critical thinking indicators experienced a significant increase. The evaluation indicator increased from 48.3% to 97.2%, inference from 59.8% to 96.8%, analysis from 57.5% to 90.6% and interpretation from 53.6% to 94.1%.

The analysis indicator is the indicator with the lowest percentage score compared to other critical thinking ability indicators, after learning using differentiated e-modules. The low score of analysis compared to the other three indicators is because students have not been able to identify conceptual and actual linkages from statements or questions. Students are still rarely trained in analysis indicators. Students must be able to test ideas and express reasons and statements. Students have not been able to analyze a problem and choose the right strategy in solving the problem (Agnafia, 2019). The evaluation indicator is the indicator with the highest score after learning using differentiated e-modules. The high score of evaluation compared to the other three indicators in two of the three test classes was due to the utilization of technology as a learning medium that could improve students' evaluation skills. This is in line with the research of Muthmainnah et al (2022), which states that with the use of technology and exposure to information presented digitally, it can make students able to evaluate the reliability of their information sources. In the case of differentiated e-modules, students are presented with a variety of representative and diverse learning media on one platform, such as text, images, audio and video, so that students are easier to access material and are able to compare and evaluate the reliability of the material sources presented.

The percentage of completeness of pretest and posttest scores obtained by 91 students combined from classes XI-3, XI-4 and XI-5 is presented in Figure 3.

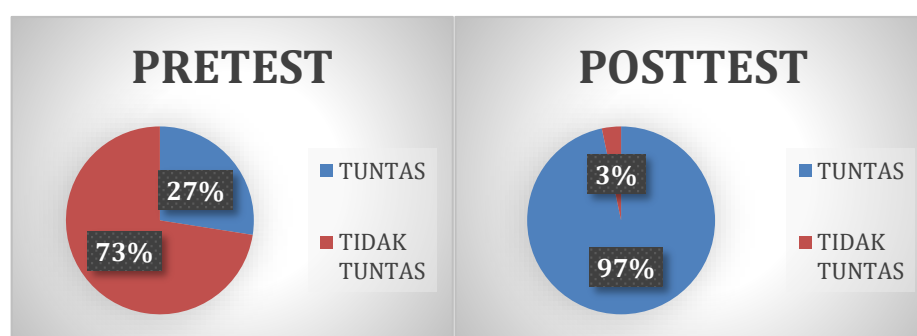


Figure 3. Pretest and Posttest completeness of students

The effectiveness of differentiated e-modules in improving student learning outcomes is seen from the percentage of student learning completeness before and after e-modules. The pretest results showed that the percentage of complete students was only 24% of a total of 91 students. After giving the e-module, the percentage of students' completeness tested using posttest questions showed a significant increase, namely to 97% of students completed out of a total of 91 students.

Analysis of the increase in the ability of student learning outcomes is not only calculated from the completeness value of students, but also calculated as a whole using the N-Gain test. The combined N-Gain test results of 91 students from classes XI-3, XI-4 and XI-5 get an average of 0.85, so it falls into the high category.

Improving critical thinking skills is one of the indicators that correlates with student learning outcomes (Ramdani & Badriah, 2018). The results showed an increase in learner outcomes. This further strengthens the opinion that critical thinking skills correlate with student learning outcomes. Of the three test classes, all three experienced an increase in learning outcomes. Before learning using differentiated e-modules, class XI-3 got a percentage of completeness of 73% of 33 students. After learning, the percentage of completeness rose to 100%, or all students completed by scoring above the KKM. Similar to XI-3, class XI-4 also experienced an increase in completeness, from the original 4% completeness percentage increased dramatically to 88% after learning using differentiated e-modules. In class XI-5 with 33 students, the percentage of completeness before learning using differentiated e-modules was only 3%. After learning to use differentiated e-modules, the results increased sharply to 100%, or all students completed with scores above the KKM.

Based on the N-Gain test, student learning outcomes in all three classes have improved and are in the high category with an average score of 0.85. The high N-Gain score is due to the fact that students have learned with media that can facilitate their learning style, so that critical thinking skills and learning outcomes can be improved. This is in line with previous research which stated that differentiated learning is effective in improving student learning outcomes (Herwina, 2021). In differentiated learning, the main orientation is the creation of a learning environment that is in accordance with the characteristics of students. Therefore, students are more comfortable in learning and have implications for improving student learning outcomes (Jefri & Yasa, 2024). Apart from differentiated learning, the increase in student learning outcomes is also due to the effective use of learning media. This is in accordance with the research of Faradila & Aimah (2018)

## **CONCLUSION**

Based on the results of the analysis and discussion that has been carried out, it can be concluded that the interactive e-module on differentiated learning has proven to be feasible and effective in improving students' critical thinking skills and learning outcomes in the Body Defense System material. However, in the development of the next differentiated e-module, it is better to design the e-module by having more features, content and questions that train students' analytical skills. In addition, the feasibility validation instrument needs to be further refined, especially on the indicator of critical thinking ability.



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