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Development of Based Biology Modules Discovery Learning to Improve Critical Thinking of Class XI High School Student's

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ABSTRACT: Critical thinking is one aspect of thinking skills that have to be developed in the 4.0 century. Critical thinking has an important role in the learning process. Students with high critical thinking skills will make a high contribution in increasing mastery of concepts. Therefore, an initial investigation was carried out by interviewing biology teachers and giving questions to students of class XI science at SMA 12 Negeri Padang. It is known that critical thinking in students is still low. One of the causes is an inadequate module. Therefore, students need appropriate modules to improve critical thinking. This type of research is development research using the Ploompdevelopment model. The model stage consists of the initial investigation, prototyping, and assessment. The research data were obtained from validity, practicality, and effectiveness tests. The results showed that the biology module that was developed according to the expert review obtained a value of 87.70% very valid category. The results of the practicality test by the teacher obtained a value of 93.97% in the very practical category and the results of the practicality test by the students obtained a score of 86.67% in the very practical category. The results of the effectiveness test of the critical thinking aspect in six categories showed a significant increase in students' critical thinking based on the N-Gain test carried out on the respiratory system. While the excretory system results in the N-Gain value of the experimental class 0.36 medium category and controls 0.30 medium categories

KEYWORDS: Development, Module, Discovery Learning, Critical Thinking

I. INTRODUCTION

The development of Science and Technology (IPTEK) which is currently taking place is happening very rapidly in various fields, especially in the field of information. This allows for information to be obtained quickly and easily. Therefore, with the increasing development of science and technology, it should be accompanied by an increase in the quality of Indonesian human resources, especially Indonesian youth who act as agents of change and agents of control in the development of science and technology. Entering the 21st century, the national education system faces very complex challenges in preparing quality human resources (HR) that can compete in the global era. Quality efforts and the only forum that can be seen and should function as a tool to build high-quality human resources in education.

Education is a basic thing needed to live life. The educational challenge that must be faced in the life of the 21st century is that students are required to master various skills. In general, important skills in the 21st century are still relevant to the four pillars of life which include learning to know, learning to do, learning to be, and learning to live together. Learning to know is an activity to acquire, deepen, and utilize knowledge and skills material and be able to inform it. Learning to be, students can work and study together with various groups in various types of work and social environments, and can adapt to changing times. Learning to live together, students learn together so that students can be actively involved in discussions, monitor learning strategies and achievements, and students become critical thinkers. Each of these four principles contains specific skills that need to be empowered in learning activities, such as critical thinking skills, problem-solving, metacognition, communication skills, collaboration, innovation and creation, information literacy, and various other skills [1].

The ability to think critically is contained in the principle of learning to do and is the main ability in 21st-century learning. Critical thinking skills include the ability to access, analyze, synthesize information that can be taught, trained, and mastered. In addition to these abilities, critical thinking skills also describe other abilities such as communication and information skills, the ability to examine, analyze, interpret, and evaluate evidence. Therefore, critical thinking skills are needed by students to face the era of digital literacy where information is very abundant from various sources and the truth is not yet known [1]. When students have critical thinking skills, these students do not just believe in the facts around them without doing proof and trying to prove that the information is very valid and can be accounted for [2].

According to Greenstein critical thinking is a way of thinking about any subject, content, or problem where thinking can improve the quality of its thinking by changing the structure of thinking and increasing intellectual standards [4]. Meanwhile, Permana defines critical thinking as a logical and reflective thinking skill that focuses on determining what to do. Critical thinking skills include analyzing, evaluating, and reconstructing information to make decisions and follow-up skills [6]. Furthermore, Mahanal argues that critical thinking skills will help students to deal with social problems, scientific problems, and practical problems effectively. Therefore, these skills can be integrated into the learning process through practice and stimulation [7]

According to Facione, critical thinking is one of the main goals of the contemporary curriculum. It is reflective decision-making and a wise decision about what to believe and do. Facione divides critical thinking skills into 6 skills and each is broken down into sub-skills [10]. more details can be seen in Table 1.

Table 1. Critical Thinking Skills

Aspects of Critical Thinking Skills	Definisi
Interpretation	Learners understand and express the meaning or significance of various experiences, situations, data, events, judgments, conventions, beliefs, rules, procedures, or broad criteria.
Analysis	Learners identify inferential relationships between statements, concepts, descriptions, data, or other forms of representation intended to express beliefs, judgments, experiences, reasons, information, or opinions.
Inference	Learners identify and define the elements needed to draw reasonable conclusions; formulate conjectures and hypotheses; consider relevant information and mitigate the consequences that flow from data, statements, principles, evidence, judgments, beliefs, opinions, concepts, descriptions, questions, or other forms of representation..
Evaluation	Students assess the credibility of statements or other representations that provide explanations or descriptions of a person's perceptions, experiences, situations, judgments, beliefs, or opinions; and to assess the logical strength of actual or intended inferential relationships including statements, descriptions, questions, or other forms of representation.
Explanation	Students state the results of reasoning, justifying the reasoning based on considerations of evidence, concepts, methodology, criteria, and context; Presenting reasoning in the form of convincing arguments
Self-Evaluation	Self-aware learners monitor one's own cognitive activity, the elements involved in that activity, especially by applying skills in analysis, and self-evaluation.

Facione divides critical thinking into six abilities, namely interpretation, analysis, inference, evaluation, explanation, and self- regulation. In fact, what is found in the field is that students only memorize concepts to achieve learning goals and tend to be less able to use biological concepts to solve problems in everyday life. Most students are still not able to connect the knowledge they have acquired by applying this knowledge to new conditions or situations. As a result, students do not understand science well [10].

Furthermore, according to Watson and Galser critical thinking is a series of activities in the discovery learning process is a structured activity in critical thinking skills. Thus the science learning process with discovery can stimulate students to think critically. Improvement efforts to improve critical thinking skills with discovery learning are focused on providing opportunities for students to actively build knowledge, meaning that knowledge is found, formed, and developed by students both individually and in groups using cooperative learning [5]. This is because learning is a social process that cannot occur without interaction between students [11]. Learning activities and working cooperatively in small groups can facilitate the development of critical thinking skills.

The discovery learning model makes students play an active role in the learning process by answering various statements or problems, solving problems to find basic concepts [] Furthermore, Discovery Learning is chosen as a learning model in developing modules because the problems encountered in SMA Negeri 12 Padang are that learning is still not optimal. in improving students' critical thinking skills, so students need to be trained to carry out critical thinking processes with teacher guidance first. The problem-solving process in the Discovery Learning model includes a critical thinking process. Critical thinking can provide opportunities for students to understand problems more directed and systematic, encourage students to gain experience by doing activities that allow them to find concepts and principles for themselves, students will always be actively involved in observing, identifying, analyzing, reason, classifying and draw conclusions. therefore critical thinking and problem-solving are important aspects of learning in the 21st century. The relationship between discovery learning models and critical thinking skills can be seen in Table 2.

Table 2. Relation of Discovery Learning Model with Critical Thinking Ability

Stages	Activity	Critical thinking skills
Stimulation	Students read reading material in the form of articles to train students to understand and express the meaning contained in the article	Interpretation
Identification of problems	Students identify problems by formulating problems and making hypotheses so that they train students to express the meaning contained in articles/discourses.	Interpretation
Data Collection	Students collect data from various sources of information so that students are trained to identify relationships from the information used to express opinions	Analysis
Data Processing	Learners process the information obtained by answering the questions presented	Inference & self-regulation
Verification	Students prove the results of the information that has been collected against the hypotheses that have been made	Evaluation
Generalization	Students make conclusions based on the information that has been collected and communicate it	Explanation

Based on the description above, it is necessary to research about "Development of Discovery Learning-based biology learning modules to improve students' critical thinking skills in class XI SMA".

II. METHOD

This type of research is design and development research to produce valid, practical, and effective learning modules. Development research aims to produce certain products and test the effectiveness of these products. In the study, a Discovery Learning-based module was developed to improve student's critical thinking on the material of the respiratory system and excretory system for class XI students of SMA N 12 Padang. The development of this Discovery Learning-based module uses Ploomp development. the research phase consists of three stages, namely: the first stage of the initial investigation (preliminary research phase), consisting of 3 stages, namely curriculum analysis, teacher interviews, analysis of student needs, analysis of teaching materials, and concept analysis. Then the second stage of development or prototyping phase (development or prototyping phase) consists of 4 stages, namely Prototype 1, Prototype 2, Prototype 3, and Prototype 4 then the third stage is the assessment (assessment phase) [12].

III. RESULTS AND DISCUSSION

The development of the Discovery Learning-based module to improve the critical thinking of class XI students of SMAN 12 Padang was developed through a series of processes. The process is by the stages of research that exist in research development (research development). This development research consists of three stages, namely the initial investigation stage, the development stage and the prototyping phase (development and prototyping phase), and the assessment phase (assessment phase). This module was developed based on several revisions, the results of which were a valid, practical, and effective product. According to Nieveen in Plomp that the criteria for getting quality [14].

a good product is determined from the assessment of validity, practicality, and effectiveness. The process of expert validation involves three lecturers as validator experts (expert review) and 3 teachers of Biology as a validator practical, following the opinion by Sugiono that product validation can be done by an expert or experts who are experienced to assess new products that are designed so that the next strengths and weaknesses can be identified. The criteria for the validity of a product being developed are in several aspects of didactic, construct, and technical [15]. Based on the validation results from the constructed aspect. The criteria for the level of validity can be seen in Table 3.

Table 3. Criteria for Determining Module Validity Level

Validation Value (%)	Category
0-20	Invalid
21-40	Less Valid
41-60	Quite Valid
61-80	Valid
81-100	Very Valid

The category targeted by the researcher in this study was a validation value of 61-80% in the valid category. Based on the results of validation by experts, the results obtained 87.7% with very valid categories from didactic aspects, construct aspects, technical aspects, and language aspects. The value for each aspect can be seen in Table 4.

Table 4. Validity Results by Experts

No	Aspect	Score (%)	Category
1	Didactic aspect	84.9%	Very Valid
2	Construct aspect	91.2%	Very Valid
3	Technical aspect	88.4%	Very Valid
4	Language Aspect	90.0%	Very Valid
Average		87.7%	Very Valid

On the practical aspect according to Nieveen in Plomp states that practicality for good product quality refers to interventions (products) that are developed and taken into consideration for use by teachers and students as users and make it easier for them [14]. Based on this, the target for the practicality assessment of the Discovery Learning-based module developed is the use of Discovery Learning-based modules, in this case, assessed by teachers and students. The practical assessment of the Discovery Learning-based module is carried out in stages, starting from the assessment of the one-on-one evaluation stage, small groups and large groups, and assessments by teachers. For practicality, criteria can be seen in Table 5.

Table 5. Criteria for Determining the Practicality Level of the Module

Practicality Value (%)	Category
0-20	Not Practical
21-40	Less Practical
41-60	Practical enough
61-80	Practical
81-100	Very Practical

The category targeted by researchers in this study is the practicality value of module 61-80% in the practical category. Based on the results of the one-to-one, small group practicality questionnaire, it is seen in Table 6.

Table 6. Results of the Practicality Level of one to one and Small Group module based on Discovery Learning

No	Question	Score		Category
		one to one	Small group	
1	Component Fittings	86.3	75.0	Very Practical
2	language	88.3	82.0	Very Practical
3	Presentation	95.8	85.4	Very Practical
4	Graphics	98.0	84.0	Very Practical
Average		92.1	82.0	
		Very Practical	Very Practical	

Based on the results of the large group and teacher practicality questionnaire, it can be seen in Table 7.

Table 7. Results of Field and Teacher Practicality Levels for Discovery Learning-based modules

No	Question	Score		Category
		Field	Teacher	
1	Ease of use	86,6	94,8	Very Practical
2	The attraction of the dish	87,0	97,9	Very Practical
3	Efficient usage time	85,6	91,6	Very Practical
4	Benefit	87,3	91,6	Very Practical
Average		86,6	93,97	
		Very Practical	Very Practical	

After the Validation test by the experts and the Practicality test by the teacher and all students were carried out, the Effectiveness test was carried out with the Valid and Practical module. Effectiveness Test This research was conducted to determine students' critical thinking skills using discovery learning-based modules. The concept used in this study is the respiratory and excretory system which was carried out in 8 meetings with different treatments in each class. Discovery Learning is a demanding cognitive learning teacher to be more creative to create situations that make active learners find knowledge alone [17]. Based on the results of the Effectiveness Test, the results of the increase in Critical Thinking of students in class XI SMA Negeri 12 Padang.

The process of finding one's knowledge can be done through discussion, reading, and self-testing, independently seeking information from various sources. Thus, students will play an active role in learning. The six syntaxes in the discovery learning model are followed by the opinion of Jerome S. Bruner which includes simulation, problem identification, data collection, data processing, verification, and generalization can improve students' critical thinking. Following Ennis' opinion that someone with critical thinking skills can behave systematically and regularly with parts of the whole problem. Existing systematic thinking will be further helped by the application of the six syntaxes that exist in the discovery learning model (Utomo, 2017: 1309).

Critical thinking ability is the thinking of someone who does not immediately believe what other people are doing, before he considers it with logical reasoning, and looks for other information in obtaining the most rational truth from that information (Suratman, 2017: 5). Critical thinking skills can help students solve problems in their lives by providing evidence and supporting reasons. According to Facione, critical thinking skills have six aspects, namely interpretation, analysis, inference, evaluation, explanation, and self-regulation [10]. The results of the effectiveness test of students in critical thinking on the respiratory system material can be seen in Table 8.

Table 8. Results of the Effectiveness of Students on the Materials of the Respiratory System

Indicators of critical thinking skills	Experiment class	Category	Control class	Category
Interpretation	88.3	Superior	80.0	Strong
Analysis	58.1	Not Manifest	28.1	Not Manifest
Inference	81.6	Strong	67.2	Not Manifest
Evaluation	86.1	Superior	88.8	Superior
Explanation	66.6	Weak	34.4	Not Manifest
Self-Regulation	67.2	Weak	73.3	Moderate

The results of the effectiveness test of students in critical thinking of the excretory system on the indicators of critical thinking skills in the experimental class and control class can be seen in Table 9.

Table 9. Results of the Effectiveness of Students on Excretory System Materials

Indicators of critical thinking skills	Experimentt class	Category	Control class	Category
Interpretation	95.0	Superior	87.2	Superior
Analysis	76.1	Moderate	53.3	Not Manifest
Inference	70.0	Moderate	60.0	Not Manifest
Evaluation	86.1	Superior	73.0	Moderate
Explanation	81.0	Strong	55.0	Not Manifest
Self-Regulation	67.0	Weak	47.8	Not Manifest

Based on Tables 8 and 9 above, it can be concluded that the indicators of critical thinking skills in the experimental class are higher than the control class. Furthermore, the N-Gain Test was carried out to measure the increase in learning outcomes after the learning was carried out by the teacher. In the experimental class, learning is applied using the Discovery Learning-Based Module that has been validated, while in the control class, learning uses the modules provided at school [8]. Based on the calculation results, the N-Gain value of critical thinking skills in the experimental class and control class based on the results of the Posttest and Pretest scores can be seen in Table 10.

Table 9. Students' N-Gain Values on the Materials of the Respiratory System and Excretion System

Material	Class	Test	N	X Min	X max	X	N-Gain
Respiratory system	Experiment	Pre-test	36	20	84	52.00	0.37
		Post-test		64	90	77.00	
	Control	Pre-test	35	57	83	70.00	0.04
		Post-test		37	97	67,00	
Excretory System	Experiment	Pre-test	36	60	85	72.50	0.36
		Post-test		70	90	80.00	

Based on the value of the N-Gain test, it is known that the critical thinking of students in the experimental class on both materials is higher than the N-Gain value of the control class on both materials [8]. More details can be seen in Diagram 1.

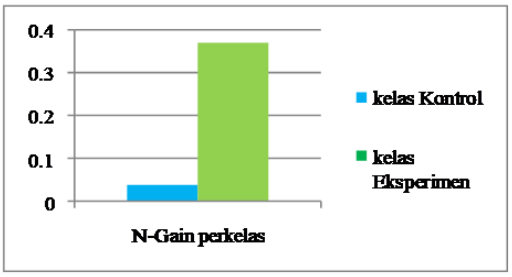

Diagram 1. N-Gain Value of Critical Thinking Ability Per Experiment Class and Control Class

Furthermore, the N-Gain grouping of critical thinking skills is based on the number of students in the experimental class and control class which can be seen in Diagram 2.

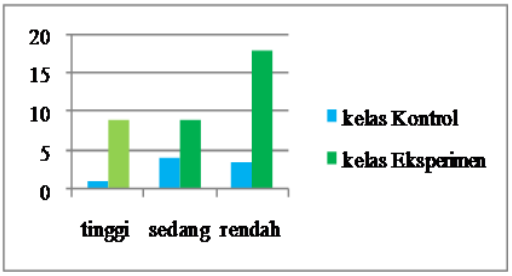

Diagram 2. N-Gain Value of Critical Thinking Ability in the Experiment Class and Control Class Based on the Number of Students

Diagram 2 shows that the ability to think critically in the low category in the experimental class is less than the control class, in the experimental class 50.00% students while in the control class 83.33% students. In the medium category in the experimental class, there are 25.00% students while in the control class 11.11% students. In the high category in the experimental class, there are 25.00% students while in the control class 2.77% students. So it can be concluded that the critical thinking ability of students in the experimental class is higher than the control class. Furthermore, the grouping of values based on indicators of critical thinking ability can be seen in Diagram 3.

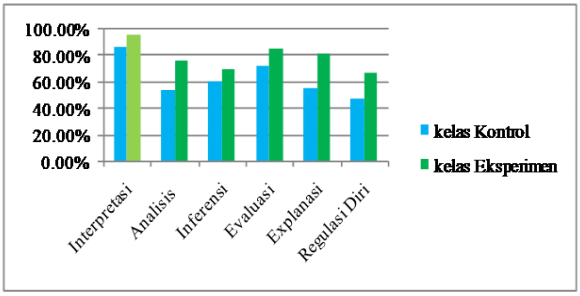

Diagram 3. Critical Thinking Ability Indicator Value in Experiment Class and Control Class

The diagram above shows an increase after each was given a different treatment, both in the experimental group and the control class. Aspects of interpretation, analysis, inference, evaluation, explanation, and self-regulation have a high improvement compared to the control class. This shows that the use of Discovery Learning-based modules has a very good effect on increasing critical thinking for students in class XI IPA SMAN 12 Padang.

IV. CONCLUSION

Based on the results of research and testing of Discovery Learning-based modules to improve critical thinking for class XI senior high school even semesters that have been carried out, it can be concluded that Module Validation is assessed based on the expert review, expert reviews are carried out according to the results of expert assessments of the module product developed which is considered valid by minor revision. The average number of assessments of didactic aspects, construct aspects, and technical aspects are an average of 87.7% with a very valid category.

The results of the practicality test show that the Discovery Learning Biology Module to improve critical thinking in terms of practicality, starting from the aspect of feasibility, language, presentation, and graphics based on the teacher's assessment, obtained a score of 93.97 with very practical criteria, and from the assessment of students obtained a score of 86, 67% with very practical category.

The results of the effectiveness test were carried out in class XI of SMA N 12 Padang, which amounted to 36 people with an average cognitive aspect learning competence result in the experimental class of 80.00 and the control class of 65.37 there was a significant difference between the experimental class and the control class. Furthermore, based on the results of the N-Gain data calculation, the experimental class and the control class showed an increase in critical thinking skills. With the acquisition of the average N-Gain value in the experimental class on the respiratory system material of 0.37 and the excretory system obtained by 0.36 while in the control class on the respiratory system the average N-Gain value of 0.04 and excretory system material by 0.30. The average value of N-Gain in both classes is in the medium category, which means that the critical thinking skills of both classes are classified as good.

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