



The effectiveness of discovery learning module classification of materials and its changes to enhance critical thinking skills

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Abstract: This study aims to determine the effectiveness of natural science modules with discovery learning to enhance students' critical thinking skills in the topic of material classification and its changes. Critical thinking skills are one of the essential skills of the 21st century and are needed in various fields. Students with high critical thinking skills in general also can calculate various possibilities so that they can make decisions by applying logical thinking. Discovery learning trains students to build knowledge and develop student competencies independently. The research method was quasi-experimental with a nonequivalent pretest and posttest control groups design. The sampling technique employed was purposive sampling. The research instrument used a test of critical thinking skills. Data analysis was carried out with a different power test (t-test) to determine the difference between the experimental and control classes, and an N-Gain calculation was done to determine the effectiveness of the discovery learning module. The results showed a difference in critical thinking skills between the experimental class and the control class. The N-Gain result of the experimental class was 0.59, with a moderate category, and the control class was 0.31, with a moderate category.

Keywords: Critical thinking skills, Discovery learning, Material classification and its changes

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INTRODUCTION

The development of education takes place quickly and adjusts to the current development. Rapid changes occur in various fields, such as technology, knowledge, economics, information, and so on (Sümen & Çalişici, 2017; Redhana, 2019; Rizza et al., 2019). Education currently directs the efforts to achieve competencies, especially 21st-century skills, through the learning process. The learning results are the final part of a stage of the process. Students directly involved in the learning process to reach specific knowledge or concepts gain helpful experience in understanding other concepts. Hands-on and mind-on activities in learning show an increase, and students become active and have better learning outcomes (Ateş & Ali, 2011; Salami, 2014).

21st Century skills become essential for students for academic and life matters (Chalkiadaki, 2018). One of the changes in education is the role of the teacher not being a centre of learning to gain knowledge, but students explore and understand knowledge from learning activities with friends. Student activities can be constructing concepts independently through practicum, exploring places, looking for sources of knowledge from various parties, or designing independent activities. The teacher encourages students to construct understanding and ask supporting questions; the delivery of information does not only come from the teacher (Wong et al., 2016).

Natural science learning is synonymous with investigation and discovery. The dimension of natural science consists of attitudes, processes, and products. Investigation activities are part of the science dimension in a process. An investigation will produce findings in the form of products. Investigation activities stimulate students to be motivated to learn, develop skills, and build meaning from scientific knowledge (Suduc et al., 2015). Natural science teaching is complex because it allows



students to develop conceptual understanding, procedural knowledge, the nature of science, application, and socio-scientific issues (Moeed, 2013).

Based on the results of observations and interviews in one of the schools, natural science learning has not directed students to develop 21st-century skills, namely critical thinking skills. Some facts found are first, learning in class has not presented a natural phenomenon to be observed or investigated. Second, students have not been involved in the investigation process, so it could affect students' ability to investigate and analyze the results of experiments. The ability to analyze is part of critical thinking skills. Third, students have not been trained in critical thinking as evidenced by the difficulty in giving reasonable answers, did not have alternative opinions other than from books, did not provide arguments accompanied by facts, and the ability to evaluate a statement was not correct. Classroom learning was done by giving materials and the question-and-answer section. Investigation activities were still rarely performed.

During the time, learning in schools using books from the government, teachers have no other alternative as a source of learning. One example is a module. Modules as teaching materials benefit that students can learn independently according to the speed of learning ability, explore more through module activities, and practice the ability to analyze the phenomena contained in the Module. Some researchers explain that the application of the Module is practical for the use of chemistry learning and science competence (Yerimadesi et al., 2018; Herlily et al., 2018).

The material classification and its changes have sub materials, namely the form of matter; classification of elements, compounds, and mixtures; the nature of the acid, base and salt solutions; mixed separation method; and physical and chemical changes. The scope of this material is classified as many, and students have difficulty understanding the material that is mostly chemistry. Students have not studied chemistry in depth at the previous level, which causes weak critical thinking skills. Types of difficulties for students are writing elemental symbols, changing the colour of litmus indicators, working principles of mixture separation, and objects undergoing physical or chemical changes.

The use of discovery-based modules becomes a learning process tool to develop thinking skills. Student discovery through proving the results of practicum train the ability to think, students think intensely accompanied by supporting reasons so that trained critical thinking. Critical thinking skills training can be carried out in learning by integrating appropriate learning models and incorporating critical thinking indicators from experts. One learning model that can be used is discovery learning. Through this learning, students can build knowledge through inquiry activities. Data obtained as evidence from the investigation reveal a specific meaning. This learning requires students to be active, creative, and innovative in developing concepts, laws, and principles. The involvement of cognitive processes affects the intellectual development of students, especially in higher-order thinking (Arianda et al., 2018).

The basis of discovery learning is constructivism. Students need meaningful experience in constructing knowledge. The role of the teacher in learning is not much involved and not as a focus in class (Anyafulude, 2013). Submission of material in this learning is not given directly, but students are asked to actively find concepts or principles from practicum (Sahara et al., 2017). Students develop knowledge based on information and data collected from the environment (Jong & Joolingen, 1985).

Discovery learning is one of the cognition learning models that involve students actively seeking knowledge independently. Students learn by finding solutions to a problem. Previous experiences are linked to becoming meaningful knowledge (Dalyono, 2009). Discovery learning focuses students on gaining knowledge in their way. Students develop creativity to solve problems with practicum or science experiments. The investigation results obtained by the students were then analyzed thoroughly. At this stage, students connect previous knowledge or experience obtained with data from practicum to obtain the concept of science. Discovery learning stages are observation, manipulation, generalization, verification, and application. The discovery learning models are included in the early learning level with discovery learning sequences, interactive demonstrations, inquiry teaching, inquiry laboratories, real-world applications, and inquiry hypotheses. These levels of learning are known as levels of inquiry, as seen in Table 1 (Wenning, 2011).

Tabel 1. The Hierarchy Levels of Inquiry

Discovery Learning	Interactive Demonstration	Inquiry Lesson	Inquiry Laboratory	Real-world Applications	Hypothetical Inquiry
Low	←	Intellectual Sophistication	→	High	
Teacher	←	Locus of control	→	Student	

The distinguishing factor between levels is intellectual ability and controlling the learning process. Discovery learning is for students with low intellectual abilities and gets more teacher supervision. The teacher guides students to observe, practicum, analyze and discuss, and make concepts and knowledge from the activities carried out during learning. At the same time, the different levels of inquiry are explained in Table 2 (Wenning, 2011).

Table 2. Primary Pedagogical Purpose in Inquiry

Levels of Inquiry	Primary Pedagogical Purpose
Discovery Learning	Students are trained to develop concepts based on direct experience
Interactive Demonstration	Students provide explanations and predictions that make it possible to get, identify, face, and complete concepts
Inquiry Lesson	Students identify scientific principles and relevancy
Inquiry Laboratory	Students establish empirical laws based on variable measurements
Real-world Applications	Students solve authentic problems individually or in groups using a problem and project approach
Hypothetical Inquiry	Students make an explanation of an observed phenomenon

Critical thinking skills have become one of the aspects of prioritized skills in learning today. Critical thinking for students is vital as part of an ongoing thinking process. The education system prepares students with dynamic character to ask questions, solve problems, think critically, and be creative (Barell, 2010). In line with this, the 2013 curriculum expects an increase in critical thinking in learning (Setianingih et al., 2019). Students can develop critical thinking skills, think logically, make sense, and be directed. The ability to be achieved can be in the form of explaining the problem, analyzing the statement, evaluating, assessing the truth of the statement, and concluding. A process that involves critical thinking will enable a person to make reliable and valid decisions, act ethically, and adapt to changes in the particular environment (Chukwuyenum, 2013). According to Sarigoz (2012), critical thinking skills include the ability to express opinions, analyze, understand scientific and creative thinking processes, and judge and make decisions correctly. There are five steps in developing critical thinking skills, as seen in Figure 1 (Limbach & Waugh, 2012).

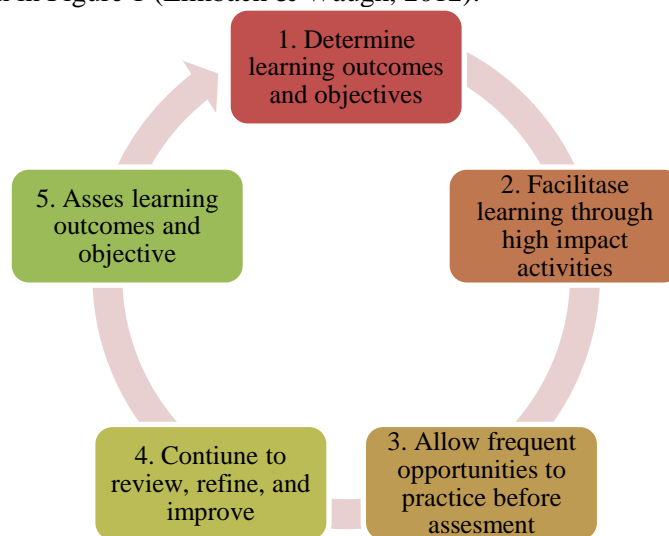


Figure 1. Steps to Development Critical Thinking

Learning development in schools is carried out by teachers to make learning variations. The teacher tries to develop various learning models to improve critical thinking skills. According to Yusuf (2012), the teacher makes pedagogical methods so that development goals can be achieved, namely: 1) Discussion of the importance of applying critical thinking; 2) Use of questions to analyze problems, compare and evaluate, make reasons for plans, and predict outcomes; 3) Doing exercises in decision making; 4) Providing critical issues; 5) Assignments in analyzing problems and discussing alternative theories; 6) Demonstrate active learning methods in completion using analysis and discussion of the assessment of scientific evidence.

RESEARCH METHODOLOGY

The research method employed a quasi-experimental design with a control group and pretest and posttest groups. The research was carried out in Magetan Regency Junior High School in 2019/2020. The study population was all students of VIIA-VIIH classes, as many as 224. The samples were 64 students. The research sample involved students of the VIIA class as an experimental class and VIIB as a control class, conducted by purposive sampling. The experimental class used the discovery learning module, and the control class utilized books from school. The research design is shown in Table 3 (Sugiyono, 2012).

Table 3. The Research Design

Classes	Pretest	Treatment	Posttest
Experimental	O ₁	X ₁	O ₂
Control	O ₃	X ₂	O ₄

Where O₁ =student ability before experimental treatment class, O₂ =student ability after experimental treatment class, O₃ = student ability before treatment control class, O₄= student ability after treatment control class, X₁ = treatment using discovery learning module, and X₂ = treatment using book from school

The research instrument was a critical thinking skill test with as many as six essay questions in the form of a description using indicators from Facione (2011). There are interpretation, analysis, inference, evaluation, explanation, and self-regulation, as seen in Table 4.

Table 4. Instrument of Test Critical Thinking Skills

Indicators of Critical Thinking Skills	Description	Question
Interpretation	Reveal the meaning of events, data, or observations	Interpret the type of solution based on the material
Analysis	Analyze scientific phenomena and their causes	Analyze the acidic, alkaline, and salt content
Inference	Summing up phenomena based on facts	Summing up the effects and causes of iron rust
Evaluate	Assess and review the correctness of the statement or data obtained	Evaluating the manufacture of fermentation-based foodstuffs
Explanation	Describe events according to facts and supporting evidence	Explain the impact of using chlorine in swimming pools
Self-regulation	Understand the thought process and validate the truth	Assess the type of change of an object

Two expert lecturers had validated the instruments with the results of the instrument declared valid and could be used. Before using the test, the validity and reliability tests were carried out. Pretest and posttest data were analyzed, employing normalized gain (N-gain). The calculation of N-Gain is shown as follows (Hake, 1999).

$$N-Gain = \frac{\text{posttest} - \text{pretest}}{\text{score max} - \text{pretest}}$$

The criteria of N-Gain are shown in Table 5 (Hake, 1999).

Table 5. Criteria of N-Gain

Score	Criteria
$(g) \geq 0.7$	High
$0.3 \leq (g) < 0.7$	Moderate
$(g) < 0.3$	Low

The effectiveness of discovery learning modules to improve critical thinking skills is known from the N-Gain value. Data were analyzed using IBM SPSS 25 software with statistical tests in normality, homogeneity, and t-test (independent sample t-test). Provisions for decision making using a significance level (α) of 0.05, that is, if sig (2-tailed) < 0.05 means that H_0 is rejected, whereas if sig (2-tailed) > 0.05 means that H_1 is accepted.

RESULT AND DISCUSSION

Two evaluation experts assessed the critical thinking skills test instrument. The instrument is an essay with six questions representing each indicator of critical thinking skills—initial analysis by doing validity and reliability tests in Tables 6 and 7.

Table 6. Validity Test

No.	r_{count}	r_{tabel}	Explanation
1.	0,508	0,349	Valid
2.	0,607	0,349	Valid
3.	0,462	0,349	Valid
4.	0,667	0,349	Valid
5.	0,415	0,349	Valid
6.	0,362	0,349	Valid

Table 7. Reliability Test

Cronbach's Alpha	N of Items
0.713	6

The result of critical thinking skills using the N-Gain normalized test is shown as follows:

Table 8. Result of Critical Thinking Skills

Classes	Pretest	Posttest	N-Gain	Criteria
Experimental	2,90	7,13	0,59	Moderate
Control	2,67	4,98	0,31	Moderate

The achievement of students' critical thinking skills on the topic of material classification and its changes through the use of discovery learning modules in the experimental and control classes as indicated by the value of N-Gain. The experimental class was 0.59 in the low category, while the control class was 0.31 in the moderate category. There were six indicators of critical thinking skills, namely, interpretation, analysis, inference, evaluation, explanation, and self-regulation. The highest indicator of the experimental class was the explanation with a value of 0.70, and the lowest was the evaluation with a value of 0.45. In the control class, the highest indicator was the interpretation with a value of 0.36, and the lowest indicator was self-regulation with a value of 0.24

In this study, learning science using discovery learning modules influenced students' critical thinking skills. This research aligns with Bayharti et al. (2019), who suggested that the discovery learning module could improve critical thinking skills and student learning outcomes. Besides, learning activities become more active because students connect new knowledge with knowledge acquired to get new concepts (Sulistiani et al., 2018). The use of discovery learning had an impact on students' thinking abilities. Students had direct experience in exploring this environment, making students have meaningful learning.

The achievement student of critical thinking skills was converted to the criteria:

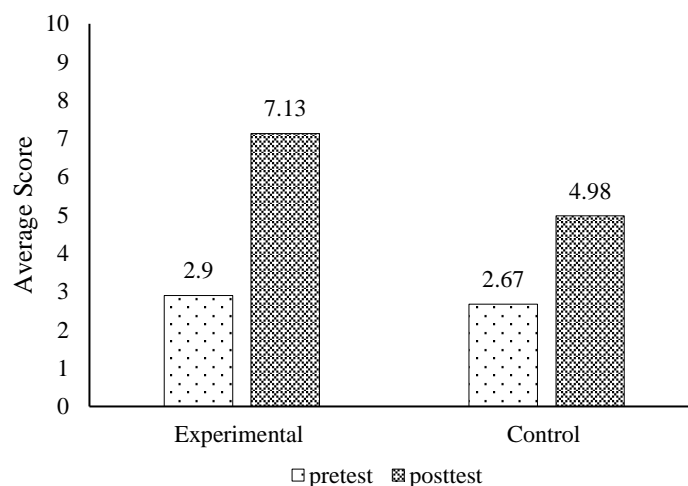


Figure 2. The score of Critical Thinking Skills

Then, data of student achievement for every indicator provides in Figure 3.

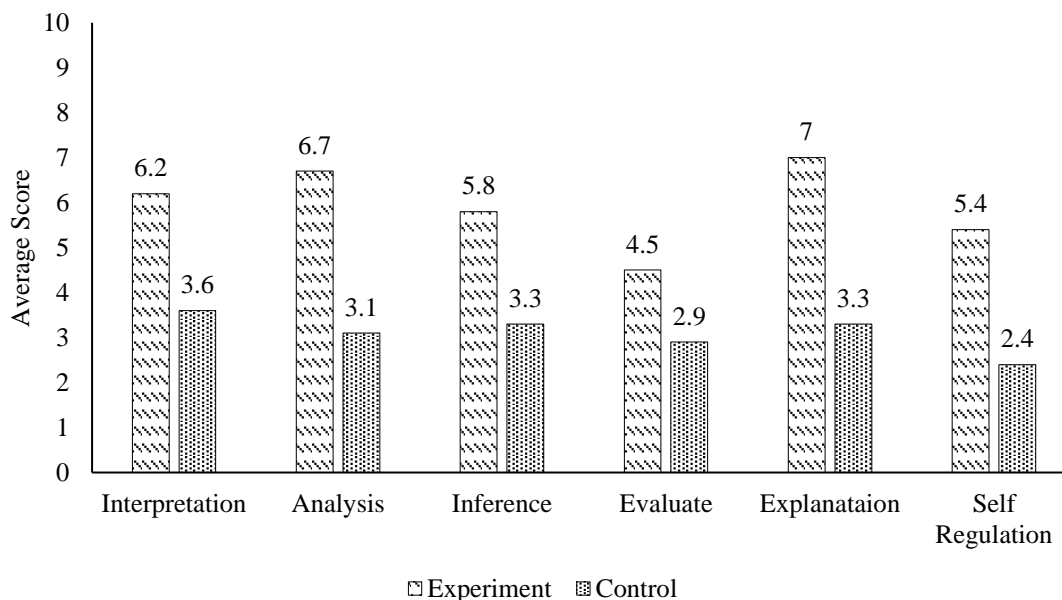


Figure 3. Achievement of Indicator Critical Thinking Skills

Table 9. Result of Critical Thinking Skill

Variable	Pretest			Post Test		
	Experiment	Control	Explanation	Experiment	Control	Explanation
Normality (Shapiro Wilk)	0,112	0,099	>0,05 (Normal)	0,722	0,059	>0,05 (Normal)
Homogeneity (Levene Statistic)	0,567		>0,05 (Homogenous)	0,277		>0,05 (Homogenous)
T-test (independent sample t-test)	0,204		(There was no significant difference)	0,000		(There was a significant difference)

According to Table 9, the effectiveness of using the discovery learning module was known from the t-test results of sig. 0.000 (sig <0.05). It was stated that the two classes had significant differences in the results of critical thinking skills with the treatment of learning using modules and utilizing teaching materials from school. Based on these results, learning the discovery learning module could improve critical thinking skills.

Student achievement for each indicator was different. The explanation indicator was 0.70 in the high category in the experimental class. The explanation is required for declaring a sentence, justification based on evidence, and reasoned arguments. Students had good ability in this indicator because, in the learning process, there were activities to explain the results of the experiment. These activities assisted students in thinking deeply, structured, and directed in problem or statement.

The lowest indicator was the evaluation, with a value of 0.45 in the medium category. It was evaluating means assessing a statement about the truth. Evaluation is intended to review statements used in expressing ideas, thoughts, opinions, or perceptions. In this indicator, students had difficulty because they could not assess an event being confronted appropriately. Besides, other factors can also be because junior high school students are at the formal operational stage, according to Piaget's cognitive theory. Grade VII students did not fully understand thoroughly because they were new to assessing and evaluating statements. It is in line with other researchers who argued that the evaluation indicators did not achieve maximum results and included the lowest category (Anggiasari et al., 2018; Andika & Setyarsih, 2019).

The implementation of discovery learning modules in this research impacted students' activities and thinking. Presentation of events or phenomena at the beginning of learning gave interest and curiosity to the studied material. The stage encouraged active students to conduct group investigations to find the results of the investigation as a basis for building knowledge. Students have the opportunity to practice collecting new data and information (Kurnianto et al., 2016).

In this study, the discovery learning module had characteristics that integrated the discovery learning model to improve critical thinking skills. Each stage of discovery learning had a range of critical thinking indicators. The implementation of each stage facilitated students in developing critical thinking skills. Observation activity is the initial stage of students to observe phenomena that increase curiosity and direct the next stage. This stage trains students in using the five senses to observe phenomena. Observation is an essential part of forming scientific knowledge in learning science (Hakkarainen & Ahtee, 2010). Manipulation is a stage where students explore curiosity through inquiry. Students develop the thought process of analyzing the results as findings are obtained.

Further, generalization is the activity of students discussing with friends about the data obtained, in which some questions lead to getting the concept. The verification phase is a means of conveying the results of discussions with other groups. At this stage, there is a process of assessing or evaluating other people's answers so that the truth of the findings can be justified. Students explain by linking information obtained before observation with findings during an investigation (Odja et al., 2014). The last step is the application, which is to apply findings obtained in other situations. Students provide other applications of the concepts given in certain conditions.

Based on these results, the application of discovery learning modules could improve students' critical thinking skills. It is supported by research from Wartono et al. (2018), Noviyanti et al. (2019), Fahmi et al. (2019) that the application of discovery learning can improve critical thinking skills. The other benefits are increased learning outcomes, the activeness of students learning improves, and more motivation in learning (Wahjudi, 2015; Rosdiana et al., 2017).

Learning material classification and its changes gives students the freedom to explore nature to investigate according to the material. According to the module instructions, student activities investigate the sugar content, classified into elements, compounds, and mixtures. Sub material properties of acidic, essential, and saline solutions by investigating the solution content, students can bring several types of solutions to be investigated. Furthermore, the mixture sub-material separation is filtration separation with several solutions, sublimation separation, and chromatographic separation. The last sub matter is physical changes and chemical changes by observing peeling and cutting fruits, lighting the wick of wax, cutting tissue, and dissolving yeast.

This learning material is quite complex, so teaching should provide hands-on experience. Students who carry out practicum or learning activities with activities have long memories rather than just reading, seeing, or listening as explained by (2013), students understand scientific knowledge with activities. The discovery learning module helps students learn and practise critical thinking. Students can fill in observations, practicums, or discussions independently. This activity can help students understand the phenomenon, look deeper and in detail, and remember the phenomenon (Yustyan et al., 2015).

Discovery learning module as teaching material supports students to understand the material more directed. Students can adjust their learning abilities and try more materials or objects to investigate. The modules are presented systematically and entirely so that users can study independently at school or home (Yerimadesi, 2016). The Module provides comfort for students to study in groups and discuss with friends or the community. The facilities and instructions for using the discovery learning module are well explained so that students can learn according to the direction of the Module so that learning objectives are achieved.

Learning science using discovery learning is related to the scientific way to acquire knowledge. The scientific approach is applied in science learning by integrating it into the discovery learning model. The scientific approach is related to working in the laboratory through observing, questioning, experimenting, associating, and communicating. Science prioritizes the scientific process to achieve results. A scientific process that is carried out correctly and coherently impacts the results of the experiment. If the stages are correct, the experimental results can be following the researcher's expectations.

Discovery learning module through scientific stages accompanied by a scientific approach trains students to think openly, increase curiosity, discipline, responsibility, and honesty. This trait belongs to the value character of scientists. The disclosure of facts based on observations and data from the discovery process makes students think about the meaning of the phenomenon. The development of knowledge by students is evidence that students have carried out the scientific process of science and discovery. One of the essences of science is the product. Products are knowledge buildings in concepts, facts, theories, laws, postulates, and models. Students have implemented the nature of science during the learning process.

The implementation of the discovery learning module in the classroom involves the active role of students to think and analyze to form general knowledge and principles from the material provided by the teacher. The constraints faced are time management which requires a proper preparation. Experimental activities and information processing take time to analyze and form concepts. Jacobsen (2009) suggested that the weakness of discovery learning is that learning takes a long time compared to other methods but has the advantage of forming long-term memory and exchanging better information or knowledge. For more information, see Table 10.

Table 10. Learning Activities using Module

Activities	Indicators
Observe the object in the environment	Interpretation
Perform sugar content experiments	Analysis
Discuss the results of practicum and make provisional conclusions	Inference
Evaluate the results of the experiment and give each other feedback	Evaluate
Explain and construct knowledge concepts based on facts	Explanation
Implement the results of knowledge in other activities	Self-regulation

The process of finding by the students in learning influences the way of thinking about something that is obtained. Students develop those results of the acquisition to find concepts. Discovery teaching involves students thinking from observing, obtaining data from inquiry, analyzing, and conveying results. This activity is related to students' critical thinking in dealing with phenomena. Students become more sensitive to the environment and understand natural science related to daily life to make learning more meaningful. Students with critical thinking skills will determine evidence-based actions to achieve the expected results (Anwar, 2017). Critical thinking can make students use evidence to achieve specific goals. When thinking critically, students use opinions to provide logical and relevant explanations.

The knowledge construction process is included in the natural science learning section. Students connect the results of the investigation obtained with previous experience. Through this, the students can understand knowledge directly. Understanding, in this way, can have a tremendous long-term impact that can be useful in dealing with everyday problems.

Learning by applying critical thinking skills according to the implementation design of learning in schools impacts student achievement and understanding. Motivation influences critical thinking,

which includes two factors, such as 1. There is belief, achievement, and learning objectives to carry out the thought process and learning efforts; 2—differences in the desire of each student's way of thinking.

The impact of learning that trains students' critical thinking skills in the classroom are shown in students' attitudes and behaviour. Students do tasks seriously, have persistence and independence, and make decisions rationally. Facione (2011) states that students who think critically are seen by taking action, namely carrying out practicum or working on problems sincerely, curiosity and always looking for information, choosing carefully, being diligent in facing problems, and solving problems with the right policies. In the long term, critical thinking aims to prepare to become successful citizens because it can make decisions, policies and solve problems in modern and developing life sensibly (Hodges, 2012).

Learning activities by discovery can increase students' critical thinking skills. It is consistent with Gustika et al. (2018) research that discovery learning can improve students' critical thinking. When students can think critically, they can influence how they act, think rationally, determine the right decision, and judge actions or statements. In everyday life, critical thinking skills are needed by students as a way to respond and solve problems so they can act wisely.

CONCLUSION

Based on the study results, it was indicated by the N-Gain results with a value of 0.59 in the moderate category by pretest and posttest in material classification and its change in the experiment class. In contrast, the control class obtained an N-Gain of 0.31 by the moderate category. The Module of discovery learning can enhance students' critical thinking. Critical thinking indicators are interpretation, analysis, inference, evaluation, explanation, and self-regulation. All indicators have an increase from the pretest to posttest results, and the highest N-Gain is indicator explanation by 0.70 while the lowest N-Gain is indicator evaluation by 0.45. Besides, learning in science can improve critical thinking skills by practising sustainability. Training students in critical thinking skills can be done by providing description questions that accommodate indicators of critical thinking skills, discussion in solving problems, and discovery activities involving physical and thinking skills.

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