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The Analysis of Students' Mathematical Critical Thinking Ability through Discovery Learning Models

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ABSTRACT

Critical thinking ability is an important part of mathematics learning for students in solving mathematical problems. A student who has critical thinking skills is a student who able to analyze facts, generalize and organize ideas, draw conclusions, discuss arguments, and solve mathematical problem. The focus of research is to measure students' critical thinking skills in mathematics. One way to measure students' critical mathematical thinking skills is to apply discovery learning models. Discovery learning model is one of the learning models that involves students actively in the learning process. This model has learning steps that can be applied to measure mathematical critical thinking skills. The study was conducted by giving students questions about pre-test and post-test. Data obtained from the results of the pretest and posttest were analyzed to measure the level of critical thinking skills of students using the gain index formula.

***Keywords*:** *critical thinking ability, mathematics learning,, discovery learning, mathematic education, learning models, critical thinking skills*

INTRODUCTION

One of the problems that often arise in the process of learning mathematics is the lack of students' ability to think critically mathematically. The learning problem is caused by several things, including the role of the teacher who tends to dominate learning, and lacks the opportunity for students to find their own strategies in solving problems, so students are accustomed to solving problems with direction from the teacher. In addition, mathematical concepts are often conveyed algorithmically and procedurally, and students are trained to solve many problems without deep understanding, the teacher lacks opportunities and facilities for students to conduct discussions, negotiations, presentations, and opportunities to ask less. As a result, students are accustomed to guided learning patterns and do not hone students 'mathematical critical thinking skills so that students' mathematical communication and problem solving abilities do not develop as they should.

In the 2013 curriculum, one of the competencies that students need to achieve is developing creativity, curiosity, and skill in formulating questions to form critical thoughts and lifelong learning. Thus, students also need to be equipped with certain skills so that they are able to develop and evaluate arguments in a particular problem solving and can be a quality human being and able to compete.

One of the skills that must be developed to achieve these goals is critical thinking skills. Critical thinking is an important part of the purpose of learning mathematics. This can be seen from the purpose of mathematics learning which emphasizes students to have: (1) mathematics-related abilities that can be used in solving mathematical problems, other lessons or problems related to real life; (2) the ability to use mathematics as a

communication tool; (3) the ability to use mathematics as a way of reasoning that can be used in every situation such as logical thinking, critical thinking, systematic thinking, honesty, discipline, in viewing and solving problems A student is said to have critical thinking skills if he is able to analyze facts, generalize and organize ideas, defend, opinions, make comparisons, draw conclusions, test arguments, and solve problems (Chance, 1986) in Rasiman (2013). Critical thinking skills can also improve systematic thinking and awareness in thinking so that these skills can support students in learning abstract mathematics and mathematical abstracts are one of the causes of students' difficulties in learning mathematics.

From the facts found in the field shows that mathematics teachers do not realize that students are also required to be able to think critically, so that they have a strong basis for learning mathematics. But to improve students' critical thinking skills through learning mathematics is not an easy job. The teacher must have the courage to take a stand by applying some innovative learning models using varied learning media so that the abstract mathematics can be simplified into a more concrete form and also directly related to the real world.

Fruner and Robinson in Rochaminah (2008:4) state that to improve mathema-tical critical thinking skills learning must be focused on learning models with various approaches rather than procedural skills. Success in learning is largely determined by the state of the learning process that is applied. One learning model that is thought to be used to improve students' mathematic critical thinking skills is mathematics learning through the application of *discovery learning* models.

According to Ruseffendi (2006: 329) the *discovery* model is a teaching model that regulates teaching in such a way that the child obtains knowledge that he did not know before but not through notification, partially or wholly by his own discovery. In other words, the learning model discovery is one way to convey the idea / ideas with the process of finding, in this process the students try to discover the concepts and formulas and the like with the guidance of teachers. The series of activities in the learning process of discovery are activities in critical thinking (Rochaminah 2008: 4).

LITERATURE REVIEW

Critical thinking is an important and vital topic in modern education. All educators are interested in teaching by giving critical thinking to their students. Critical thinking means thinking correctly in pursuit of relevant and reliable knowledge about the world. Another way to describe it is thinking that is reasonable, reflective, responsible, and focused on what needs to be done. Someone who thinks critically can ask the right questions, gather relevant information, efficiently and creatively sort through this information, reason logically from this information and come to the conclusion that can unbelievable. Critical thinking is a critical investigation, so that people who think critically are investiga-ting the problem, clicking ask question, clicking submit new answers that chal-lenge, discover new information ques-tioning the authority and traditional beliefs, challenging the accepted dogma and doktrin (Schafersman,1991).

In the research journal Emir (2009) states that there are significant beneficial diffe-rences in the 24-year age group that have been observed in the Critical Thinking. Disposition Points, self confidence and curiosity of various ages. Relying on these findings it can be stated that with increasing age groups an increase in the disposition of critical thinking. In his study that aims to determine the power level of critical thinking, level thinking skills that build on these strengths and factors affecting critical thinking skills, Kürüm (2002) have found that the ability of critical thinking of teachers trained in show variations with respect to their age. It was stated that the power of critical thinking and the level of interpretation-deduction as indicators of this

strength were higher in younger teachers than older ones.

However, in the research there is a fact that as we get older, the individual's confidence in his mental processes and his tendency to acquire and learn new things increase. As a result, teachers must have critical thinking facilities at first to teach them to their students. Moreover, a variety of methods and techniques should be used, and the number of studies in this area should be improved to develop the ability to think critically and character of the great students of faculty of education. Training for teachers is also needed to be able to teach with critical thinking skills in accordance with a curriculum designed by The Ministry of Education. In addition, various activities must also be carried out to make students use their critical thinking skills in other fields as well as in the academic field.

In the research journal of Aizikovitsh and Amita (2010) is written that the implication is general in its research showed that the intellectual development of students can be improved by creating a learning environment that fosters critical thinking skills, and that in turn will encourage students to investigate the problems encountered, evaluate, information and react as critical thinker. It's important to in the notice that, in addition to the skills critical thinking, in this lesson the students also acquire intellectual / skills such as conceptual thinking and develop the culture of the (climate) that encourages *critical thinking.*

In the research journal Seibu (2011) about critical thinking ability, it is known that from this study it shows that students' initial mathematical abilities can play a role in determining the level of critical thinking in mathematics. Critical thinking skills, when applied can result in an increase in mathematical achievement. Therefore, it is worth investing time in encouraging the use of critical thinking skills, which in turn will help improve learning outcomes.

Critical thinking skills reported by Kosiak (2004), correlated with mathematics test scores, in his study of online problem solving sessions for algebra courses, critical thinking skills and academic achievement have been shown to be significantly related by Semerci (2005). Some researchers (Landsman and Gorski, 2007; Sandholtz et al., 2004; Sheldon and Biddle, 1998; Wong, 2007) suggest that current educational trends shift the learning process from teacher-centered students and place an emphasis on content. Critical thinking is not an innate ability.

Although some students may want to know naturally, they need training to be systematic, analytical, fair and open-minded in pursuing knowledge. With these skills, students can be confident in their grounds and apply critical thinking skills to the content area or discipline of any sort (Lundquist,1999). In efforts to improve the ability of mathematics crtitical thinking students' and *self-confidence* students, there are many things that can help the process of learning in the achievement of mathematics itself. One of the ways to do is to choose a learning model accordingly.

Model discovery learning is learning oriented students, meaning students follow every process of discovery learning actively from the start to identify problems to draw conclusions with the aim of students gain experience learned directly and gain new knowledge of every process of learning that has passed Students not only understand the course material but knowing the concept. Until a time when students encounter complex problems and need critical thinking skills, students can apply concepts that have been understood. In applied discovery learning model, teachers act as mentors to provide an opportunity for students to learn active-ly, as some think teachers should be able to guide and direct the learning activities of students in accordance with the purpose (Haeruman, et al, 2017) Still in the Haeruman research journal (Haeruman, et al, 2017).

Based on the results of the first hypothesis testing proves that the increase in mathematical critical thinking skills in students who are treated by *discovery learning* models and expository learning treatment has a significant difference. The results of the study indicate that there is an interaction between the learning model and students ' initial mathematical abilities towards the improvement of mathematical critical thinking abilities.

The results of data analysis showed that students' mathematical critical thinking ability was strongly influenced by the learning model and viewed from a significant level that the increase in the ability to think critically mathematically students who received the *discovery learning* model was very significantly increased.

Based on the results of data analysis the average *N-gain* mathematical critical thinking ability of students who use *discovery learning* models is higher than students who get expository learning models. The results of data analysis also show that there are differences in mathematical critical thinking skills for students who are treated to *discovery learning* models with high mathematical initial abilities.

Students who are treated with *discovery learning* models get more benefits in improving students' mathematical critical thinking skills. Indicators of critical thinking can be seen from its characteristics so that by having these characteristics a person can be said to already have the ability to think critically. Facion (Filsaime, 2008) revealed six main critical thinking skills involved in the process of critical thinking, namely: (1) Interpretation. It is understanding and expressing the meaning or significance of various kinds of experiences, situations, data, events, judgments, habits, or customs, beliefs , rules, procedures or criteria. (2) Analysis, namely identifying the intended and actual inferential relationships between statements, questions, concepts, descriptions or other forms of representation intended to express trust, judgment, experience, reasons, information or opinions. (3) Evaluation. Evaluation means estimating the credibility of statements or representations which are reports or descriptions of a person's perceptions, experiences, situations, beliefs, opinions, or judgments, and assessing the logical strength of inferential relationships or referred to among statements, descriptions, question, or other forms of representation. (4) Inference. It means identifying and obtaining the elements needed to make reasonable conclusions, making assumptions and hypotheses, considering relevant information and inferring the consequences of data, situations, questions or other forms of representation.

METHODS

This type of research is research development or Research and Development (R&D) which is used to produce a product and test the effectiveness of the product. According to Borg and Gall (2003), development research is research-oriented to develop and validate products used in education. The product that will be developed in this research is the development of a discovery learning model based on a realistic mathematical approach to improve students' critical thinking skills.

3.1. The participants

The subjects in this study were students of class X SMA N 1 Pringsewu consisting of 33 experimental class students and 32 control class students.

3.2 Data Collection

3.2.1. Instruments

Data collection techniques in this study were through critical thinking skills tests, student assessment rubrics, interviews and documentation. Students' critical thinking ability tests are carried out using mathematical test questions to measure critical thinking skills.

3.2.2. Procedure

Table 1. Scoring Guidelines for the Mathematical Critical Thinking Ability Test

Indicator	Reaction To Problems / Problems	Score
1. Interpret Students interpret. write the known, state the questions in writing precisely and completely	Not writing the known and the asked.	0
	Write what is known and what is asked incorrectly.	1
	Write just what is known correctly or just what is asked correctly.	2
	Write what is known from the problem correctly but is incomplete	3
	Write the known and asked questions of the problem precisely and completely.	4
2. Analyze Make a mathematical model of the problem given correctly and provide a correct and complete explanation.	Not make a mathematical model of the problem given.	0
	Make a mathematical model of the problem given but not right.	1
	Make a mathematical model of the problem given precisely without giving an explanation.	2
	Make a mathematical model of the problem given precisely but there are errors in the explanation.	3
	Make a mathematical model of the problem given correctly and give a correct and complete explanation.	4
3. Evaluate Students use the right strategy in solving problems, complete and correct in calculations and explanations.	Not use strategy in solving problems.	0
	Using incorrect and incomplete strategies in solving problems.	1
	Using the right strategy in solving problems, but not complete or using strategies that are not right but complete in solving problems.	2
	Use the right strategy in solving problems, complete but make mistakes in calculations or explanations.	3
	Using the right strategy in solving problems, complete and correct in making calculations / explanations	4
4. Inference Students to make conclusions precisely according to the context of the problem and are complete	No make conclusions.	0
	Make conclusions that are not right and do not fit the context of the problem.	1
	Making inaccurate conclusions, although adjusted to the context of the problem.	2
	Make conclusions precisely, according to context but not complete.	3
	Make conclusions precisely, in accordance with the context of the problem and complete.	4

In a study researchers conducted a study to make the learning process as much as two meetings with the allocation of time for meeting the first s e a lot of 2 times in 40 minutes and the second meeting of 4 times in 40 minutes in two different classes, namely the experimental class is a class that is getting learning model discovery learning and class control classes with conventional learning.

The first meeting is used for tests conducted at the beginning of the meeting before the discovery learning model is conducted (pretest), then the test is also given at the end of the learning meeting (posttest) which aims to measure the increase in critical thinking skills. The first meeting of the control class students and the experimental class was given a pretest and posttest at the end of the lesson. Then at the second meeting, the experimental class was given the treatment of learning with discovery earning and then at the end of the learning class the experimental class students were given posttest.

Furthermore, data obtained from filling the results of pretest and posttest mathematical critical thinking skills are analyzed to find out the magnitude of the increase in students' Mathematic critical thinking abilities.

To measure the level of critical thinking skills of students, researchers scoring for each indicator of critical thinking researcher give the score for each indicator on each student's response to each question as in the following table. The researcher gives a score for each student response in each indicator on each question as in the following table 1.

Furthermore, researchers calculate the value of the acquisition of critical thinking ability scores with the following calculations in table 2.

Table 2. Criteria For Students' Critical Thinking Skills	
Interval	Criteria
80.1-100	Very high
60.1-80	High
40.1-60	Middle
20,1-40	Low
0.0-20	Very low
(modified from Arikunto, 2010: 245)	

The data obtained from the results of the Pretest and posttest critical thinking skills were analyzed using the gain index formula to measure the magnitude of the students' critical thinking abilities.

According to Melzer, the magnitude of the increase can be calculated by the formula of the gain index (Noer, 2010), while the formula for the gain index is:

$$g = \frac{pos\ test\ score - pre\ test\ score}{maximum\ possible\ score - pre\ test\ score}$$

Table 3 Gain Index Criteria

Gain Index (g)	Criteria
G> 0.7	High
0.3 <g ≤ 0.7	Middle
g ≤ 0.3	Low

The gain calculation results are then interpreted using the classification of Hake (Noer, 2010: 105) as shown in Table 3.

RESULTS

Table 4. Preliminary Score Data On Students' Critical Thinking Ability.

Group Research	Many Students	Average	Standard Deviation	Lowest Value	The Highest Score
Experiment	33	57.52	14.92	37.50	81.25
Control	3 2	58.06	9.95	40.63	79.69

Analysis of students' initial critical thinking abilities using discovery learning models was obtained from the scores of the Pretest results given at the beginning of the meeting. Pretest result data is then analyzed to find out whether students in the class have low, medium, or high critical thinking skills. From the data collection that has been done, the initial critical thinking skills of students in the two classes are obtained as presented in Table 4.

Table 5. Final Score Data On Students' Critical Thinking Ability Ideal Maximum Value (Nmi) = 100

Group Research	Many Students	Average	Standard Deviation	Lowest Value	The Highest Score
Experiment	33	86.60	6.96	71.88	96,875
Control	3 2	68.46	8.28	46,875	81.25

Based on Table 4. it can be seen that the average critical thinking ability of the experimental class students is lower than the average critical thinking ability of the control class students. It showed that early ability control class and experimental class did not show a significant difference. this means the ability to think critically students before getting learning with the discovery learning model is still the same. To analyze the students' final critical thinking abilities through mathematics learning using discovery learning learning models obtained from the posttest score given at the end of the studying. Posttest result data is needed to calculate the gain index of students 'critical thinking abilities and to analyze the achievement of indicators of students' critical thinking skills after learning. From the data collection that has been done, the final critical thinking abilities of students in both classes are obtained as presented in Table 5.

Based on Table V. shows the average final critical thinking ability of the experimental class students is higher than the average final critical thinking ability of the control class students. This shows that there are significant differences between classroom control and experiment class in the acquisition value. This means that the experimental class with discovery learning can improve students' critical thinking skill.

As the research Martaida, Nurdin and Eva (2017) that Capacity of critical thinking of students taught by learning discovery learning better than students with conventional teaching. Capacity of cognitive students taught with discovery learning better than students taught with conventional teaching and the ability to think critically students with a model of discovery learning is better than classroom

with learning convensional. Next is analyzing the N-Gain index of students' critical thinking skills. In the analysis of students' initial critical thinking abilities, it is found that students in the experimental class and the control class have the same initial abilities. Furthermore, an analysis of the gain index of students 'critical thinking skills was carried out to find out how students' critical thinking skills improved in both classes. After calculating the gain index from the pretest and posttest score data, the data presented in Table 6 as follows:

Table 6. Gain index results for critical thinking ability

No	Class	Test	N	X_{Min}	X_{Max}	Score	Mean N-Gain
1	Experiment	Pretest	33	24	52	55	0.65
		Posttest	32	46	52	37	
2	Control	Pretest	33	26	51	37	0.23
		Posttest	32	30	52	44	
Ideal Maximum Score = 64							

Based on Table 6 the average N-gain experimental class are 0, 65, this means that an increase in critical thinking skills of students using the learning model of discovery learning is included in the improvement of the criteria being, whereas the increase in the ability of critical thinking of students using instructional conventionally included in improvement of the criteria low when viewed from the average N-gain control class that is equal to 0, 23. Based on the results of data analysis using the formula of Index Gain, critical thinking skills mathematical students after got the lesson using the model of discovery learning is higher than in prior to getting models learning discovery learning . The level of students 'critical thinking skills was also measured to find out the percentage of students' critical thinking abilities in the class. Following are the results of the calculation of the percentage of students based on the criteria of students' critical thinking abilities measured from the results of the pretest and posttest.

Based on the results of the analysis of the data in table 7 shows that the frequency of critical thinking skills of students is very high after learning with discovery learning, and in table 8 it can be seen that the highest indicator is on the interpretation indicator that is as much as 87.48% of students answered correctly but on the indicator inference or draw conclusions the percentage of students at 78.59%. This shows the ability to think critically mathematically for students who are treated discovery learning model included in the high category. Some relevant research shows that the characteristics of discovery learning that give rise to students 'curiosity to find and find solutions can help students improve students' critical thinking skills. As in the research of Sulistiani Waluya and Masrukan (2017) students curiosity influences students' critical thinking abilities.

Table 7. Frequency distribution of students' critical thinking ability

The Interval	Frequency	Percentage	Category
80.1-100	27	81.82	Very high
60.1-80	6	18.18	High
40.1-60	0	0	Low
20,1-40	0	0	Low
0.0-20	0	0	Very low
Total	33	100	

Table 8. Percentage of critical thinking abilityfor each indicator

Indicator	Percentage (%)	Category
Interpretation	87,48	Very high
Analysis	83,58	Very high
Evaluation	79.92	High
Inference	78.59	High

Analysis of the students' critical thinking through the model of discovery is able to master the six indicators of critical thinking skills mathematical sedangkan student group type Curiosity Perceptual have not been able to master the critical thinking math indicator to the fullest.

CONCLUSION

The conclusion that can be drawn based on the results of this study is that the application of discovery learning models

can improve students' critical thinking skills. The results of data analysis show that there are significant differences in the level of critical thinking skills of students who obtain learning with discovery learning models with students who learn with conventional models. The ability to think critically students before and after the implementation of learning using discovery learning models showed significant differences, where the results of the analysis of student test data showed the gain index of students with discovery learning of 0, 65 where the gain index showed the criteria being in measuring ability students' critical thinking.

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