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HOW DOES THE STUDENTS' CRITICAL THINKING ABILITY IN GEOMETRY OPTICS?

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Abstract

One of the abilities that must be possessed by students in the 21st century is the ability to think critically. This article aims to analyze students' critical thinking skills in geometric optical materials. This research is descriptive research with subject of research consisted 116 student grade 12 SMA. The critical thinking skills test instrument consists of 12 items about the description of geometric optical material with reliability coefficient of 0.701. The results of this study indicate that the average ability of critical thinking students 14.54 of scale 100 with the highest score of 48 and the lowest value 1.3. This shows that students' critical thinking skills are still in the low category. The weakest aspect of critical thinking ability is argument analysis. Need efforts to improve students' critical thinking skills, one of them is by applying learning that requires students actively in solving problems.

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INTRODUCTION

21st century skills can help students to learn and adapt to various forms of change that occur over time (Ongardwanich et al, 2015). Students need some skills to deal with such conditions, such as problem solving skills, critical thinking, communication skills, and cooperation with others (Lindawati et al, 2017).

Critical thinking is one of the abilities to explain the thinking that it possesses with reasoning (Güneş et al, 2015). It can also be interpreted as an activity to evaluate a statement that will result in a decision to refuse or accept the statement (Martawijaya, 2015). If critical thinking skills are well developed, students can develop and refine their ideas when conducting an investigation (National Research Council, 2012), so that students will be more actively contributing to the development of science. The ability to think critically can also be interpreted as one of the more complex forms of thinking activity which involves analyzing more specific ideas, differentiating, selecting, identifying and developing in a more perfect direction (Usmeldi et al, 2017).

Reasons students study physics, one of which is to develop critical thinking skills (Etkina & Planinšič, 2015). Not only does it produce a decision in response to a statement, the mental activity that the student does in evaluating a truth statement is also influenced by critical thinking skills (Martawijaya, 2015). The importance of other critical thinking skills can be used as a means of obtaining and gathering facts that can be used in the conclusion (Seals, 2010). Of these statements show that critical thinking skills will greatly contribute and assist students in the process of idea development and conclusion.

The ability to think critically has been developed by some experts. Ennis (2011) states that there are five activities in critical thinking: 1) provide basic explanation, 2) make decisions 3) conclude, 4) give further explanation, 5) give assumptions and integration. Then Paul & Elder (2010) argues that a good critical thinker has characteristics, namely: 1) formulate questions and answers of a problem clearly and accurately; 2) collect relevant information and use thinking effectively; 3) conclude and good solutions in accordance with relevant criteria and standards, 4) have open thinking, and 5) communicate effectively to find solutions to problems. Measuring critical thinking skills in physics was also developed by Tiruneh, et al (2017). Some categories of critical thinking ability according to Tiruneh, et al (2017) include 1) Reasoning, 2) Testing hypothesis, 3) Argument analysis, 4) Likelihood and uncertainty of analysis, 5) Problem solving and decision making.

Based on some opinions from experts, this research uses the indicators of critical thinking ability developed by Tiruneh, et al (2017) with consideration of material context relating to instruments is optical geometry, which matter is one of the material in the field of physics.

Geometry optical material is a branch of IPA in which to study the nature of light using the approach of light by applying the principle of optical geometry. Although optical geometry is a basic material that has been learned since the junior high school level, it is still considered difficult material to be understood by students (Sutopo, 2014).

The difficulties are caused by a lack of students' understanding of the material, as well as the misconceptions experienced by students on geometric optical materials (Agnes et al, 2015; Sutopo, 2014; Galili, 2007). Some of the difficulties experienced when learning optical geometry is the propagation of light (Chu & Treagust, 2014), and reflection and refraction (Aydin et al, 2012). From that circumstance, it will have an impact on students' difficulties in determining how the image will be formed from reflection events and light refraction (Chang et al, 2007).

Apart from the material factors, the difficulty in understanding the optical geometry is also due to the learning process. The learning of optical geometry materials tends to be done verbally or by lecture, which is only supported with the package book (Pratiwi et al, 2013).

Meaningful learning can improve students' overall knowledge. The students' critical thinking ability can be improved by applying a learning model that involves students actively in obtaining information. Learning models should be integrated with appropriate approaches to help develop students' skills, especially critical thinking skills (Usmeldi et al, 2017).

Results of research conducted by (Khasanah et al, 2017) states that the aspect of critical thinking ability that gets the highest percentage is on giving explanation. Based on these studies the aspect gives an explanation of an increase of 70.8% after using the respiratory module.

Although many have expressed students 'difficulties in understanding the material of optical geometry, but so far not many who reveal how students' critical thinking skills in optical geometry. This article focuses on describing students' critical thinking skills in geometrical optics.

METHODS

This research uses quantitative descriptive method to explain the average of students' critical thinking ability on optical geometry materials. The subjects of this study consisted of 116 students of grade 12 MIA SMAN 9 Malang who have received optical geometry material at the previous level.

The instrument used in this study is a matter of geometry optical related description of 12 questions. The instrument of this study has a reliability coefficient of 0.701. This instrument is used to measure 5 aspects of students' critical thinking skills in accordance with those developed by Tiruneh, et al (2017). This instrument consists of 3 items for aspects of reasoning, 2 items for aspects of hypothesis testing, 2 items for aspects of argument analysis, 3 items for aspects of probability and uncertainty of analysis, and 2 questions for aspects of problem solving and decision making.

Technique of collecting data in this research is to give item description to student, without giving treatment first. So from the results obtained will be able to map what the average value on each critical thinking ability. While for data analysis is done by calculating the average value of each critical thinking ability. Then conclude on the critical thinking skills which students get the highest and lowest average scores.

RESULTS AND DISCUSSION

Based on the data analysis, the mean value of students' critical thinking ability is 14.54 from the 100 scale, with standard deviation of 10.46. The highest score is 48 and the lowest value is only 1.33. The lowest aspect of critical thinking ability is the argument analysis, 0.73 (6.72%). The highest aspect of critical thinking ability is reasoning, which is 41.26%. The mean of all aspects of critical thinking ability can be examined in Table 1.

Table 1. Mean Average Critical Thinking Skills

No.	Aspects of Critical Thinking Ability	Percentage (%)
1	Reasoning	41.26
2	Testing hypothesis	11.78
3	Argument analysis	6.72
4	Likelihood and uncertainty of analysis	31.38
5	Problem solving and decision making	8.85

The lowest average score is in item 7 which represents the aspect of argumentation analysis with a value of 0.31 or 2.85%. As for the matter with the average value the highest obtained in item 3 point with a value of 1.97 or equal to 18.10%. Here is the percentage of critical thinking ability on each item distributed in Figure 1.

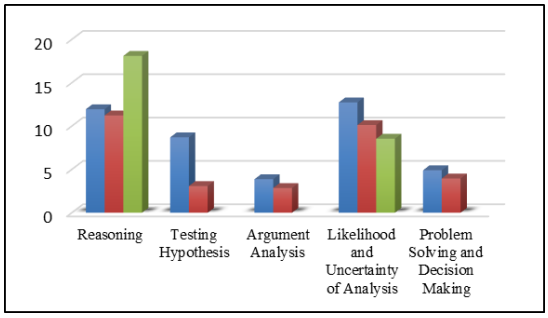
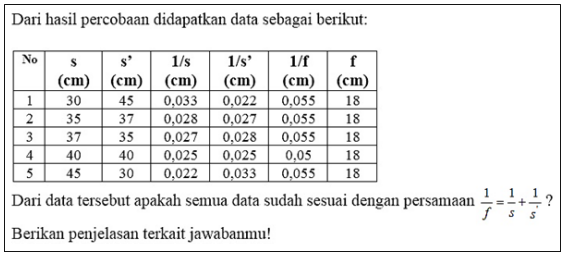


Figure 1. Percentage of students' critical thinking ability on each item problem

Aspects of Critical Thinking Ability: Reasoning

Students have been able to solve the problem on the aspect of reasoning quite well, seen from the percentage obtained is quite high with 41.26%. Which is the highest value of the other four aspects. In the aspect of reasoning is represented by three questions, where the problem discusses the relation between the distance of the object (s) to the distance of the shadow (s'), then when it is connected to the equation $\frac{1}{f}=\frac{1}{s}+\frac{1}{s'}$ is it appropriate. Some students can already calculate using mathematically he equation, so it is correct in solving the problem. But also not a few students who find it difficult to evaluate whether the data contained in the problem is in accordance with the equation. So it can be said that students also have difficulty in mathematical calculations (Rodriguez et al, 2013). Of the three questions that represent the aspect of reasoning, item 3 is a matter that gets the highest percentage compared

to the other two questions. The following is Figure 2, regarding item 3.



Dari hasil percobaan didapatkan data sebagai berikut:

No	s (cm)	s' (cm)	1/s (cm)	1/s' (cm)	1/f (cm)	f (cm)
1	30	45	0,033	0,022	0,055	18
2	35	37	0,028	0,027	0,055	18
3	37	35	0,027	0,028	0,055	18
4	40	40	0,025	0,025	0,05	18
5	45	30	0,022	0,033	0,055	18

Dari data tersebut apakah semua data sudah sesuai dengan persamaan $\frac{1}{f}=\frac{1}{s}+\frac{1}{s'}$?

Berikan penjelasan terkait jawabanmu!

Figure 2. Item number 3

Aspects of Critical Thinking Ability: Hypothesis Testing

This aspect is represented by two questions, which are related to the concept of shadow formation in the microscope and on the concept of refraction. The average value is obtained in this aspect is 1.28 and if used as a percentage of 11.78%. Students are able to identify the position of objects when in refraction, according to item 5, which asks about the position of the fish when observed from one of the aquarium surface positions. Most students explain that the fish are not in the real position, but when explaining using the concept of refraction where there are two different medium densities, they still encounter difficulties. This is in accordance with the statement (Chu & Treagust, 2014; Aydin, et al., 2012) which states that students still have not mastered the concept of light propagation carefully.

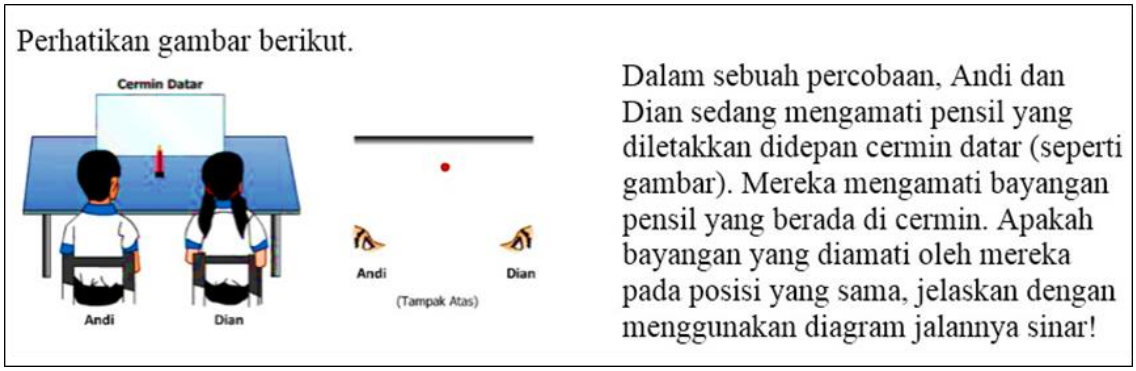


Figure 3. Item number 7

Aspects of Critical Thinking Ability: Argument Analysis

In this aspect there are 2 items, which are related to the concept of light reflection. Argument analysis ability in this research get the lowest percentage, that is only equal to 6,72%. Of the 12 items used in this study, the lowest value is also in the aspect of argument analysis ie item number 7. The percentage obtained in item 7 is 2.85%.

The following Figure 3 shows the number item 7. Many of the students respond to the shadows formed on the flat mirror will vary the position, because the observer is in a different position. So when they explain by illustrating the path diagram of the rays, their answer is still wrong. They are less focused in understanding the meaning of the problem, so they forget if the flat mirror affecting the shadow is the distance of the object to the mirror, not the position of the different observer. In the context of question number 7 when the observer is in a different position, but observing the same object and the position of the fixed object, the shadow formed in the mirror should be in the same position. This is because students still do not understand carefully about the statement of Snellius Reflection Law, more specifically the reflection of a flat mirror light. If students have a basic understanding of the underlying concepts, they will experience difficulties when faced with more complex issues related to the concept of reflection and refraction (Aydin, et al., 2012; Galili & Hazan, 2000).

Aspects of Critical Thinking Ability: Likelihood and uncertainty of analysis.

This ability is represented by three items. The problem is related to the material of optical devices, namely microscopes and abnormalites in the eye. The percentage obtained in this aspect is 31.38%. This is the second highest after the reasoning aspect. Many students have been correct in answering problems related to

abnormalities in the eye, they have been able to identify whether the eye disorders are nearsighted or farsighted, besides the students also have been able to determine what solutions can be used to help people with eye disorders. Of the three questions, item 10 gets the lowest average value. The problem relates to the concept of light reflection, more specifically on the reflection of a concave mirror. In the question is given the question if the top of the mirror is covered with paper how the shadows are formed on the screen. Many of the subjects who thought that the shadow can only be generated by special rays only. Other rays do not contribute to the shadow formation process, and may not even produce shadows. Thus if two of the three special rays are blocked, no shadow will be formed. So from the thought, the answer written by most students is that there will be a shadow on the screen but only the bottom of it, or formed only half shadow. Very few of the students who answer with answers will form an intact but dimmer shadow than before being covered with paper. It can be said that students still do not understand the concept of light reflection in depth, and still difficult if faced with more complex problems (Aydin et al, 2012).

Aspects of Critical Thinking Ability: Problem solving and decision making.

In the latter aspect is represented by the problem, where the problem is related to the mathematical calculation in determining magnification of the loop and one problem related to reflection on the convex mirror. The fifth aspect gets a percentage of 8.85%, which is the second most probable value after the aspect of argumentation analysis. Most of the students still have difficulty in determining the equations that will be used to solve the problem. Besides still having difficulty in using equations, they are also less precise in mathematical calculations so it is still wrong in determining magnification of the loop. In the last question the students also still look confused in choosing the position of convex mirror that will be placed at the fork of the road, seen from the answer sheet most students still have not answered correctly on problem number 12. The statement refers to (Rodriguez et al, 2013) still lacks the mastery of optical geometry and is still weak in mathematical calculations.

CONCLUSION

The results of this study indicate that students' critical thinking ability in optical geometry is still relatively low. Of the five aspects of critical thinking ability, it is found that in the aspect of argument analysis shows the lowest value, while for the aspect that gets the highest percentage is on the aspect of reasoning.

Of the 12 items used to find out how students' critical thinking skills in geometry optics, obtained on item number 7 get the lowest average value, while for the highest average value in item 3.

Based on these findings, efforts are needed to improve students' ability, especially to develop critical thinking skills. One of them is by applying a learning model that requires students to be active in experiments and problem solving such as Problem Based Learning (PBL), Problem Solving, Inquiry. This will assist students in understanding and assembling their knowledge into a unified whole and can be used to hone their critical thinking skills.

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