Students’ representation based on high order thinking skills for the concept of light

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Abstract. Light is one of the concepts in physics which is close with daily life. This descriptive study aims to explore student representations in terms of high order thinking skills (HOTS) on the concept of light. The research subjects were 30 students of junior high school in Purworejo. Data collection techniques using a test with three items in the form of descriptions based on indicators of HOTS. The data obtained were analysed qualitatively and the presentation of data analysis results through tables. The results showed that there are three forms of students’ representation in understanding the concept of light, namely mathematics, picture and verbal representation. Image representation is the most commonly used concept of shadow while the concept of light propagation uses more verbal representation. The use of diverse representations in solving problems can facilitate the improvement of HOTS.

1. Introduction
One of the difficulties students have in learning physics can come from the ability to represent abstract concepts [1]. In learning science, multi representation can be interpreted by describing a similar concept in a different format [2]. Multi representations mean to re-represent the same concept with different formats such as verbal, image, graphic and mathematical [3], [4].

Most teachers, in giving problems to students do not see problems in each category of representation [5], [6]. Teachers sometimes only focus too much on problems that usually appear on the final exam. This causes students not to be accustomed to solving problems in various types of representations. The result is that students will be confused in solving problems in different representations, even though sometimes the questions are relatively easy [7]. Sometimes Students can only solve by memorizing formulas without analyzing, evaluating, and creating. These three indicators are higher order thinking (HOT). When students are confronted with HOT questions, it will produce various solutions or solutions to the problems [8].

Furthermore, in solving problems someone has strengths and weaknesses depending on the ability of each student. It is possible there are differences in strategies undertaken in solving problems. Each student has different abilities as well as different learning styles. Likewise, some students find it easier to learn by using pictures and others are easier with text or language. So, with these differences in solving problems the possibility of students using different representations. Problems in some representations are difficult to do with only a quantitative approach, sometimes requiring a qualitative approach [9]. For example, graphs and symbol representations, students need evaluation skills to be able to imagine events that occur in problems.
As one of the main parts of science subject, light and optics topic is also hard to be learned by the students. Light and optics is a rapidly developing and often encountered its technological practices in everyday lives [10]. However, teaching and learning the subject of lights and optics is challenging for teachers and students. It is because in the adolescent phase students are facing the transition phase means that students are in the process of trying to understand the abstract concepts where in the previous school level or child phase they only learn the concrete one [11].

Students still experience confusion in understanding the events of refraction, reflection and direction of the propagation of light [12]. Understanding can be formed from students' initial experience or knowledge [10]. Students' experiences can build representations about phenomena [9]. Therefore, it is necessary to know students' representations of the concept of light as an initial understanding to analyze the workings of optics using the principle of refraction and reflection on optical material.

2. Method
This research is a descriptive study conducted at a junior high school in Purworejo. The research subjects were 60 students. Data collection techniques using representation tests. The test instrument uses three items of diagnostic test representation in the form of description. The test instrument was adapted from previous research [13], [14]. Students are asked to make hypotheses, design and construct the properties of light. Data analysis was performed by presenting data in tabular form.

3. Result and Discussion

3.1. Representation of students on the concept of refraction of light
Refraction events describe the behavior of the propagation of light between before and after passing through the boundary plane of two mediums that have different optical densities (refractive index). So, it is a dynamic phenomenon of light. In the paper and pencil test format, the propagation of light is usually depicted with a trajectory in the form of static lines.

In this concept, students are expected to be able to analyze the process of propagation of light in various media through everyday cases. For example, in the indicators making hypotheses, students are given the case "how does one's position illuminate a ring that falls in a pool by using a flashlight?". Some of the representations used by students are presented in table 1.

| Indicators           | Percentage of student answer types |
|----------------------|-----------------------------------|
|                      | Mathematics representation | Image representation | Verbal representation |
| Making hypothesis    | 20                       | 10                      | 70                     |
| Design               | 10                       | 60                      | 30                     |
| construction         | 5                        | 20                      | 75                     |

Based on the results of students' answers, it was found that only a few students were able to describe and explain the direction of the propagation of light if it passed through a medium that was less dense to a denser medium. Students use verbal representations to explain light events through two different media. The average student answers "His position is tilted in order to take the ring that falls at the bottom of the pool because the light can be refracted". But students are not able to determine the magnitude of the refractive angle is smaller than the angle of incidence so students draw refractive rays away from the normal line. Students' ability to draw light through the medium of air to the glass plate will be continued straight when passing through the glass plate. Most students give reasons based on the nature of the material glass plate glass is a transparent and translucent object so that the light coming from the air will be transmitted straight as it passes.
On the indicator of producing (constructing), the case of the phenomenon of perfect reflection that can be found in everyday life where the average student responds "mirage events that occur because light from the sky crosses cold air and enters hot air near the surface of the earth, hot air has refractive index is smaller than cold air, because of the heat density is also small ". This is in line with previous research mentioned another effect of developing thinking skills is to increase student interest and motivation [15], [16]. Curiosity of a phenomenon provides the opportunity for students to improve understanding through observation. And in the end encourage the development of scientific concepts by linking the knowledge that students get at school with what students get in their daily activities.

3.2. Representation of students in the concept of shadow
In this concept students are expected to understand mirrors and lenses as optical devices, both the processes and the nature of the shadows that are formed. The basic knowledge students must have to answer this problem is that they must understand the process of the running of special rays on each optical device [10], [11]. Students have difficulty describing the process of running a special beam from the existing scheme. So, it is known that students only memorize the scheme without understanding the description of the course of the special light. There are still students who only memorize examples of refraction in the water medium, without being able to explain the description of the refraction.

| Indicators      | Percentage of student answer types |                |
|-----------------|-----------------------------------|----------------|
|                 | Mathematics representation | Image representation | Verbal representation |
| Making hypothesis | 20                                | 50              | 30              |
| Design          | 20                                | 60              | 20              |
| Construction    | 10                                | 80              | 10              |

The next understanding is about the eye organ as an optical instrument, both the process and the nature of the shadows that are formed. Basic knowledge that must be possessed to answer this problem is that students must know the organs of the eye so they know the process. In table 2 shown that image representation has higher percentage than another representation. It found that students have understood the components and workflow of the formation of shadows in the eye, but have not been able to give an explanation of the reason the eye is called a natural optical device.

On the other hand, the mathematics representation was not used to many students in answering the question. They did not write any relevant formula or just listed a formula without explaining. Many previous studies mention that many students choose a formula based on the variables in the question without considering its relevance to the question situation [6], [17], [18].

4. Conclusion
In this study we explored representations that student used in light concepts. The test was design based on higher order thinking skills. It found that there are three forms of students’ representation in understanding the concept of light. Image representation is the most commonly used concept of shadow in all indicator of HOTS. While the concept of light propagation uses more verbal representation in 2 indicators of HOTS, namely making hypothesis and construction. The use of diverse representations in solving problems can facilitate the improvement of HOTS.

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