Misconception Level Analysis of Prospective Physics Teacher Students in Geometric Optic Using Multiple-Misconception Revealing Test

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ABSTRACT

This study aims to identify the level of misconceptions that prospective physics teacher students have on the subject of optics. The diagnostic test instrument developed follows the Multiple-Misconception Revealing Test (MMRT) format. The research subjects are prospective physics teacher students in the Physics Education Department who have graduated Basic Physics course and are programming the Optical Waves course in the even semester of 2021. MMRT is a test in the form of open questions and is at the creative level, namely in the form of building with certain rules. This test requires solving problems with additional explanations so that it is easy to identify true or false quickly and arouse curiosity in students to solve them. Problem-solving is equipped with a level of confidence and an explanation of why they answered that way. The results of this study will be used as a first step to developing appropriate learning strategies and teaching materials to be able to remediate misconceptions that occur in students. The test used consisted of 10 items consisting of 7 items about reflection by a mirror and 3 items about refraction. The results of the analysis showed that 14.7% of students experienced misconceptions-1, 13.7% of students experienced misconceptions-2 and, 10.5% experienced misconceptions-n.

Keywords: Mirror, Lens, Concave, Misconception, Shadow

INTRODUCTION

When students take part in a lesson, not all of the concepts given can be understood correctly by students. During learning, students certainly have an initial understanding obtained from sources other than teachers/lecturers, for example from books and other teaching materials. The wrong initial concept will make it difficult for students to understand and interpret a further physics concept. This can cause students to experience misconceptions because the concepts they catch are different from the concepts of scientists. Students' conceptions become contradictory to physicists' concepts, and usually involve the relationship between concepts. The causes of misconceptions can be caused by several sources, namely from students, teachers, textbooks used, context, and teaching methods of lecturers [1]. Sometimes the textbooks become a source of student misconceptions with the information they provide [2], [3], [4], [5]. Misconceptions are defined as misunderstandings that may occur during or as a result of the teaching that has just been given, as opposed to scientific conceptions that were brought or developed over a long time [6]. The causes of misconceptions can be caused by several sources, namely, from students, teachers, textbooks used, contexts, and teacher teaching methods [1].

Misconceptions can be found at various levels of educational units and cultural backgrounds [6]. Misconceptions are one of the main obstacles in studying physics [7] and can lead to failure in studying

physics.

Misconceptions can occur in a wide variety of Physics topics. Wandersee etal [8] in their article on Research on Alternative Conceptions in Science, explains that alternative concepts occur in all fields of physics. Of the 700 studies on alternative concepts in physics, there are 300 that examine misconceptions in mechanics; 159 on electricity; 70 on heat, optics, and the properties of matter; 35 on earth and space; and 10 studies on modern physics [1]. According to Berg [6] in Misconceptions of Physics and Remediation, misconceptions about electrical circuits are not single in one concept but tend to be interconnected between concepts. Investigation of the contents of physics textbooks carried out by Gurel & Erylimaz [4] stating that misconceptions can occur regarding image formation and the observation process without taking into account the role of the observer's eye in Geometric Optics. In addition, students tend to have misunderstood more than one concept or multiple misconceptions.

Overcoming misconceptions can be done, but not easy. This is because students will tend to stick to the explanations or knowledge they have formulated in their minds. To teach physics effectively, misconceptions must be seen and overcome [9]. To see whether students have misconceptions or not, a quick way is needed to uncover misconceptions that may occur to them.

Various methods of uncovering misconceptions have been developed, including Certainly Response Index (CRI) test, Two-tier test, Three-tier test and, Four-tier Test. However, some of these tests require quite a long time to carry out tests, analyze, and determine misconceptions for students. In addition, the multiple-choice question model is only related to a single misconception. Then often students are not interested in doing it so they tend not to be serious. Therefore, some of these test methods are not suitable for classroom diagnostic purposes.

Widodo et al [10] in their research found that a method called the Multiple-Misconceptions Revealing Test (MMRT) can reveal students' misconceptions in electrical circuits relatively quickly. In addition, the simple form of the test also makes it easier for teachers to uncover misconceptions that occur. So that it can be a diagnostic tool in the learning process. Therefore, this research analyzes students' misconceptions on Geometric Optics of prospective teacher students at Tadulako University.

Seven categories help to classify scientifically acceptable and unacceptable explanations, namely i). The true scientific explanation takes part in this level. The graphs made are correct and equipped with correct and complete explanations of the reasons (A), ii) The answers to the graphs are correct but the explanations are still incomplete (B), iii) Wrong ideas including correct and incorrect explanatory sentences simultaneously match with this level (C), iv) Explanations that focus on the minority or majority components of the problem, v) Ideas involving concepts and explanations other than Geometric Optics correlate with this level and involve arguments that are completely scientifically unacceptable, vi) Explanations that it is difficult to understand what is implied or has nothing to do with the questions included in this level and vii) Respondents who do not make graphs and/or explanations of reasons. These categories consist of similar explanatory classifications that fall within the same level.

This study aims to investigate the types of student misconceptions in Geometric Optics using MMRT, reveal the level of misconceptions in Geometric Optics material obtained from the results of the analysis of students' answers to prospective physics teachers and facilitate the implementation of further research to investigate lecture strategies and make appropriate teaching materials, which can correct the misconceptions of prospective physics teacher students on Geometric Optics.

RESEARCH METHODS

This research is a descriptive study using a qualitative descriptive method in explaining the results of the

study. Where, in qualitative research, all data were collected based on the facts obtained in the field. Creswell [11] states that qualitative research methods are research methods used to examine the condition of natural objects, where the researcher is the key instrument. This research was conducted for 1 year which aims to investigate the level of misconceptions that exist in prospective physics teacher students in Geometric Optics.

The subjects of this study were physics students at the Faculty of Teacher Training and Education, Tadulako University. According to Creswell [11], the subject in qualitative research was carried out using a purposive sampling technique. The number of participants is 38 students. To obtain information on the level of student misconceptions, a purposive sampling technique was used to determine the respondents who were involved in the interview. The researcher grouped the interviewed students based on the student's test answers, namely the categories of correct answers, partially correct answers,misconceptions-1, misconceptions-2, misconceptions-n, cannot be categorized and there are no graphs and explanations as in table 1. In this study, the data collected was primary data meaning that the data obtained were data sourced directly from the research subject. The primary data sources of this research are data from the results of the misconception test using the MMRT as well as data from interviews with several selected respondents.

TABLE 1**.** INTERPRETATION OF MMRT RESULTS

Decisions	Type Answer					
	Answer	Confidence	Explanation	Confidence	Additional explanation	Confidence
Scientific Conception	Correct	Sure	Correct	Sure	Correct	Sure
	Correct	Sure	Correct	Sure	Correct	Not sure
	Correct	Sure	Correct	Not sure	Correct	Sure
	Correct	Sure	Correct	Not sure	Correct	Not sure
	Correct	Not sure	Correct	Sure	Correct	Sure
	Correct	Not sure	Correct	Sure	Correct	Not sure
	Correct	Not sure	Correct	Not sure	Correct	Sure
	Correct	Not sure	Correct	Not sure	Correct	Not sure
Lack of Knowledge	Correct	Sure	Correct	Not sure	Correct	Sure
	Correct	Not sure	Correct	Sure	Correct	Sure
	Correct	Not sure	Correct	Not sure	Wrong	Not sure
	Correct	Sure	Wrong	Not sure	Wrong	Not sure
	Correct	Not sure	Wrong	Sure	Wrong	Sure
	Wrong	Not sure	Wrong	Not sure	Wrong	Sure
	Wrong	Sure	Correct	Not sure	Wrong	Not sure
	Wrong	Not sure	Correct	Sure	Wrong	Not sure
	Wrong	Not sure	Correct	Not sure	Wrong	Sure
Misconception-1	Wrong	Sure	Correct	Sure	Wrong	Sure
	Wrong	Not sure	Correct	Not sure	Correct	Sure
Misconception-2	Wrong	Sure	Wrong	Sure	Correct	Sure
	Wrong	Not sure	Wrong	Not sure	Correct	Sure
Misconception-n	Wrong	Sure	Wrong	Sure	Wrong	Sure
	Wrong	Not sure	Correct	Sure	Correct	Sure

The research instrument used was a multiple-misconception revealing test instrument. The diagnostic

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instrument was developed based on the misconceptions in Geometric Optics referred to from several related journals. This diagnostic instrument is in the form of an MMRT consisting of 10 open-ended questions and an interview question instrument as supporting data. Data collection techniques in this study were through tests and interviews. The diagnostic result data is expressed in the form of a percentage of the student's conception category. Data were analyzed qualitatively and quantitatively. The stages are (a) reducing data, (b) presenting data, and (c) verification and drawing conclusions. The diagnostic result data is expressed in the form of a percentage of the student's conception category as in table 2.

TABLE 2**.** CATEGORIES OF CONCEPT UNDERSTANDING, PARTIAL UNDERSTANDING, AND MISCONCEPTIONS

Conception	Percentage (%)	Categories
Scientific Conception, Lack of Knowledge and Misconceptions	0 – 30	High
	31 – 60	Enough
	61 – 100	Low

The data analysis technique carried out in this study is first grouped the student test results into several categories, namely Understanding Concepts, Not Understanding Concepts, and Misconceptions, according to the criteria in Table 2.

RESULTS AND DISCUSSION

Geometric optics is a branch of science that studies the behavior of light through a ray approach by applying the principles of geometry. In geometric optics, light is represented as rays, i.e. straight lines drawn following the direction of light propagation. The object of study is related to the events of propagation, reflection, and refraction of light. A good understanding of the propagation of light and how light interacts with other objects is necessary for understanding everyday phenomena related to light and the various technologies developed based on the principles of reflection and refraction of light.Some educators claim that knowledge of light and its interactions with other objects is indispensable in studying other branches of science. Therefore, careful planning is needed in learning geometric optics.

The analysis implemented in this study refers to 7 categories of MMRT test results analysis, namely; Scientifically True (A), Partially True (B), Misconception-1 (C), Misconception-2 (D), Misconception-n (E), Uncoded (F), No graph and explanation (G). The number of questions used is 10 questions about Geometric Optics in the form of open-ended questions with a choice of confidence levels. The question instrument used by the researcher is a question that has been modified from several question instruments used in several previous studies related to geometric optics and then has been validated by expert validators. In this study, respondents answered the questions by using mathematical, making pictures in the column provided and each answer was accompanied by a choice of the level of confidence in answering.

Based on the results of the analysis of answers from the MMRT Test given to 38 respondents, the results are as shown in table 3. The concepts analyzed consist of reflection by a flat mirror 4 questions, a concave mirror 3 questions, a flat lens 1 question and, a concave lens 2 questions. Students experience misconceptions on all the concepts investigated. The most dominant type-1 misconception occurs in the concept of refraction by water and a concave lens. The dominant type-2 misconception occurs in the concept of refraction by a convex lens. The n-type misconception is dominant in the concept of perfect reflection and by a concave lens.

TABLE 3**.** THE PERCENTAGE OF STUDENTS' MISCONCEPTION LEVEL CATEGORIES RESULT

No	Indicators	Categories (%)						
		A	B	C	D	E	F	G
1	Describe the formation of an image by a plane mirror	36	20	16	10	8	8	2
2	Determine the angle of reflection on two plane-parallel mirrors.	16	22	20	12	6	24	0
3	Determine the angle of reflection on two plane mirrors inclined to each other at an angle of ?	10	24	20	12	16	18	0
4	Describing a critical angle and total internal reflection	45	25	7	10	10	3	0
5	Describe the formation of an image by a concave mirror	20	28	14	12	8	10	0
6	Describe the formation of an image by a concave mirror	15	45	14	10	8	8	0
7	Describe the formation of an image by a convex mirror	28	34	10	9	9	10	0
8	Refraction by a flat surface	42	12	18	20	4	4	0
9	Refraction by a convex lens	20	12	18	24	26	0	0
10	Refraction by a concave lens	22	24	10	18	8	12	6

Students were expected to be able to determine the image distance of an object located in front of a plane mirror that is shifted away from the mirror and describe the image formation was the question in number 1. Virtual image formation and observation in plane mirrors are encountered in nearly all textbooks, like the ones analyzed in this item.The formation of an image by a virtual plane mirror, without emphasizing the role of the observer and the observer's place can cause students to build misunderstandings [12], [13], [14], [15], [16]. Ingeneral, students have understood the law of reflection correctly, but when investigated further, those who asked for a scientific explanation showed that students stated confidently with their answers but the answers were not by scientific truth. The analysis results was shown in Fig.1. The test results show that only 36% of students can provide answers with correct scientific explanations to questions on items a, and b, and are grouped at level A. They are very sure of the correctness of the answers they get both on reason points and additional exclamation points. They have been able to solve the problem correctly and are equipped with a proper and complete explanation of the reasons. Students can explain correctly the changes that occur in the position of objects and their shadows after being shifted and can apply the law of reflection correctly.

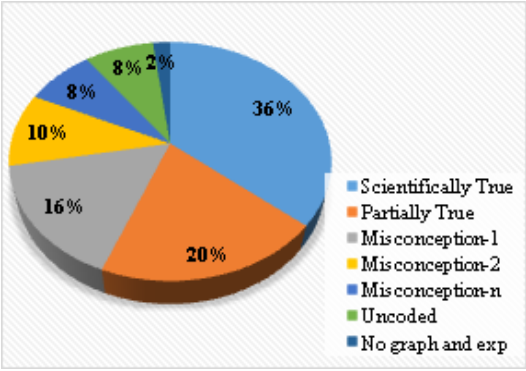

Fig. 1 Graph of the percentage of students misconception level on the Snell"s Law

There are 20% of students who answered at level B answered half correctly. Groups of students at this level are generally correct and very confident in answering questions a. They can determine the distance of the image from the object after the object is shifted, however, cannot properly describe the image formation.

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They have not been able to apply the law of reflection correctly to get the image of objects correctly. Students' understanding shows that what they understand from determining the location of the image by a plane mirror is that the object distance is the same as the image distance.

Students who experience misconceptions at level C, which is "False ideas including correct and incorrect explanatory sentences simultaneously fit into this level". There were as many as 16% of students who expressed confidence that the image produced by a plane mirror was real, but could not explain how to determine the formation of the image. What is formed in the pattern of student thinking is the image formed is real. Student statement that the image of objects by plane mirrors is real, because of wrong intuition [17]. They assume that their reflection in the mirror is real because they see the image is the same as themselves. The answers at level C are the category of misconception-1. Students are fixated on the shape of the shadow that is formed that can be seen by the naked eye. In the concept of a ray diagram for the formation of an image on a flat mirror, students assume that the process of the path of light in the formation of an image is that the ray hits the object and is then reflected the mirror perpendicularly and through the mirror until an image is formed as far as the distance from the mirror to the object. From the position of the image then light is reflected into the eye of the observer so that the image of the object can be seen by the eye. In this context, the correct concept is that the light that hits the object is reflected in the mirror, then the light is reflected again by the mirror to the observer's eye. The image of the object lies in a straight line with the object and the distance from the image to the mirror is the same as the distance from the object to the mirror. This type of misconception has also appeared in research by Widodo [10].

Students who are at level D i.e. giving "Minority or majority-focused explanations of any image formation and connected image properties coincide with this level" there are as many as 10%, and are the most dominant answers. Respondents who answered at this level included misconception-2 where they tried to draw the formation of shadows by luxating the lines of incident rays and reflected rays without applying the law of reflection on a flat plane. Regarding the formation of an image on a plane mirror, most students have difficulty relating the principles of geometrical optics to the occurrence of the image. Most students also think that the position of the image in a plane mirror depends on the position of the observer. This misconception is in by the results of a study by Syarif [18].

There were 8% of students who answered at the level E which gave "Ideas involving concepts and explanations other than the formation of images by plane mirrors correlated with this level and involving arguments that are completely scientifically unacceptable." They assume that the elongation of the reflected ray passing through the mirror is a continuous line. They also assume that when two observers see the image of the same object simultaneously with different positions, the location of the image seen by observer 2 will be different from the image seen by observer 1. Conceptually, the location of the image formed has the same distance as the original object's distance to the mirror so that the image location will not change even if observed from a different observer position.

There were 8% of students who answered at level F, who gave answers in the category of explanation/image that could not be understood, the answer given the respondent could not be understood because there was no relationship between the image and the explanation given. Answers like at this level also become second dominant after Misconception-2. In the concept of a ray diagram for the formation of an image on a flat mirror, students assume that the process of the path of light in the formation of an image is that the ray hits the object and is then reflected the mirror perpendicularly and through the mirror until an image is formed as far as the distance from the mirror to the object. From the position of the image then light is reflected into the eye of the observer so that the image of the object can be seen by the eye.

There were 2% of students who have misconceptions at level G. The group of students at this level assumes that the change in the position of objects after being shifted does not affect the position of the object's

image. They confidently stated that the distance of the object from its image after being shifted 2x the original distance was 3x. This group has not been able to apply the law of reflection on a flat plane to determine the location of an object's image, even though the object shifts, the location of the image remains in its original position.

In question number 2, students are expected to be able to determine the angle of reflection by a plane parallel mirror after several reflections have occurred correctly. The analysis results was shown in Fig. 2. There are 16% of students who have been able to give the right answer, the right explanation the answer with confidence. They have been able to solve the problem correctly and are equipped with a proper and complete explanation of the reasons. Students' explanations are also equipped with the direction of the reflected light, the angle of reflection and, the last reflecting mirror.

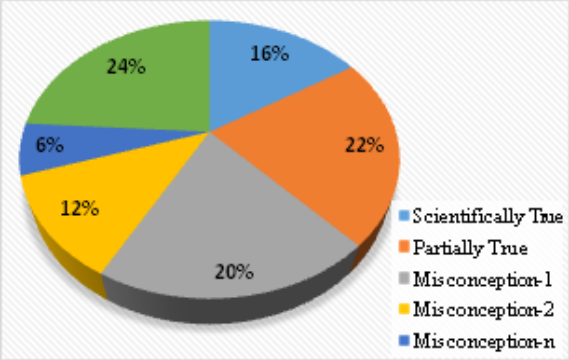

Fig. 2 Graph of the percentage of students misconception level the angle of reflection on two plane-parallel mirrors

There were 22% of students who answered at level B or answered half correctly. This is "The answer to the graph is correct but the explanation is still incomplete". That is to describe the direction of the reflected ray by the 2nd mirror which is not correct. Students have not been able to provide a correct explanation of which mirror gives the last reflection after several reflections have occurred either by mirror1 or by mirror 2. The results of the analysis of student explanations show that they still cannot combine the concepts of trigonometry and the law of reflection correctly.

There were 20% of students have misconceptions at levels C. At this level "false ideas including correct and incorrect explanatory sentences match this level simultaneously". Students have not been able to determine the angle of reflection by the first mirror. Some students are still wrong in determining the angle of incidence if the known angle is the angle between the plane of reflection and the incident ray or the angle between the reflected ray and the plane of flat reflection. These results are under research conducted by Shetiyawan et al [19].

Students at level D were "Explanations that focused on the minority or the majority of components on the problem by 12%. They very confidently stated that the ray of light after being reflected by mirror-1, will go to mirror-2, but the ray of light will be reflected back by mirror-2 through the previous path to mirror-1. The results of this analysis show that students with this type of misconception believe that light can be reflected, but have not been able to apply the law of reflection correctly.

At the third level, students who answered at level E namely "Ideas involving concepts and explanations other than the reflection of light by a plane mirror are correlated with this level and involve arguments that are completely scientifically unacceptable" as much as 6%.

They assume that the reflection of light only occurs in a -1 plane mirror. They can apply the equation to the

law of reflection correctly, but the event of reflection only occurs once, namely by mirror-1.

There were 24% of students who answered at level F, who gave answers in the category of explanations/images that could not be understood, the answers given by respondents could not be understood because there was no relationship between the images and the explanations given. Students still cannot explain correctly the components in the law of reflection, namely incident rays, normal lines and, reflected rays. When a ray of light goes to a plane mirror, it will be difficult to determine the direction of the reflected ray, so it is impossible to predict where the next reflected ray will go. There were no students who answered at level G. Students at this level did not provide explanations or did not provide pictures in the answer column.

In question number 3, students are expected to be able to determine the angle of reflection by a plane mirror formed by two plane mirrors with one end of each mirror forming an angle. The percentage of students' misconceptions levels is shown in Fig. 3. There were 10% of students who have been able to give the correct answer, the right explanation and, answer with confidence.

They have been able to solve the problem correctly and are equipped with a proper and complete explanation of the reasons. Students' explanations are also equipped with the direction of the reflected light, the angle of reflection, and the last reflecting mirror. Students have been able to relate the concepts of trigonometry and the law of reflection correctly.

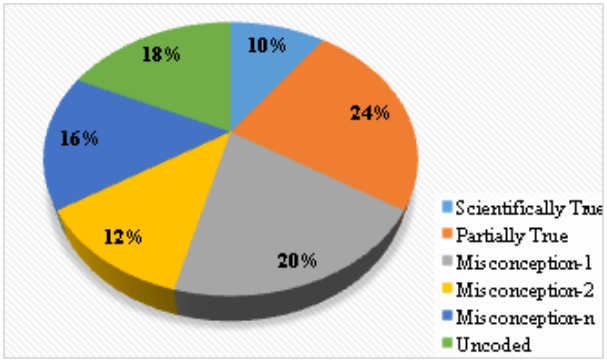

Fig. 3 Graph of the percentage of students misconception level on the angle of reflection on two plane mirrors inclined to each other at an angle of 37^{o}

There are 24% of students who answered at level B or answered half correctly. This is "The answer to the graph is correct but the explanation is still incomplete". That is to describe the direction of the reflected ray by the 2nd mirror which is not correct. Students have not been able to give a correct explanation of the direction of the reflected ray if the incident ray hits the second plane mirror at a certain angle to the first plane mirror. The results of the analysis of the students' explanations showed that they still could not determine the place of the angle of incidence according to the law of reflection.

There were 20% of students have misconceptions at levels of C. At this level "false ideas including correct and incorrect explanatory sentences match this level simultaneously". Students can determine the size of the angle reflected by the first mirror, but cannot determine the size of the angle reflected by the second mirror because the fulcrum of mirror1 and mirror2 form an angle. In determining the direction of reflection from the second plane mirror in reflecting light, it is correct and answered with confidence. Some students are still wrong in determining the angle of incidence if the known angle is the angle between the plane of reflection and the incident ray or the angle between the reflected ray and the plane of flat reflection.

Students who answered at level D were "Explanations that focused on the minority or the majority of components on the problem by 12%. They very confidently stated that the ray of light after being reflected

by mirror-1, will go to mirror-2, but the ray of light will be reflected by mirror-2 through the previous path to mirror-1. Students assume that the adjustment of the angle between the first plane mirror and the second plane mirror will force the light beam to be reflected through the same path. The results of this analysis show that students with this type of misconception believe that light can be reflected, but have not been able to apply the law of reflection correctly.

Students who answered at level E namely "Ideas involving concepts and explanations other than the reflection of light by a plane mirror are correlated with this level and involve arguments that are completely scientifically unacceptable" as much as 16%. Students assume that the reflection of light only occurs in a -1 plane mirror. They can apply the equation to the law of reflection correctly, but the event of reflection only occurs once, namely by mirror-1.

There were 18% of students who answered at level F, namely the group of respondents who gave answers in the category of explanations/images that could not be understood, the answers given by respondents could not be understood because there was no relationship between the images and the explanations given. Students still cannot explain correctly the components in the law of reflection, namely incident rays, normal lines, and reflected rays. When a ray of light goes to a plane mirror, it will be difficult to determine the direction of the reflected ray, so it is impossible to predict where the next reflected ray will go. There were no students who answered at level G. Students at this level did not provide explanations or did not provide pictures in the answer column.

In problem number 4, students are expected to be able to determine the critical angle between two mediums that are traversed by a light beam so that perfect reflection occurs correctly. The percentage of students' misconceptions levels is shown in Fig. 4. There are 45% of students who have been able to give the right answer, the right explanation, and the answer with confidence. They have been able to solve the problem correctly and are equipped with a proper and complete explanation of the reasons. Students' explanations are also equipped with the direction of the reflected ray, the angle of reflection by the second medium. Students are also able to correctly relate the concepts of the law of reflection and critical angles.

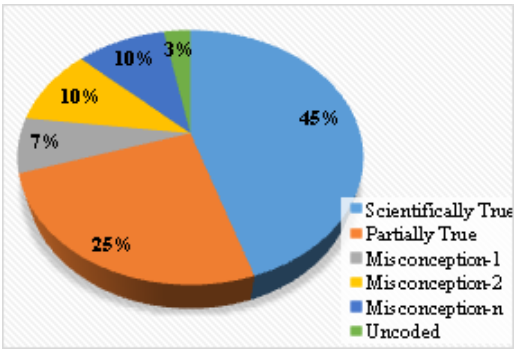

Fig.4 Graph of the percentage of students misconception level on a critical angle and total internal reflection

There were 25% of students who answered at level B or answered half correctly. This is "The answer to the graph is correct but the explanation is still incomplete". Students have been able to describe the process of perfect reflection correctly, but have not been able to explain the application of mathematical equations so that perfect reflection occurs. As a result, students cannot determine the size of the critical angle. The results of the analysis of the students' explanations showed that they still could not determine the place of the angle of incidence according to the law of reflection.

There were 7% of students have misconceptions at levels of C. At this level "false ideas including correct and incorrect explanatory sentences match this level simultaneously". Students understand the meaning of perfect reflection well but cannot explain well the requirements for perfect reflection to occur. Students

assume that it is impossible for two events can't occur at once in a designed condition, namely reflection and refraction.

Students who answer at level D, are explained that focus on the minority or the majority of components on the problem by 10%. They very confidently stated that perfect reflection could occur when light passed through two different mediums, but could not calculate the critical angle. At the third level, students who answered at level E namely "Ideas involving concepts and explanations other than the reflection of light by a plane mirror are correlated with this level and involve arguments that are completely scientifically unacceptable" as much as 10%. Students assume that light reflection only occurs when light rays come from a less dense medium to a denser medium.

Furthermore, there were 3% of students who answered at level F, namely the group of respondents who gave answers in the category of explanation/image that could not be understood, the answer given the respondent could not be understood because there was no relationship between the image and the explanation given. Students can still explain correctly the components in the law of reflection, namely incident rays, normal lines, and reflected rays, but do not understand the requirements for the law of reflection and critical angles. When a ray of light goes to a medium with a lower index of refraction, it will be difficult to determine the direction of the reflected ray, because the light is usually transmitted. There were no students who answered at level G. Students at this level did not provide explanations or did not provide pictures in the answer column.

In question number 5, students are expected to be able to explain the application of the law of reflection, apply mathematical equations in determining the nature of the image and describe the formation of an image by a concave mirror. The analysis results was shown in Fig.5. The percentage of students' misconceptions levels is shown in Fig. 5. There are 20% of students who are sure they are right and can give scientific reasons correctly. Students in this group are categorized as level A (Scientific correct) which is under the category "True scientific explanations have taken part in this level, where, the graphs made are correct and equipped with correct and complete explanations of reasons". Students have also been able to use mathematical equations in determining the height of the image formed by the first mirror, the height of the image by the second mirror, and showing the difference in height of the image formed by the first and second mirrors using special rays.

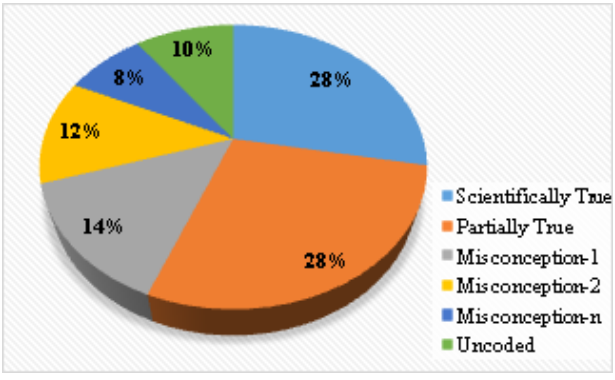

Fig 5. Graph of the percentage of students misconception level on the formation of an image by a concave mirror

There were 28% of students who answered incompletely. This group of students is categorized as level B. Students have been able to understand the use of mathematical equations in determining the magnification of an image by a concave mirror, and the results are scientifically proven to be correct. However, there are still imperfections in describing the formation of the image. At this level, several respondents answered with the correct answer, namely the image of the formation of shadows correctly, but were unable to express a

strong reason for the answer.

Students who experience misconceptions are at three levels. The first is at level C, which is "False ideas including correct and incorrect explanatory sentences simultaneously fit into this level". There are 14% of students revealing that the smaller the radius of the concave mirror, the smaller the image formed and if the concave mirror is replaced with another concave mirror with a larger radius of curvature, the image formed will also be larger. Students do not consider the distance between the object and the mirror in determining the final image of the object. This can be seen from the way they describe the formation of an image either by a concave mirror 1 or by a concave mirror 2. Students have been able to describe the formation of an image by a concave mirror 1 correctly. However, after mirror1 is replaced with mirror 2, they still maintain that the mirror's focal length is fixed.

The student who answered at level D was "Explanations that focused on the minority or majority of the shadow-forming components coincided with this level". There are as many as 12% of students who experience misconceptions at this level. Respondents who answered at this level were included in misconception-2. Students have been scientifically correct in applying the equations in determining the image by a concave mirror and in describing the formation of an image by a mirror 1 and have also applied the principle of special rays to a concave mirror. However, when mirror 1 is replaced with a second mirror with a smaller radius of curvature, the object's distance to the mirror does not change, students assume that the distance of the image formed will be farther away from the mirror, so the image height of the object will be smaller. Students cannot provide the same explanation for the reasons obtained based on the results of calculations and pictures.

There were 8% of students in n-type misconceptions. The ideas or ideas they have to solve problems based on concepts or pictures are not scientifically acceptable. Students assume that the difference in the radius of curvature of mirror 1 and mirror 2 does not affect the location of the final image produced, so the height of the image formed is the same. The most influential in the formation of the image of an object in a concave mirror is the distance of the object to the mirror. Scientifically, students in this group have understood the mathematical equations in determining the location of an object's image, but they think, even though mirror1 has been replaced with mirror-2 with a smaller radius of curvature, the focal length remains the same. So that in determining the location of the final image by mirrors, either through the use of equations or by depicting using special rays, the results are not correct.

There were 10% of students who answered at level F, namely the group of respondents who gave answers in the category of explanations/images that could not be understood, the answers given by respondents could not be understood because there was no relationship between the images and the explanations given. Students in this group do not yet understand the formation of images by concave mirrors. There are no students who are at level G

In question number 6, students are expected to be able to explain scientifically the application of the law of reflection, apply mathematical equations in determining the nature of the image and describe the formation of an image by a concave mirror. To see the truth of the concepts possessed by students, the MMRT problem on a concave mirror is used, which is to compare the image height of an object whose position is changed by an object mirror. The analysis results was shown in Fig.6. There are 15% of students who are sure they are right and can give scientific reasons correctly. Students in this group are categorized as level A which categorize as "True scientific explanations have taken part in this level, where, the graphs made are correct and equipped with correct and complete explanations of reasons". Students have been able to use mathematical equations in determining the image height of an object formed by a mirror at position 1 and position 2. Students have also been able to describe the image formation by mirrors at position 1 and position 2.

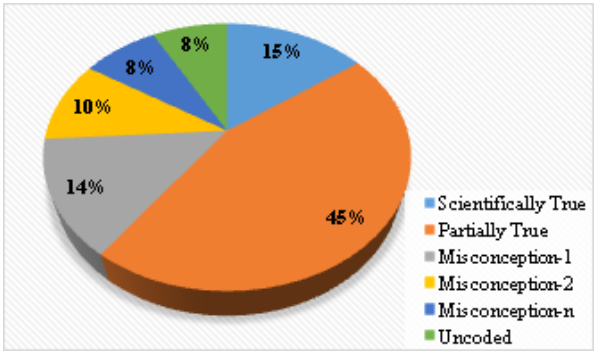

Fig.6 Graph of the percentage of students misconception level on the formation of an image by a concave mirror

There were 45% of students who answered incompletely. This group of students is categorized as level B. Students in this group have been able to understand the use of mathematical equations in determining the magnification of an image by a concave mirror, and the results are scientifically proven to be correct. However, there are still imperfections in describing the formation of the image. At this level, several respondents answered with the correct answer, namely the image of the formation of shadows correctly, but were unable to express a strong reason for the answer.

Students who experience misconceptions at level C "Wrong ideas including correct and incorrect explanatory sentences are compatible with this level". There are as many as 14% of students said that the location of the object will affect the height of the image. They assume that the farther the object is from the mirror, the farther the image from the mirror will be, so the image height of the object will also be greater. However, because the image formed at position 1 is virtual, the image formed at position 2 is real, students assume that the two images cannot be compared.

The student who answered at level D was "Explanations that focused on the minority or majority of the shadow-forming components coincided with this level". There are as many as 10% of students who experience misconceptions at this level. Students are scientifically correct in applying the equations in determining the image by a concave mirror at position 1 and position 2. However, when they describe the formation of an image of an object at position 1, they cannot give a reason why the image is called virtual. Likewise, when the object is in position 2, students are hesitant to answer whether the image is virtual or real. Students cannot provide the same explanation for the reasons obtained based on the results of calculations and pictures.

For students who are at level E, there are 8% of n-type misconceptions. The ideas or ideas they have to solve problems based on concepts or pictures are not scientifically acceptable. Students assume that the difference in the position of objects does not affect the shape of the object's image. The most influential in the formation of the image of an object in a concave mirror is the distance of the object to the mirror. Scientifically, students in this group have understood the mathematical equations in determining the location of an object's image, but they assume that the image formed by a concave mirror is always real.

Furthermore, there were 8% of students who answered at level F, namely the group of respondents who gave answers in the category of explanation/image that could not be understood, the answer given the respondent could not be understood because there was no relationship between the image and the explanation given. Students in this group have not understood the problem correctly. They wrote on the reasoning sheet, that the object only moved a distance x from its original position. There are no students who are at level G.

In question number 7, students are expected to be able to explain the application of the law of reflection, apply mathematical equations in determining the nature of the image and describe the formation of an image by a convex mirror correctly. To investigate the concepts that students have on this topic, a written test is conducted, which is to compare the image height of an object by mirrors with different curvature radii. The analysis results was shown in Fig.7.

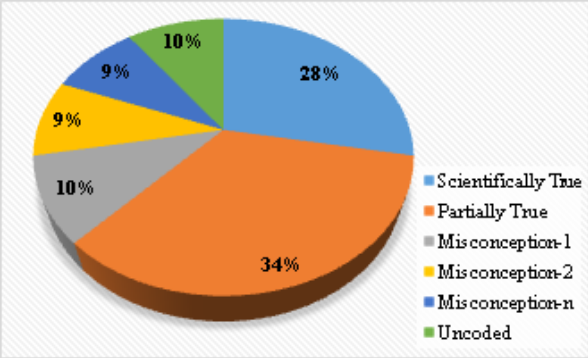

Fig. 7 Graph of the percentage of students misconception level on the formation of an image by a convex mirror

There are 28% of students who are sure they are right and can give scientific reasons correctly. Students in this group are categorized as level A (Scientific correct) which is under the category "True scientific explanations have taken part in this level, where, the graphs made are correct and equipped with correct and complete explanations of reasons". Students have also been able to use mathematical equations in determining the height of the image formed by the first mirror, the height of the image by the second mirror, and showing the difference in height of the image formed by the first and second mirrors using special rays.

There were 34% of students who answered incompletely. This group of students is categorized as level B. Students have been able to understand the use of mathematical equations in determining the magnification of an image by a concave mirror, and the results are scientifically proven to be correct. However, there are still imperfections in describing the formation of the image. At this level, several respondents answered with the correct answer, namely the image of the formation of shadows correctly, but were unable to express a strong reason for the answer.

There are three levels of misconceptions that students have about this concept. The first is at level C, which is "False ideas including correct and incorrect explanatory sentences simultaneously fit into this level". As many as 10% of students are in this level of misconception. Students assume that the larger the radius of the convex mirror, the larger the image formed and they are very sure of this assumption. However, in the process of determining the final image using mathematical equations, students do not consider changes in the distance between the object and the mirror even though the radius of curvature of the mirror has been changed. Students have been able to describe the formation of an image by a convex mirror1 correctly. However, after mirror1 is replaced with mirror 2 which has a larger radius of curvature, they still maintain that the object's position is still in the same space.

The student who answered at level D was "The explanation that focuses on the minority or the majority is related to the component of the formation of the image by the mirror. As many as 8% of students experience misconceptions at this level. Respondents who answered at this level were included in misconception-2. Students have been scientifically correct in applying the equations in determining the image by a convex mirror1 and describing the formation of an object's image by applying the principle of special rays. However, when mirror 1 is replaced with a second mirror with a larger radius of curvature, they assume that

the distance from the object to the mirror is also getting bigger. Students assume that even though the mirror has been replaced, the distance of the image formed will remain the same so that the image height of the object does not change. Students cannot provide the same explanation for the reasons obtained based on the results of calculations and pictures.

For students who are at level E, there are 8% of n-type misconceptions. The ideas or ideas they have to solve problems based on concepts or pictures are not scientifically acceptable. When explaining through pictures, students assume that the difference in the radius of curvature of mirror 1 and mirror 2 does not affect the location of the final image produced, so the height of the image formed is the same. However, in solving problems using mathematical equations, they provide the correct explanation.

Furthermore, there were 12% of students who answered at level F, namely the group of respondents who gave answers in the category of explanations/images that could not be understood, the answers given by respondents could not be understood because there was no relationship between the images and the explanations given. Students in this group do not yet understand the formation of images by concave mirrors. There are no students who are at level G.

In question number 8, students are expected to be able to explain the application of the law of refraction by Snell's Law on a flat surface, apply mathematical equations in determining the nature of the image and describe the formation of the image correctly. To investigate the concepts students have about this topic, a written test is conducted, which compares the actual position with the relative position of a stone located at the bottom of a pool filled with water. There are 42% of students who are sure they are right and can give scientific reasons correctly. Students in this group are categorized as level A (Scientific correct) which is under the category "True scientific explanations have taken part in this level, where, the graphs made are correct and equipped with correct and complete explanations of reasons". Students have also been able to use mathematical equations to determine the actual depth of the rock and the visible depth due to refraction by light. When a wave or ray of light changes its speed as it travels from one medium to another. The direction of the rays can also change due to changes in speed in these different mediums. This property of waves is called refraction of refraction. When light travels from air to a denser medium such as water or glass, it refracts toward the normal. This means that light will move toward a line that is perpendicular to the surface of these two mediums. When light travels from a denser medium (such as water) into the air, it refracts away from the normal.

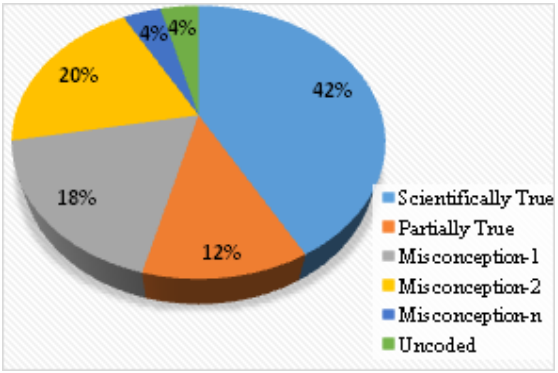

Fig. 8 Graph of the percentage of students misconception level on Refraction by a flat surface

There were 12% of students who answered incompletely. This group of students is categorized as level B. Students understand the use of mathematical equations in determining the position of the stone by considering the medium in which the stone is placed. They have also understood why rocks appear closer than they are, which is caused by light coming from the air (less dense) towards water (denser) and will refract away from the normal. However, there is still incompleteness in describing the formation of the

shadow. At this level, several respondents answered with the correct answer, namely the image of the formation of shadows correctly, but were unable to express a strong reason for the answer.

As many as 18% of students who are in the level of misconceptions at level C, namely "Wrong ideas including correct and incorrect explanatory sentences match this level at the same time". Students assume that light rays from the water medium to the air are refracted closer to the normal line. Whereas the actual concept is that light will be refracted away from the normal when light moves from a dense medium (water) to a less dense medium (air) or n2 < n1, then 2 > 1. Students experience misconceptions because they cannot process properly and correctly their initial concepts (the phenomenon of the pool looks shallow) into new knowledge about the concept of light refraction. This is related to Gagne's theory of information processing, namely natural phenomena around (in the form of facts) which become students' initial concepts can become new knowledge if processed and processed correctly [20]. Under the results of interviews, students also assume that the density of air is greater than water so that the bottom of the swimming pool looks shallower to the eye. The wrong initial concept was obtained by students from the process of asking their parents and siblings as well as from browsing the internet (not necessarily the truth). This is in line with research conducted by Wahyuningsih et al [21], which found misconceptions in class VIII students on one of the characteristics of light.

Students who answered at level D were "Explanations that focus on the minority or the majority are related to the problems to be solved. As many as 20% of students experience misconceptions at this level. Respondents who answered at this level were included in misconception-2. The student was scientifically correct and confidently explained that the ground floor of the pool filled with water looks shallower than its actual position due to refraction factors, but failed to provide additional explanations and explanations in solving the problem. Rays coming from air to water are refracted closer to the normal line. However, they cannot explain using the equations in determining the apparent depth of the pool floor and also describing the formation of shadows that occur. The results of interviews with students explained that the bottom floor of the pool looks shallower because the water is clean and clear,

For students who are at level E, there are as many as 4% of n-type misconceptions. Students were scientifically correct but unsure of their answers in explaining that the ground floor of a pool filled with water looked shallower than its actual position due to refraction factors, but failed to provide additional explanations and explanations in solving the problem. The ideas or ideas they have to solve problems based on concepts or pictures are not scientifically acceptable. In this group, students believe in their answers but cannot be accepted scientifically correctly. Explanations and additional explanations given by students are not under scientific rules.

Furthermore, students, who are at level F there are as many as 4%, namely the group of respondents who gave answers in the category of explanation/image that could not be understood, the answer given by the respondent could not be understood because there was no relationship between the image and the explanation given. Students scientifically cannot explain that the ground floor of a pool filled with water looks shallower than its actual position due to refraction factors, and fails to provide additional explanations and explanations in solving problems. On the other hand, students in this group are very sure of the truth of the explanation given. There are no students who are at level G.

In question number 9, students are expected to be able to explain the application of Snell's law of refraction on positive lenses, apply mathematical equations in determining the nature of images and describe the formation of images correctly. To investigate the concepts that students have on this topic, a written test is conducted, which compares the changes in the position of the image of an object that is located in front of a positive lens. The analysis results was shown in Fig.9. There are 20% of students who are sure they are right and can give scientific reasons correctly. Students in this group are categorized as level A (Scientific correct) which is under the category "True scientific explanations have taken part in this level, where, the

graphs made are correct and equipped with correct and complete explanations of reasons". Students have also been able to provide additional explanations and explanations and are confident in their answers. They can determine the location of the image of an object after the object is shifted 10 cm away from the lens and describe the formation of the image correctly.

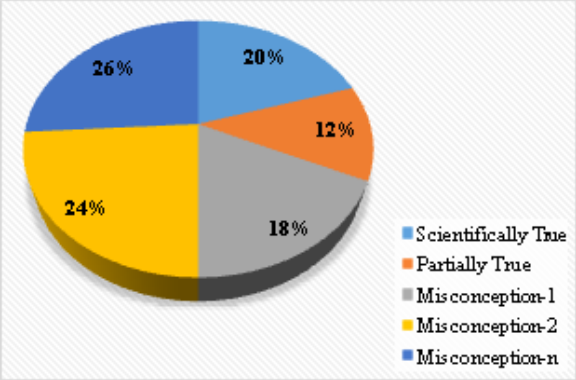

Fig.9 Graph of the percentage of students misconception level on Refraction by a convex lens

There were 12% of students who answered incompletely. This group of students is categorized as level B. Students understand the use of mathematical equations in determining the position of the stone by considering the medium in which the stone is placed. Students have been able to solve problems confidently and correctly and can provide an appropriate explanation, but they failed to provide an answer when they were asked to provide additional explanations by describing the formation of shadows. They did not yet fully understand the use of special rays in the formation of images by convex lenses.

As many as 18% of students who are in the level of misconceptions at level C, namely "Wrong ideas including correct and incorrect explanatory sentences match this level at the same time". Students give incorrect answers to existing problems but are sure that they are correct. However, they can provide correct explanations and additional explanations. The results of interviews with students in this group stated that the formation of an image by a positive lens is in principle the same as the formation of an image by a convex mirror. Students experience misconceptions because they cannot distinguish properly and correctly the initial concepts they have into new knowledge about the concept of light refraction. This is related to Gagne's theory of information processing, namely natural phenomena around (in the form of facts) which are students' initial concepts that can become new knowledge if processed and processed correctly.

Students who answered at level D were "Explanations that focus on the minority or the majority are related to the problems to be solved. As many as 24% of students experience misconceptions at this level. Respondents who answered at this level were included in misconception-2. The student was scientifically correct and confidently explained that if the object is shifted 10 cm away from the lens, the image of the object will shift towards the lens by 15 cm. However, students failed to give a correct solution when they were asked to explain the form of a solution with an equation and an additional explanation by describing the formation of shadows.

For students who are at level E, there are 26% types of n-type misconceptions. Students cannot answer questions correctly but are confident in their answers in explaining the change in the position of the image of an object when the initial position of the object changes. This group of students also failed to provide additional explanations and explanations for the problem. The results of the interview show that the process of image formation by a positive lens is the same as the process that occurs in a convex mirror. This group also experienced problems in interpreting the word change in the position of objects. There are no students who are at levels F and G

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In question number 10, students are expected to be able to explain scientifically the application of the law of refraction, apply mathematical equations in determining the nature of images and describe the formation of images by a concave lens or a negative lens. To see the truth of the concepts possessed by students, the MMRT problem on a concave lens is used, which is to compare the image height of an object whose position is changed by a lens. The results of student level misconception are shown in figure 10. There are 22% of students who are sure they are right and can give scientific reasons correctly. Students in this group are categorized as level A (Scientific correct) which is under the category "True scientific explanations have taken part in this level, where, the graphs made are correct and equipped with correct and complete explanations of reasons". Students have been able to use mathematical equations in determining the location of the image of an object formed by a negative lens at position 1 and position 2. Students have also been able to describe the image formation by mirrors at position 1 and position 2.

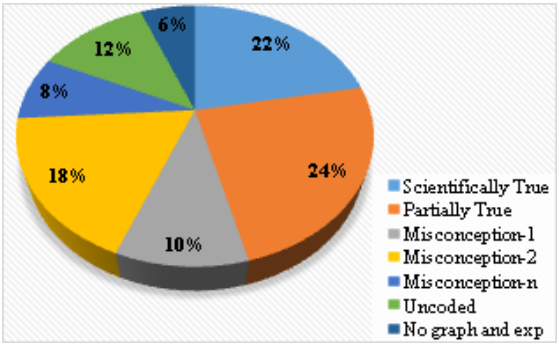

Fig. 10 Graph of the percentage of students misconception level on refraction by a concave lens

There were 24% of students who answered incompletely. This group of students is categorized as level B. Students in this group are confident and have been able to understand the use of mathematical equations in determining the magnification of an image by a concave mirror, and the results are scientifically proven to be correct, but there are still imperfections in describing the formation of the image. At this level, several respondents answered with the correct answer, namely the image of the formation of shadows correctly, but were unable to express a strong reason for the answer.

Students who experience misconceptions at level C are "Wrong ideas including correct and incorrect explanatory sentences are compatible with this level". There are as many as 10% of students who can not answer correctly because the location of the object will affect the height of the image. They assume that the farther the object is from the lens, the farther the image will be from the lens. However, in providing additional explanations and explanations they can answer correctly and completely.

The student who answered at level D was "Explanations that focused on the minority or majority of the shadow-forming components coincided with this level". There are as many as 18% of students who experience misconceptions at this level. Students are scientifically correct and confident in giving choices in solving problems. However, they are hesitant in explaining by applying the equation in determining the image by a concave lens at position 1 and at position 2. This group also hesitates in providing additional explanations in the form of painting the image formation of objects at position 1, Likewise, when objects are in position 2, students hesitate to answer whether the image is virtual or real. Students cannot provide the same explanation for the reasons obtained based on the results of calculations and pictures.

For students who are at level E, there are 8% of n-type misconceptions. The ideas or ideas they have to solve problems based on concepts or pictures are not scientifically acceptable. Students believe that the difference in the position of objects does not affect the shape of the object's image. The most influential in the formation of the image of an object on a concave lens is the distance of the object to the mirror.

Scientifically, students in this group do not yet understand the mathematical equations in determining the location of the shadow of an object and use special rays to determine the location of the final image of an object.

Furthermore, there were 12% of students who answered at level F, namely the group of respondents who gave answers in the category of explanations that could not be understood, the answers given by respondents could not be understood because there was no relationship between the images and the explanations given. Students in this group, although they can understand the problem correctly, they fail to provide additional explanations and explanations. They are also not sure of the answer. There are 6% of students who are at level G. This group does not provide a clear response to the problems given.

CONCLUSION AND SUGGESTIONS

Research shows that prospective physics teacher students still experience misconceptions about the concept of geometric optics even though they have studied it since elementary school, junior high school, high school, and elementary physics courses. Research analysis using the multiple-misconception revealing test (MMRT) diagnostic test revealed that prospective physics teacher students who experienced misconception-1 were 14.80%, misconception-2 was 13.60% and experienced and misconception-n was 10.20%. . The misconception experienced by students in reflection by a plane mirror is to assume that the resulting image is real. The student's misconception on reflection by a curved mirror is to assume that the image properties of an object located in front of a curved mirror will remain the same even if the object is changed in position or replaced by another curved mirror with a different radius. The student's misconception that occurs in determining the location of the image of an object at the bottom of a pool filled with clear water is that the image distance is the same as the object distance. The student's misconception in determining the image properties of an object by a lens that has a curved surface is that it does not change even though the lens is replaced with a lens with a different curvature. This reveals that students come to campus with preconceptions and sometimes these preconceptions are misconceptions. The preconceptions possessed by students can come from everyday experiences when interacting with the surrounding environment. Misconceptions can affect student learning outcomes. So that there is a need for remediation of misconceptions so that student learning outcomes can be maximized. Remediation of misconceptions cannot be carried out before the identification of misconceptions is carried out. It is important for education actors, especially educators, to know how to identify students' misconceptions and then take action to remediate misconceptions.

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