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# Level of Students Conceptual Understanding and Resource Theory View: Geometric Optics

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**Abstract:** This study aims to identify the level of understanding (LoU) and resources that students activate. This is a descriptive study. The study used a survey method by distributing ten multiple-choice questions. The focus of the study is geometric optics. The research was conducted on 64 physics students who were taking Basic Physics III courses. Data analysis was carried out by determining descriptive statistics and categorizing students' LoU based on the reasons given. The LoU includes Sound Understanding, Partial Understanding, Partial Understanding with Specific Misconceptions, Specific Misconceptions, and Not Understanding. Based on the analysis of the research results, the average score of students' conceptual understanding was 53.44. Furthermore, the average levels of understanding are 15.9% for Sound Understanding, 28.1% for Partial Understanding, 14.7% for Partial Understanding with Specific Misconceptions, 16.4% for Specific Misconceptions, and 26.2% for Not Understanding. Meanwhile, the resource that is activated by students when showing possible rays in the formation of images on a convex lens is "there are only three possible rays". It means that students do not understand that it is not only "three special rays" reflected by objects towards the lens to form an image.

## INTRODUCTION

Physics is often found in human life and is related to natural phenomena. One of the important learning goals in physics is conceptual understanding (Taqwa et al., 2020; Taqwa & Taurusi, 2021). In learning physics, mastery and understanding of concepts are very important for every student. Students who can understand the concept well are also expected to be able to solve related problems (Docktor & Mestre, 2014a; Etikamurni et al., 2020; Ryan et al., 2016). Without a good understanding of the concept, other thinking skills will also be difficult for students to achieve.

One of the physics materials related to everyday events is optics. Optical representations that occur in daily events are reflection and refraction. Examples include the reflection of sunlight hitting the mirror surface and the refraction that occurs when a ray of light penetrates the pool water. Although closely related to life, many students are still wrong in explaining the concept of reflection and refraction.

University students still have many misconceptions on the topic of Geometric Optics (Admoko et al., 2018). A study conducted by Aydin (Aydin, 2012) also obtained the results of misconceptions on the concept of reflection and refraction of light, where students assume that to be able to see objects on a flat mirror, the light source must shine on the mirror, the mirror and the object must be illuminated so that the object can be seen. In a mirror in a dark room, and when light passes through a concave mirror and a convex mirror, the light will be refracted into the back of the mirror. Another finding on the same topic conducted by Suniati, et al., (Suniati et al., 2013) in his research found misconceptions on the concept of light propagation in a medium, the nature of the image on a plane mirror, the nature of the image on a convex mirror, refraction of the lens, and the process of image formation on a plane mirror. Lens. The same results were also found by Hakim (2017) who stated that 30% of students had misconceptions about the concept of shadows, 80% of students did not know the idea of actual images, and 30% of students did not understand the concept of virtual images. Meanwhile, in a study conducted by Handayani & Rukmana (2018) on the topic of optics, it was stated that students who experienced the highest misconceptions at 77% on indicators identified the properties of light, and indicators understood the image formation process on a concave mirror.

Understanding is a level of ability where students can master the concepts, situations, and facts they experience. Therefore, understanding can be interpreted as a process or way to understand correctly or know correctly. In contrast, a concept is used to organize knowledge and experience into categories (Arends, 2012). Concept understanding is a link between concepts and how to apply concepts or perform procedures in a flexible, accurate, efficient, and precise manner in solving a problem. Students must be able to distinguish between one concept and another to be able to learn concepts well. The criteria for understanding the concepts used in this study are classified into 5 levels, namely Solid Understanding (PM), Partial Understanding (PS), Partial Understanding with Specific Misconceptions (PSMS), Specific Misconceptions (MS), and Not Understanding (TP) (Taqwa, 2017).

One of the cognitive theories that can explain student learning difficulties is resource theory (Docktor & Mestre, 2014b). According to the resource theory, students fail to solve problems not because they do not have the proper knowledge but because they fail to activate knowledge relevant to the problem (Hammer, 2000). Resource theory states that students' prior knowledge is not wrong, so that if the theory is applied in learning, educators will not eliminate prior knowledge and replace it with new ones. Still, educators will help students build understanding according to contexts and concepts recognized by experts and help students assemble pieces of knowledge so that it becomes a whole concept. Resource theory assumes that the knowledge possessed by students is in the form of pieces of knowledge. Based on research conducted by Hammer & Disessa (diSessa & Sherin, 1998; Hammer, 2000), it is told that the knowledge of students who are activated to explain a phenomenon is very dependent on the context used to explain the phenomenon, which can lead to misconceptions if it is not constructed into a complete concept. Resource theory is very important, especially in physics education, because it can better understand the phenomenon of misconceptions (diSessa, 2018). However, so far there has been no research that examines student difficulties on the topic of optics geometric based on a review of resource theory. Therefore, this research aims to identify students' conceptual understanding of the topic of optics geometric in terms of the level of understanding and resource theory.

## METHOD

Method The purpose of this study is to identify students' conceptual understanding of the topic of reflection and refraction, in terms of the level of understanding (LoU) of concepts and resource theory. The type of research conducted is descriptive research, with data in the form of quantitative data and qualitative data. The research subjects were 64 physics education students who were learning Basic Physics III.

A multiple choice test with reasoned was used in this study. This test has been developed beforehand, by adapting from journals and university lecture books. Before being reduced, there were 13 questions about the ability to understand concepts. The 13 questions were then submitted to the validator to be validated. The results of the validation of the questions by the revised validator will be distributed to 40 physics students who are taking the Learning Assessment course. The 40 students had already received the Basic Physics III in the previous semester. The data obtained will be tested empirically, which includes the validity test, reliability test, difficulty level test, and different power test. Based on the results of the empirical test, 3 items were declared invalid. Then, 10 valid questions were distributed to 64 physics students who were taking the Basic Physics III course. The results of the data obtained will be analyzed quantitatively and qualitatively. Details of the indicators for each question tested on student are shown in Table 1.

**Table 1.** Details Of The Indicators For Each Question.

| No. | Question Indicator | Number of Question |
|---|---|---|
| 1. | Students can identify the concept of angle of incidence and angle of reflection correctly. | 1 |
| 2. | Students can determine the position of objects in a concave mirror correctly. | 2 |
| 3. | Students can correctly name the image formation diagram on the lens. | 3 |
| 4. | Students can correctly identify light refraction events. | 4 |
| 5. | Students can correctly determine the distance from the center of curvature, the image distance, and the nature of the image on a convex lens. | 5 |
| 6. | Students can determine the size of a plane mirror and the distance of the mirror correctly. | 6 |
| 7. | Students can determine the frequency and refractive index of a substance correctly. | 7 |
| 8. | Students can correctly determine the angle of refraction and angle of reflection of a ray of light through the medium. | 8 |
| 9. | Students can correctly identify the angle of incidence, angle of reflection, and angle of refraction on a triangular prism. | 9 |
| 10. | Students can determine the number of reflections of light on the mirror correctly. | 10 |

The validity test on each item was carried out using the biserial point correlation formula. Questions can be said to be valid when the value of $r_{bis}$ is greater than $r_{table}$. The results of the validity of each item can be seen in Table 2.

**Table 2.** The Results Of The Validity Of Each Concept Understanding Question

| Questions | $r_{pbi}$ | < or > | $r_{critical}$ | Category |
|---|---|---|---|---|
| 1 | 0,3996 | > | 0,3044 | Valid |
| 2 | 0,1036 | < | 0,3044 | Invalid |
| 3 | 0,4649 | > | 0,3044 | Valid |
| 4 | 0,2166 | < | 0,3044 | Invalid |
| 5 | 0,4298 | > | 0,3044 | Valid |
| 6 | 0,5932 | > | 0,3044 | Valid |
| 7 | 0,5597 | > | 0,3044 | Valid |
| 8 | 0,3087 | > | 0,3044 | Valid |
| 9 | 0,5082 | > | 0,3044 | Valid |
| 10 | 0,4933 | > | 0,3044 | Valid |
| 11 | 0,3363 | > | 0,3044 | Valid |
| 12 | 0,4952 | > | 0,3044 | Valid |
| 13 | 0,2895 | < | 0,3044 | Invalid |

Based on the table above, it can be seen that there are 3 invalid questions, so the three invalid questions will be reduced. The ten questions that we used in this study are as shown in Table 1. After the validity test, a reliability test will be carried out, which aims to determine the level of consistency of the instrument in the study de Sousa Magalhães et al., (Magalhães et al., 2012). The test criteria for the reliability of the questions are adopted from Arikunto (Arikunto, 2016). Based on the results of the data analysis, the reliability value of the question was 0.633. The reliability value obtained from the study is included in the high criteria. The reliability value obtained has met the requirements and the instrument is suitable for use in research. Furthermore, based on the criteria for the discriminant index and the difficulty level index, the items are also suitable for use in research based on the Suruchi & Rana criteria (Suruchi & Rana, 2014).

The number of scores of students who answered the correct option will be analyzed by calculating descriptive statistics consisting of the mean, mode, median, and standard deviation. While the reasons for students' answers to each question will be analyzed with Miles and Huberman stage (Miles & Huberman, 1994). The reasons for students' answers to each item will be classified into five levels of concept understanding, namely Sound Understanding (SU), Partial Understanding (PU), Partial Understanding with Specific Misconceptions (PUSM), Specific Misconceptions (SM), and Not Understanding (NU) (Taqwa, 2017).

## RESULT AND DISCUSSION

### *Descriptive Statistics Concept Understanding*

Result The results of the descriptive statistical data show the ability of students to understand the topic of reflection and refraction in general. Descriptive statistical data on the ability of students to understand the topics of reflection and refraction are shown in Table 3.

**Table 3.** Descriptive Statistical Data Scores on Concept Understanding of Reflection and Refraction

| Statistics | Result |
|---|---|
| N | 64 |
| Average | 53.44 |
| Median | 60.00 |
| Mode | 60.00 |
| Standard Deviation | 20.02 |

Based on the data results in Table III above, it shows that the ability to understand students' concepts on the topic of reflection and refraction is below. This can be seen from the average test scores listed in the table, which is supported by the average category by Anggereni & Khairurradzikin (2016). While the distribution of data on the percentage of the number of correct answers for each item that students have done is shown in Figure 1.

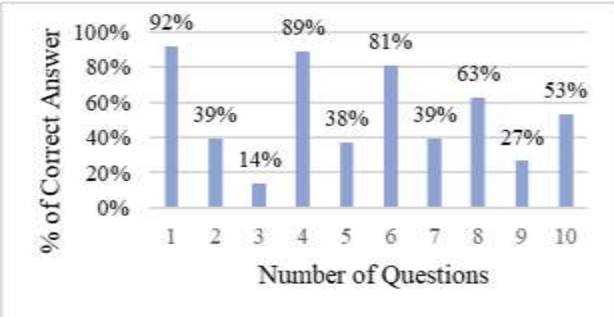



**Figure 1.** Percentage of Correct Answers to Each Question

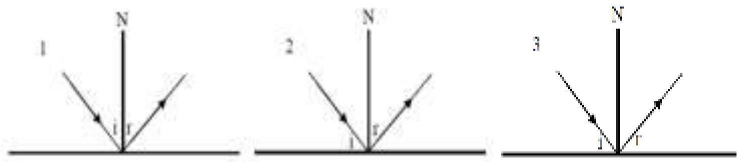
Based on the graphic data in Figure 1 above, the average number of students who can answer correctly is 53.4375. Question number 1 is the question with the most correct answers, with a percentage reaching 92%. This shows that students have good understanding skills on indicators of identifying the concept of angle of incidence and angle of reflection as in number 1. In contrast, the question with the least correct answer is question number 3 with a percentage of 14%. Problem number 3 tests the ability to name a diagram of image formation on a lens. The classification of the reasons for students' answers in terms of the understanding levels for each item as shown in Table 4.

**Table 4.** Classification of Student Reasons Judging from the Level of Understanding for Each Item

| | % of Students' for Each Understanding Level | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| LoU | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| SU | 62.50 | 34.40 | 3.12 | 12.50 | 4.69 | 12.50 | 34.40 | 45.31 | 4.69 | 3.12 |
| PU | 14.06 | 1.56 | 7.81 | 46.87 | 31.25 | 62.50 | 1.56 | 23.44 | 6.25 | 40.62 |
| PUSM | 4.69 | 0.0 | 28.12 | 1.56 | 10.94 | 7.81 | 31.25 | 12.50 | 6.25 | 21.87 |
| SM | 6.25 | 50 | 29.69 | 10.94 | 35.94 | 3.12 | 0.00 | 6.25 | 17.19 | 0.00 |
| NU | 12.50 | 14 | 31.25 | 28.12 | 17.19 | 14.06 | 32.81 | 12.50 | 65.62 | 34.37 |

Figure 2 shows the results of the classification of student reasons in terms of the level of understanding of the concept of each item. Question number 1 shows the percentage of students' steady understanding at most, which is 62.5%. This is comparable to Figure 1 which shows that most students' correct answers are at number 1. Then in question number 2, it can be seen that the highest percentage is at the level of understanding misconceptions, which is 50%, whereas the percentage of students' correct answers at number 2 is 39%. While in question 3 it is shown that the students' correct answers are 14%. This is comparable to the percentage of students' steady understanding of question number 3 in Figure 8 which is only 3.12%. Based on the three questions, it can be concluded that students who answer the correct answer option do not necessarily have a sound understanding of the concept (Nadhor & Taqwa, 2020). The three questions will be shown in Figure 2, Figure 3, and Figure 4.

Take a look at the reflection chart below !




Based on Snell's Law, the correct graph is the number….

A. 1
B. 2
C. 3
D. No correct answer

**Figure 2.** Question Number 1

Problem number 1 can be solved by means that students must first understand Snell's Law of reflection and the formation of angles of incident and reflected rays. Snell's law states that the incident ray, the reflected ray, and the normal lie in the same plane, and the angle of incidence is equal to the angle of reflection. Students must know that the angle of the incident ray is the angle formed between the incident ray and the normal line, as well as the angle of the reflected ray formed between the reflected ray and the normal line. So, the correct answer is option A.

Question number 1 is the question with the best response from students. As many as 92% of students who answered correctly question number 1 with 62.5% were in the category of steady understanding. Students in question number 1 already understood the concept of angle of incidence and angle of reflection, although there were still some who answered incorrectly. However, there are students who chose other options that are in accordance with the concept, and some are less precise with the concept. The distribution of reasons for student answers to question number 1 as shown in Table 5.

**Table 5.** Students' Reasons in Answering Question Number 1

| LoU | Option | Reasons | N |
|---|---|---|---|
| **SU** | A | Snellius law = angle of incidence (*i*) equals the angle of reflection (*r*).<br>▪ i = angle formed by the incident ray and the normal line.<br>▪ r = angle formed by the reflected ray and the normal line.<br>▪ The incident ray, the reflected ray, and the normal line lie in the same plane. | 40 (62,5%) |
| **PU** | **B** | The incident ray, the reflected ray, and the normal line lie in the same plane. The angle of incidence is equal to the angle of reflection. | 3 (4,68%) |
| | **A** | The angle of incidence is the angle of reflection measured from the normal line. | 6 (9,37%) |
| **PUMS** | A | There is a regular reflection of parallel rays falling, smoothed and then reflected parallel. | 2 (3,125%) |

| LoU | Option | Reasons | N |
|---|---|---|---|
| SM | **A** | Since i is the angle of incidence and r is the angle of reflection with respect to the medium and the normal axis. | 1 (1,56%) |
| | D | Snell's law is the law of refraction, while in Figures 1, 2, and 3, it is reflection. So there is no right answer. | 2 (3,125%) |
| | **A** | Because the angle of incidence and the angle of reflection used are the angles that lie inside. | 2 (3,125%) |
| NU | A | Not answering the reason, repeating the question. | 8 (12,5%) |

From the results of the distribution of reasons for student answers in Table 5, it can be said that students are at a sound level of understanding. This can be seen from the percentage of students' steady understanding, which is the highest, 62.5% with 40 students who answered correctly. If viewed from the number of students' correct answer options in Figure 1, this can be said to be appropriate, with the percentage of students' correct answer options on question number 1 which is 92%. Based on the students' reasons, we found that there were students who stated that Snell's law exists only for refraction. This finding shows that students' knowledge of Snell's law is still incomplete (knowledge in pieces). This finding is in line with Hammer's (Hammer, 2000) statement that students fail to solve problems because they fail to activate relevant knowledge.

A concave mirror with a focal length of 40 cm, the object's position so that the image formed is erect and magnified 4 times is...

A. 10 cm
B. 24 cm
C. 30 cm
D. 50 cm
E. 55 cm

**Figure 3.** Question Number 2.

Problem number 2 can be solved by first understanding the nature of the concave mirror image and paying more attention to the problem instructions. In the problem mentioned a concave mirror and an upright image. So, when doing calculations through the formula, s' must be negative. Therefore, the correct answer is option C.

Table 4 shows the number of students who are at the level of understanding misconceptions, which is as much as 50%. This happened because in answering the questions, many of the students did not include a negative sign (-) on the s' (shadow location). The formula they use is correct, but students did not understand the concept of the upright image, the value of s' must be negative. So, when proceeding to the next formula it becomes wrong. Likewise for students with other answer options, there are still students who answer incorrectly for reasons. The distribution of reasons for student answers to question number 2 is shown in Table 6.

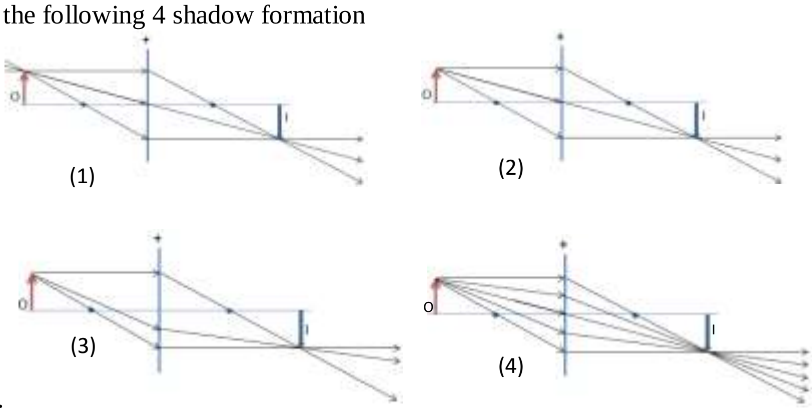
**Table 6.** Students' Reasons in Answering Question Number 2

| LoU | Option | Reasons | N |
|---|---|---|---|
| **SU** | C | Calculation using the right formula.<br>M = \|s'/s\|<br>M = -s'/s<br>(Upright image for a concave mirror, then s' is negative.) | 22 (34,375%) |

| LoU | Option | Reasons | N |
|---|---|---|---|
| | | -s' = M x s<br>-s' = 4 s<br>s' = -4s<br><br>1/f = 1/s + 1/s'<br>1/f = 1/s + (-(1/4s))<br>1/f = (4-1)/4s<br>f = 4s/3<br>s = (40x3)/4 = 30 cm | |
| **PU** | **C** | Because the location of the object is smaller than the focus and farther away from the mirror, the image of the object formed will be virtual, upright and enlarged. | 1 (1,56%) |
| **PUSM** | **-** | - | - |
| **SM** | D | Calculation using the appropriate formula, namely:<br>1/f = 1/s + 1/s' dan M = \|s'/s\|<br>However, s' is not negative; even if the image is upright, then s' will be negative. | 30 (46,875%) |
| | **A** | The closer will be bigger. | 1 (1,56%) |
| | **A** | s'/s = h'/h => 40/s = 4/1 => s = 10 | 1 (1,56%) |
| **NU** | A | Did not answer the reasons. | 2 (3,125%) |
| | **D** | Did not answer the reasons. | 2 (3,125%) |
| | **C** | Did not answer the reasons. | 2 (3,125%) |
| | E | Did not answer the reasons. | 3 (4,68%) |

From the distribution of reasons for student answers in Table V above, it can be seen that most students gave reasons that contained misconceptions, 32 students with a percentage of 50%. Meanwhile, students with a solid understanding of 34.375%. It can also be seen in table that even though there were students who chose the correct answer option, they gave incorrect reasons.

Consider the following 4 shadow formation




diagrams.
Which diagram is correct?

A. All the diagrams are correct
B. (2), (3),(4)
C. (3) dan (4)
D. (1) dan (2)
E. (1)

**Figure 4.** Question Number 3

Problem number 3 can be solved by students having to understand that the rays that hit the lens are rays that are reflected by objects, meaning that the position of the rays coming from the object is the object. In addition, students must know the special rays that exist in positive lenses. So, the correct answer for question number 3 is option B.

Based on Figure 1, it can be seen that as many as 14% of students answered correctly, 9 students. However, of the 9 students who chose the correct answer option, not all of them answered the reason correctly according to the concept. Likewise with other students who chose other options. The distribution of reasons for students' answers to question number 3 is shown in Table 7.

**Table 7.** Students' Reasons in Answering Question Number 3

| LoU | Option | Reasons | N |
|---|---|---|---|
| **SU** | B | The direction of the incident ray is exactly at point O. Because point O is measured exactly, the object is observed, and A is not right. | 2 (3,125%) |
| **PU** | D | Because there are 3 special rays:<br>▪ A ray parallel to the principal axis will be refracted through the focus.<br>▪ A ray coming through the focus will be refracted parallel to the principal axis.<br>▪ Rays coming through the center of curvature of the lens will be transmitted | 4 (6,25%) |
| | A | To form a shadow required at least 2 of the 3 shadow properties. And in the picture, everything has fulfilled this. | 1 (1,56%) |
| **PUSM** | B | Because image A is wrong because it doesn't start at point O, or the object doesn't exactly start at point O. | 1 (1,56%) |
| | D | Because there are 3 special rays on a convex lens, the most appropriate ones are as in Figures 1 and 2. | 4 (6,25%) |
| | D | ▪ A ray that is initially parallel to the central axis of the lens will pass through the focal point.<br>▪ A ray that initially passes through the focal point will emerge from the lens parallel to the central axis.<br>▪ Rays that are initially directed to the center of the lens will appear without changing the direction of the lens because the rays that meet the two sides of the lens are almost parallel | 8 (12,5%) |
| | D | Because there are 3 special rays:<br>▪ The incident ray parallel to the principal axis will be passed through the focus.<br>▪ A ray that passes through the focus will be transmitted parallel to the principal axis.<br>▪ Rays coming through the center of curvature of the lens will be transmitted. | 5 (7,81%) |
| **SM** | E | Since it describes the incident ray parallel to the principal axis, reflected at the focus, the incident ray is reflected parallel to the principal axis. | 2 (3,125%) |
| | D | The image formed in a convex lens always passes through the focal point of the object, and the image is formed perpendicular to the lens. | 1 (1,56%) |
| | A | All refract correctly according to Snell's law (law of refraction). | 1 (1,56%) |
| | D | Special rays:<br>▪ Rays that come parallel to the principal axis will be reflected through the focal point.<br>▪ A ray that passes through the focal point will be reflected parallel to the principal axis.<br>▪ Rays that pass through the center of the mirror will be reflected past that point | 3 (4,68%) |
| | D | Because the location of the image is between F and 2F with the formula.<br>$M = \frac{h'}{h} = -\frac{s'}{s}$. | 3 (4,68%) |

| LoU | Option | Reasons | N |
|---|---|---|---|
| | D | The incident ray that passes through the center of curvature of the lens will be transmitted. | 1 (1,56%) |
| | A | Because in a plane mirror, the image formed is virtual, upright, and of the same size, so the correct graph is all of them. | 1 (1,56%) |
| | E | Because a convex lens enlarges a virtual image. | 1 (1,56%) |
| | D | Which has many lines of the same diagram are Figures 1, 2, and 3. | 1 (1,56%) |
| | E | The appropriate diagram only pictures 1 because in figure 1 it is clear that before the red line there are lines that enter so that it makes it clear where the diagram was formed. | 3 (4,68%) |
| | A | Because the diagram is the formation of an image on a convex mirror. | 1 (1,56%) |
| | D | The diagrams that correspond to the formation of shadows are numbers 1 and 2. | 1 (1,56%) |
| **NU** | A | Did not answer the reason. | 8 (12,5%) |
| | B | Did not answer the reason. | 1 (1,56%) |
| | C | Did not answer the reason. | 2 (3,125%) |
| | D | Did not answer the reason. | 7 (10,93%) |
| | E | Did not answer the reason. | 2 (3,125%) |

Based on the results of the distribution of answers to student reasons in Table 7, it was obtained data that in number 3, students experienced many misconceptions. This is due to the reason that most students are at the level of understanding misconceptions, namely 19 students with a percentage of 29.69%, compared to solid understanding which is only 2 students (3.125%). If viewed from the number of students who chose the correct answer option, students with a steady level of understanding still did not match the appropriate number based on the number of students who chose the correct answer.

**Activated Resources**

Resource theory states that students fail to solve problems not because the student does not know the relevant concepts according to the problems in the problem. However, the failure was caused by incomplete knowledge of students or, in resource theory, the student's knowledge was still in pieces (knowledge in pieces) (Glogger-Frey et al., 2018). So that in solving problems students tend to use knowledge that is lacking or even irrelevant because of a lack of understanding in mastering the applicability of a concept or formula.

In answering question number 1, students almost get close to right in determining the location of the angle of incident ray and angle of reflected ray. Many students simply answered that the angle of the reflected ray is the same as the angle of the incident ray and lies in a plane. What needs to be understood is that the angle of incidence is the angle formed by the incident ray and the normal line. Likewise, the angle of reflection is the angle formed by the reflected ray and the normal, which is equal to the angle of incidence. This proves that students' understanding of the angle of incidence and angle of reflection is not complete but only partially.

Some resources that are activated by students include "the magnitude of the angle of incidence is equal to the angle of reflection". The statement is not wrong, but if it is not accompanied by a statement stating that the angle of incidence is the angle formed between the incident ray and the normal line and the angle of reflection is the angle formed between the reflected ray and the normal line, it can cause errors. This is because the statement "the angle of incidence is equal to the angle of reflection" can lead to figure 3 in problem number 1. Whereas figure 3 is not correct because the angle in question is not formed between the angle of incidence with the normal line and the angle of reflection with the normal line. Another resource that is activated is to assume that Snell's Law only exists in refraction while in reflection it does not exist. One example of the correct reasons given by students is shown in Figure 5.

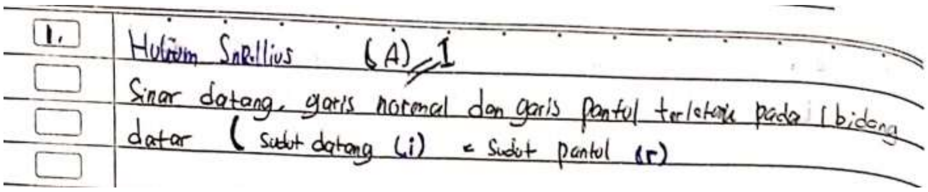



**Figure 5.** Reasons for Students Answering Question Number 1

Question number 2, many students have misconceptions. The resource that is activated by students in question number 2 is to understand the formula correctly without understanding the concept of what the image on a concave mirror looks like. Many students make a negative sign on the image distance (*s*') for upright images. Whereas every image that is upright, the nature of the image is virtual and must have a negative sign. Figure 6 shows the students' reasons for using the wrong sign in *s*'.

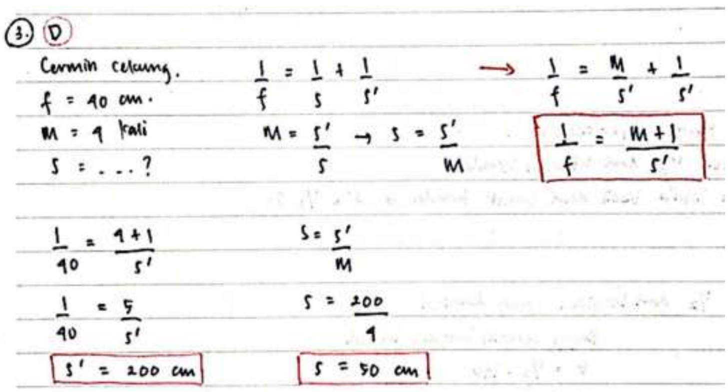



**Figure 6.** Reasons for Students Answering Question Number 2.

In question number 3, the resource activated by the student is "there are 3 special rays in the refraction event on the lens". The student's understanding is correct, but in question number 3, the required understanding is still incomplete. Students must know that refraction occurs because light coming from an object hits the surface of the lens, then there are 3 special properties of the lens. However, students' knowledge which is still in pieces causes them to not be able to correctly answer question number 3. One of the students reasons as shown in Figure 7.

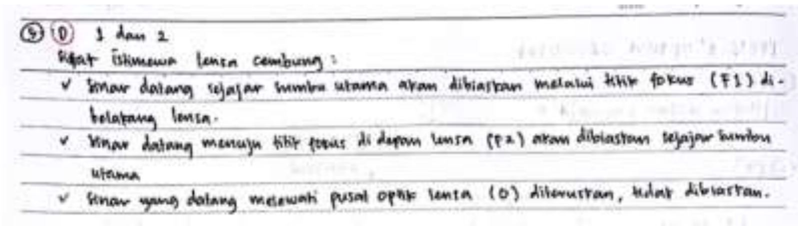



**Figure 7.** Reasons for Students Answering Question Number 3.

## CONCLUSION

Students' conceptual understanding of the topic of reflection and refraction can be said to be in a fairly low category. This is because of the 64 Physics Education undergraduate students who weare taking Basic Physics III courses, in answering 10 test questions for understanding the concepts of reflection and refraction topics, a total of only 21.72% have a sound understanding. Many students experienced errors in identifying the concept of angle of incidence and angle of reflection and mentioning image formation diagrams on lenses and alsoand dido not understand the nature of images in concave mirrors. Examples of resources that are activated by students in identifying the concept of angle of incidence and angle of reflection are (1) the angle of incidence is the same as the angle of reflection, and (2) Snell's law only exists in refraction, not reflection. The resource that is activated by students in mentioning the image formation diagram on the lens is that there are 3 special rays on the lens. Meanwhile, the resource that is activated by students in the formation of images on a concave mirror is to understand the formula correctly without understanding the nature of the upright image on a concave mirror. Furthermore, the average level of understanding of students' concepts is Sound Understanding of 21.7%, Partial Understanding of 23.6%, Partial Understanding with Specific Misconceptions of 13.9%, and Specific Misconceptions of 15.9%, and Not Understanding by 26.2%. Meanwhile, the resources that are activated by students in answering this question tend to be partially understood.

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