



Five-Tier Geometrical Optics Test Feasibility to Identify Misconception and the Causes in High School Students

Farah Salmadhia, Heni Rusnayati, and Winny Liliawati

Department of Physics Education/ Faculty of Mathematic and Science Education/
Indonesia University of Education, Indonesia.
farahsalmadhia@student.upi.edu

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Abstract

This research aimed to test the feasibility of a geometrical optics instrument to identify the misconception and its causes. The instruments used in this research were question validation sheet and five-tier geometrical optics test (FIGOT) with 14 items of questions and consisted of 48 concepts tested. FIGOT obtained from the existing four-tier test research before which was then modified by adding one more tier about the causes of misconception. FIGOT validated by six experts, in which one the aspect assessed was the suitability of the items with alternative conceptions. The analysis of construct validity tested using CVR (almost all items have a $CVR_{Average}$ value of ≥ 0.67) and the reliability was using Cronbach's Alpha ($r \geq 0.62$ for each or both tier). The identification results processed using CDQ (Confidence Discrimination Quotient). The study was conducted in two public high schools located in Bandung and two public high schools located in Jakarta with 109 students (34 males and 75 females). The result showed that most senior high school students still experienced misconceptions related to the topic of geometrical optics, 17 misconceptions from 48 concepts about geometrical optics. The biggest percentage was 81% and CPM (Confidence of Percentage Misconception) was 4,75 about plane mirror. The most dominant causes of misconception in the material of geometrical optics were due to teachers, school books, and internet. The results of the FIGOT feasibility test showed that the items of questions were possible to use to identify misconceptions and the causes of misconceptions on optical geometry.

Keywords: Five-Tier Geometrical Optics Test (FIGOT); Instrument Feasibility; Misconception; The Causes of Misconception

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INTRODUCTION

Misconception is an event which until now has been very dangerous in physics learning and other science learning, because its existence will affect student's scientific understanding development (Kaltakci-Gurel, 2017). Mastery of concepts owned by students is different,

concepts owned by students obtained from the learning process outside or inside school with different environments. Based on this, it can be said that students come to class carrying diverse initial concepts, initial concepts obtained are sometimes not in accordance with or contrary to the



scientific concepts or often called misconceptions (Suparno, 2013). Misconception is a problem that is often overcome for the sake of continuing further learning. The failure to overcome misconceptions was caused by educators not knowing the exact causes of misconceptions that student experienced (Suparno, 2013). The causes of misconceptions can be originated from several sources, namely from students themselves, the teacher's teaching method, the textbook used, the context, and how to teach the teacher (Suparno, 2013). In order to give an accurate description of the misconceptions experienced by students based on the error information they make, so diagnostic tests were used to identify the misconception.

Misconception diagnostic tests needed in identifying misconceptions experienced by students (Susanti, 2014) and more preferable in the last decades (Taslidere & Eryilmaz, 2015). Rasyid & Mansur (Muhammad & Kusno, 2015) explained that diagnostic tests are useful for knowing the learning difficulties faced by students, including misconceptions of concepts. A diagnostic tool can provide sufficiently detailed information to determine student's scientific understanding (Anam, Widodo, Sopandi, & Wu, 2019). Diagnostic tools have been widely developed and used by researchers, one of them is multiple tier test which is developed from the ordinary multiple-choice test. The multiple diagnostic test have not only advantages but also the disadvantages too, many researchers have developed multiple-choice tests with two, three, and four tiers to get the best tools to diagnose student's conceptions (Anam et al., 2019).

Four-tier is clearer to identify misconception but barely find the causes, so a five-tier diagnostic test was performed to find misconception and the causes of it. The five-tier diagnostic test is the development of a four-tier test

instrument based on the Pesian pattern that constructs the question instruments with the development form of a semi-closed three-tier test type in the answer choices of the reason section. The development of this instrument also refers to Caleon & Subramaniam (2010) research as a variety of question construction. The first tier (Tier-1) is a multiple choice question with three distractors addressing specific misconceptions and one answer key that students must choose. The second tier (Tier-2) is the level of student confidence in choosing answers. The third tier (Tier-3) is the reason students answer questions, in the form of three choices of reasons that are provided and one open reason. The fourth tier (Tier-4) is the level of student confidence in choosing reasons. At the fifth tier (Tier-5), a questionnaire is developed to find out the source of student's answers. This five-tier diagnostic test can also identify some misunderstandings in both the answers and the reasoning, and provide information about the confidence level (Anam et al., 2019), it can also detect the causes of misconceptions.

Students' understanding of geometric optics has attracted the interest of researchers in various countries from early childhood to university level (Fariyani, 2015; Hye-Eun Chu, 2009; Kaltakci-Gurel, 2017; Munawaroh, 2016). All of these studies show that each student has several misconceptions on this topic, regardless of their grade level and culture. From earlier studies, after the discovery of misconceptions on geometry optical material, the causes of misconceptions were also not identified so it was not known which learning source caused students to experience misconceptions on optical geometry material. So this research developed four-tier diagnostic test to five-tier diagnostic test that could identify the causes of misconceptions to find out the possible solutions so that further physics learning

can be improved. To get satisfactory results, the five-tiers instrument used must be tested for its validity and reliability appropriately so that it is feasible to use it to determine misconceptions and causes of student misconceptions on geometrical optics material.

METHOD

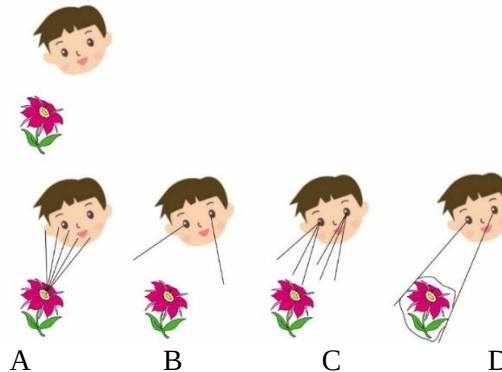
This study used a quantitative research method with a descriptive-explorative type of research. Descriptive research is research that seeks to describe a phenomenon, event, event that is happening now (Sudjana & Ibrahim, 1989) so it was expected that this research could describe student misconceptions, while explorative research is research that seeks to describe phenomena where the writer does not have a direction or an explanation map of the phenomena it faces (Singh, 2007), so this research would find out the causes of misconceptions experienced by students. The research design used in this study was One-Shot Design or research with one time data retrieval as stated by Sugiyono (2016). The approach used was a non-experimental by not giving prior treatment to the subject so that the state of the subject at the time was natural/pure condition (Wiersma & Jurs, 2009).

The population in this study was second class (XI) of high school students in the city of Bandung and the city of Jakarta. Determination of the sample taken in this study was carried out with a purposive sampling technique with consideration of the relationship of the writer with the physics teacher and with the Covid-19 disaster that happened. The participation in this study was 109 students consisting of 34 males and 75 females with the age of 16-17 years. Participants scattered from 4 high schools in Bandung (2 schools and 45

students) and in Jakarta (2 schools and 64 students). SMAN (public senior high school) that located in Bandung are SMAN A and SMAN D while SMAN in Jakarta are SMAN B and SMAN C. So, the participants in this research were class XI MIPA in SMAN A with 6 students in total (4 females and 2 males), SMAN B with 37 students in total (26 females and 11 males), SMAN C with 27 students in total (18 females and 9 males), and SMAN D with 39 students in total (27 females and 12 males).

Data collection of the Five-tier Geometrical Optics Test (FIGOT) was carried out by a survey via google-form because the research was held when the Covid-19 disaster happened. FIGOT questions consisted of 14 items with 5 levels (tiers) on each item. The question of the FIGOT was about the geometrical optical that have been found with misconceptions in earlier studies as in Fariyani (2015). Five-tier diagnostic tests were the development or adaptation of the research of Fariyani (2015), Kaltakci-Gurel (2017), Hye-Eun Chu, (2009), and Rahmadani, (2018) who began the research before and then by researchers it was added some questionnaires of the causes of misconception. Each item consists of 5 levels, the first level (tier-1) is the level of answers, the second level (tier-2) is the level of confidence in the answers, level three (tier-3) is in accordance with expectations, the levels (tier-4)) is the level of trust, and the level of response (level-5) is the level of the source of the answers. The levels of answers and reasons are like multiple choice questions with several choices, while the level of answers of participants with reasons score of 1 = just guessing ranged to the score of 6 = very sure (Caleon & Subramaniam, 2010). The following is an example of the FIGOT instrument which can be seen in Figure 1.

1.1 Reza sees a flowers in the garden. How is the example process of spreading the light so that you can see all parts of the flower?



1.2 My level of confidence answers the question:

1	2	3	4	5	6

1.3 My scientific reason for answering question **1.1** is ...

- A. There are light rays from that thing, so Reza can see
- B. Beams of light come out from Reza's eyes and then Reza can see flowers
- C. The object is located within in region of the Reza's vision
- D. Light reflected from objects seen and received by the eye

1.4 My level of confidence answers these reasons:

1	2	3	4	5	6

1.5 My sources answering the questions:

	1	2	3	4	5	6
Self-knowledge						
Teacher						
School books						
Internet						
BIMBEL/Course place						
Others :.....						

Figure 1 Example Item of *Five-tier Geometrical Optics Test (FIGOT)*

Students were given ± 3 weeks to work on FIGOT. Data was collected automatically in responses in google-form. In addition to the CDQ (Confidence Discrimination Quotient) value obtained from FIGOT data, the value of question reliability can also be obtained from student data.

To find out the validity of the Five-tier Geometrical Optics Test (FIGOT), validation was carried out by 6 experts consisting of 5 Physics lecturers at the Indonesian Education University and 1

Physics teacher in one of the State High Schools in Bandung. The six validators assessed and gave suggestions for each item. The aspects assessed were the suitability of the concepts in the items with the concepts given by experts, the suitability of the items with alternative conceptions, the ability of the items in determining students' conceptions, the use of language in accordance with Indonesian Spelling, and the suitability of item construction with the writing rules of the questions multiple choice. Then the

results of the validation was processed using Content Validity Ratio (CVR) so that it was known whether the questions were possible to be tested on students. The formula of CVR that used is :

$$CVR = \frac{n_o - \frac{N}{2}}{\frac{N}{2}}$$

Information:

n_o = the number of respondents/experts who stated "appropriate"

N = number of respondents/experts

The instrument can be declared valid if the calculated CVR value obtained is higher than the critical CVR value (minimum) based on the Schipper Table (Wilson, Pan, & Schumsky, 2012). The list of minimum CVR values for the various number of validators is listed in Table 1.

Table 1 List of minimum CVR Values for Various Numbers of Validators

Num. of experts	Min. CVR Value	Num. of experts	Min. CVR Value
5	0.736	13	0.456
6	0.672	14	0.440
7	0.622	15	0.425
8	0.582	20	0.368
9	0.548	25	0.329
10	0.520	30	0.300
11	0.496	35	0.287
12	0.475	40	0.260

(Wilson et al, 2012)

The reliability criteria for correlation coefficient value r is listed in Table 2.

Table 2 Reliability Criteria for Correlation Coefficient Value r

Correlation Coefficient	Reliability Criteria
$0.80 < r \leq 1.00$	Very good
$0.70 < r \leq 0.80$	Good
$0.60 < r \leq 0.70$	Quite
$0.50 < r \leq 0.60$	Poor
$0.00 < r \leq 0.50$	Very poor

The reliability test of FIGOT used the Cronbach's Alpha, instrument reliability test was carried out to known how much

the consistency of the questions was done by different people, different places, and at different times. All data for each tier (tier-1 or tier-3) and for both tiers (tier-1 and tier-3) show the correlation coefficient value obtained and then classified into several criteria (Sumintono & Widhiarso, 2015). If the correlation coefficient for each tier (tier-1 or tier-3) and for both tiers (tier-1 and tier-3) are more than 0.i, then it can be declared as reliable. In addition, we can pay attention to the reliability of the items with their classification listed in Table 3.

Table 3 Item Reliability Classification

The Value of r	Criteria
$0.94 < r \leq 1.00$	Excellent
$0.91 < r \leq 0.94$	Very good
$0.81 < r \leq 0.91$	Good
$0.67 < r \leq 0.81$	Quite
$0.00 < r \leq 0.67$	Poor

(Source: Sumintono & Widhiarso, 2014)

Every item from tier-1, tier-3, or both tiers can be declared reliable if the value is more than 0,67.

Data analysis using the scoring technique for each five-tier test item was adopted from the analysis technique conducted by (Caleon & Subramaniam, 2010), i.e. if the answer at the first level (first tier) and the reason chosen (three tier) are correct, then given score of 1 and other than that will be given a score of 0 for each tier one or three. In addition, for relationship between tiers one and three, if both are correct then it is given a score of 1 and if both are wrong, the given score is 0. While for questionnaire sources students were allowed to choose more than one options which was then processed also according to the value of his confidence discrimination quotient (CDQ). For the second and fourth level of confidence, a scale of 1-6 is given (Caleon & Subramaniam, 2010). For each source of answers, a confidence scale of 1-6 was also given. Furthermore, the level of confidence of students who answered correctly at A (Answer) tier, R (Reason) tier, and B (Both) tier was

averaged the level of confidence. This average was divided based on the average of all confidence levels at each level and item questions (CF), the average level of confidence of students who answered correctly at each tier or item question (CFC), and the average level of confidence of students who answered incorrect (CFW). Furthermore, these average values were used to determine confidence discrimination quotient (CDQ) which was associated with the standard deviation of student's level of confidence. Mathematically described as follows:

$$CDQ = \frac{(CFC - CFW)}{s}$$

Caleon & Subramaniam (2010)

Information:

CFC = average level of confidence of students who answered right

CFW = average level of confidence of students who answer incorrectly.

S = standard deviation of students' level of confidence

CDQ value calculation was obtained from the level of answers, the level of reason, and the relationship between the two, so that it identified misconceptions based on the level and relationship of these levels. To identify misconceptions at the level of answers, we can see CDQ_A , at the level of reason we can see CDQ_R , and at the relationship of reasons-answers we can see CDQ_B . Misconceptions were determined through acquisition of the value of confidence discrimination quotient (CDQ). If the CDQ value obtained is negative, then the item or level of the item has a misconception. Misconceptions were stated as significant misconceptions if the misconceptions were experienced by at least 10% of the total sample (Caleon & Subramaniam, 2010). Misconceptions experienced $\geq$

10% can be said to be absolute misconceptions.

The first step made a set of instruments in the form of the questions of diagnosis misconception with 5-tier and an expert validation sheet to show the quality of the questions. The 5-tier question was adapted from several journals and theses which looked at misconceptions on optical geometry. In addition, expert validation sheets were also ready to be given to experts (physics lecturers or physics teachers) to assess the validity of the question instruments. Furthermore, the five-tier geometrical optics test (FIGOT) was validated by 5 expert lecturers in the physics education department of UPI FPMIPA and one physics teacher in a state high school in Bandung. After being assessed and given advice, the instrument was revised based on the results of the judgment. Then, researchers proceeded to submit permission to schools where students were chosen as participants in research. Five-tier geometrical optics test (FIGOT) was distributed to students from 4 public high schools (two schools in Bandung and two other schools in Jakarta) via Google-form. Students were given time for ± 3 weeks to do FIGOT. After that, the data was collected and processed and analyzed using CDQ analysis (Caleon & Subramaniam, 2010). The results of misconceptions and the causes of misconceptions that were found were then discussed and conclusion was drawn. The original version of the FIGOT research was in Indonesian. However, it was translated into English in the purpose of adding it to this article.

RESULTS AND DISCUSSION

Validity and Reliability

The results of the Expert Validation Test are listed in Table 4.

Table 4 Expert Validation Test Results

Number of Item	Aspect	N	Ne	CVR	CVR _{Average}	Number of Item	Aspect	N	Ne	CVR	CVR _{Average}
1	a	6	6	1	0,8	8	a	6	5	0,67	0,6

Number of Item	Aspect	N	Ne	CVR	CVR _{Average}	Number of Item	Aspect	N	Ne	CVR	CVR _{Average}
2	b	6	6	1	0,87	9	b	6	5	0,67	0,8
	c	6	5	0,67			c	6	5	0,67	
	d	6	4	0,33			d	6	4	0,33	
	e	6	6	1			e	6	5	0,67	
	a	6	6	1			a	6	6	1	
3	b	6	6	1	0,8	10	b	6	6	1	0,87
	c	6	6	1			c	6	6	1	
	d	6	4	0,33			d	6	5	0,67	
	e	6	6	1			e	6	5	0,67	
	a	6	6	1			a	6	6	1	
4	b	6	5	0,67	0,73	11	b	6	6	1	0,87
	c	6	6	1			c	6	6	1	
	d	6	4	0,33			d	6	5	0,67	
	e	6	5	0,67			e	6	5	0,67	
	a	6	5	0,67			a	6	6	1	
5	b	6	5	0,67	0,67	12	b	6	6	1	1
	c	6	5	0,67			c	6	6	1	
	d	6	5	0,67			d	6	6	1	
	e	6	5	0,67			e	6	6	1	
	a	6	5	0,67			a	6	6	1	
6	b	6	5	0,67	0,67	13	b	6	6	1	1
	c	6	5	0,67			c	6	6	1	
	d	6	5	0,67			d	6	6	1	
	e	6	5	0,67			e	6	6	1	
	a	6	5	0,67			a	6	6	1	
7	b	6	5	0,67	0,67	14	b	6	6	1	1
	c	6	5	0,67			c	6	6	1	
	d	6	5	0,67			d	6	6	1	
	e	6	5	0,67			e	6	6	1	
	a	6	5	0,67			a	6	6	1	

If seen based on the CVR_{Average} value, almost all items have a value of ≥ 0.67 except for item number 8. Questions is valid or possible to use if the least CVR value is 0.67 with a total validation of 6 people (Wilson et al., 2012). Item number 8 shows the value of CVR_{Average} = 0.6, it indicates that the question is invalid. However, if we look at every aspect of item 8, it is only the "d" aspect whose CVR value is below 0.67, which causes the CVR_{Average} of number 8 = 0.6 to be invalid or improper to be used to test student's misconceptions. The use of language in item 8 is not suitable with Indonesian spelling, so it was revised

with better and correct Indonesian spelling so that it can still be used. Revisions were also made to other items that had poor Indonesian spelling. For other aspects, namely aspects "a", "b", "c", and "e", the CVR value is not less than 0.67 on each item. FIGOT items 1-14 are appropriate to be used in identifying misconceptions and their causes in the geometrical optical of high school students in grade XI.

The question of FIGOT Tier-1 or answer tier have enough reliability $r = 0.67$, which means that the tier-1 test questions in this study will give quite the same results if it is retested to students.

Besides that, the reliability value of the item is 0.71 (quite), means that the FIGOT items will give quite the same results if it is tested again to students (Sumintono & Widhiarso, 2015).

The question of FIGOT Tier-3 or reason tier have enough reliability $r = 0.62$, which means the tier-3 test questions in this study will give quite the same results if it is retested to students. The item reliability value is 0.85 (good), means that the FIGOT items will give the same results if it is tested back to students.

If the first tier associated with the third tier have good reliability $r = 0.76$, means that the tier-1 and tier-3 test questions in this study will give the same results if it is tested again to students. The item reliability value is 0.86 (good), means that the FIGOT items will give the

same results if it is tested again to students.

Misconception

Based on CDQ calculation of Misconceptions from all students, the 5-tier diagnosis test results showed that in optical geometry there were still many misconceptions experienced by students. It can be seen that there were a number of CDQ scores which showed the negative of the combined students in all schools studied. This was occurred because the average level of confidence of students who answered wrong (CFW) was greater than the level of confidence of students who answered correctly (CFC). A negative CDQ value indicates a misconception, while if the CDQ is positive it can be said that there is no misconception. The Significance List of Student Misunderstandings in Geometric Optics is listed in Table 5.

Table 5 List of Significance of Student Misconceptions in Geometrical Optics

Alternative Conception (Misconception)	Option	%PM ^a	Average of confidence students (CPM) ^b
Plane Mirror			
• When someone moves away from a plane mirror, the image becomes smaller and more can enter the mirror.	Q2A ^c	5	4
	Q2B	81	4,75
	Q2D	1	2
• When someone moves closer to a plane mirror, one can see more about oneself because of the increased field of view.	Q2A(A) ^e	1	4
	Q2A(C)	2	3,5
	Q2A(E)	1	5,5
• The image size is always the same as the mirror size.	Q2B(A)	38	4,3
	Q2B(B)	27	4,31
	Q2B(C)	3	4,83
• To see the whole body in a field mirror, a mirror half the length of the body is enough, regardless of where the mirror is on the wall.	Q2B(E)	13	4
	Q2D(C)	1	1,5
Convex Mirror			
• The position of the object will affect the shape of the image seen in the mirror.	Q5B	36	2,72
	Q5C	28	2,6
	Q5D	7	2,13
• To see a reflection in a mirror an object must be placed at the focus point.	Q5E	4	3,75
	Q5(A) ^d	31	2,38
	Q5(B)	21	1,87
	Q5(D)	7	2,88

Alternative Conception (Misconception)	Option	%PM ^a	Average of confidence students (CPM) ^b
- The position of the object will affect the nature of the shadow ie virtual, scaled down and upright. - Unlike real images, virtual images cannot be seen in a mirror / lens - Only images formed on the same side as the observer can be seen - Images can be seen if not at the focus point. no image is formed / visible from an object at the focal distance in a convex mirror / lens.	Q5(E)	21	3,22
Convergent Lens			
The image of shadows that are formed will get smaller if the screen is kept away from the lens	Q6A	39	3,26
Real images can be seen from different sizes / moved if placed in a different location from the point of the image.	Q6B	33	2,75
	Q6C	19	2,9
Camera			
Cameras that have a larger lens diameter capture more light, so the resulting object image is larger.	Q10(B)	24	2,54
	Q10(C)	33	3,58
	Q10(D)	19	3,05
Microscope			
Shadows formed by the objective lens must fall precisely in the ocular focus point if the eye is maximum accommodation	Q12(A)	36	1,97
	Q12(B)	35	2,39
	Q12(C)	17	2,83
Diffuse mirror reflection			
Diffuse reflection does not apply the law of light reflection	Q14A	5	3,2
	Q14C	43	3,51
	Q14D	6	3,1
The reflected angle produced by diffuse reflection is not the same as the angle of incidence	Q14A(B)	2	3,75
	Q14C(B)	8	3,44
	Q14C(C)	10	3,82
The incoming rays and reflections in the reflection that occurs in the rough plane are considered to be the same as in the smooth plane	Q14C(D)	6	3,64
	Q14D(B)	4	1,63
	Q14D(C)	1	1,5
	Q14D(D)	1	1

^a%PM = percentage of the total sample who chose this option or combination of options, which is related to a particular AC

^bAverage of confidence Misconception (CPM) is how confidence students answered with scale 1 (just guessing) until scale 6 (absolutely confident)

^cQ2A = Q2 is Question number 2, "A" is chosen answer

^dP5(A) = Q5 is Question number 5, "(A)" is chosen reason

^eP2A(A) = Q2 Question number 2, "A" is chosen answer and "(A)" is chosen reason.

In question number 1 both CDQ_A , CDQ_R , and CDQ_B are all have positive sign, which means that students who answered correctly had an average level of confidence that was higher than students who answered incorrectly. The average level of student confidence ranged from 3.6-3.9. Overall, students did not experience misconceptions about the process of spreading light. Unlike the case with research conducted by Hye-Eun Chu (2009) on the propagation of light, he found misconceptions about the process of lighting one of the human eye emits beams of light so that it could see objects.

In question number 2, the CDQ value at the answer level and the value level showed different results. The CDQ_A results are negative which means students experienced misconceptions. Because they thought that if they want to see all parts of her body in plane mirror, they must move the mirror 5% or away from the flat mirror with 81% (CPM = 4.75) according to Table 5. In addition, students also chose to doing nothing 1% (as per Table 5). Significant agreed misconceptions received a percentage value of $\geq 10\%$ of participants who chose the answer (Caleon & Subramaniam, 2010). Because of this misconception about what action needed to be done in order to see all parts body in the mirror flat with getting closer to the mirror or did not do anything was considered as not significant because the percentage of the amount was less than 10%.

The correct answer at number 2 tier-1 is to see the whole body in a flat mirror, i.e. shift the flat mirror downward so that the end of the mirror is parallel to the subject's hips. This is same misconception with research conducted by Kaltakci-Gurel (2017) and the results of CDQ_A calculations = -0.55. Significant misconceptions were found at number 2 of the answer level which is when someone moves away from a flat mirror, the image becomes smaller and more can

enter the mirror. The misconception is in accordance with one of the misconceptions that Kaltakci-Gurel (2017) found in her research. Research conducted by Sheftyawan, Prihandono, & Lesmono (2018) also found misconceptions experienced by students about the concept of the location of the image on a flat mirror.

Next, the CDQ_B score = -0.19, which means students were confident in the answers they thought were correct even though the answers were wrong. A significant misconception was that students assumed that if they go further away from mirror, the height of the object's shadow will become smaller so that the entire shadow can be seen in a flat mirror (38%) and now when the object has a distance from mirror the field view will be wider so that they can see all parts of the object (27%). In addition, there were students who thought that we should go further away from mirror and have mirror sized as half of object's body height to see his whole body (13%). The misconception found was still in accordance with one of the misconceptions found by Kaltakci-Gurel (2017) in her research, which was to see the whole body in a flat mirror, the size of a flat mirror is half of the object's body is enough, despite of the place on the wall. Misconceptions about the formation of images on mirrors depending on the position of the observer were also found by Agnes, Kaniawati, & Danawan (2015) in their research. The average level of student confidence that increased in significant misconceptions at number 2 was around 4-5.

In item 3 and 4, there was also no negative CDQ value found, either from tier 1, tier 3, and relationship tier 1 & 3. The average level of confidence of students who answered correctly at the level of answers, reasons, and both were more dominant or higher than the average level of confidence of students who answered incorrectly. CDQ values are all

marked positive, so it can be said that no misconceptions were found in item number 3 or 4. Misconceptions found by Kaltakci-Gurel (2017) in her research, i.e. there were no shadows formed as a result of concave mirrors partly closed, shadows formed were only half of the height of the object because the concave mirror is closed halfway, and (All) special rays needed to form or view images in the concave mirror were not found in the students in this study.

In question number 5, about CDQ the relationship between the tier of answer and reason, the value is not negative, the student who answered equally correct at tiers 1 and 3 had a high average level of confidence (CFC) when compared to the average the level of confidence of students who answered equally wrong (CFW). However, if we look separately or based on the tier of the answer only and the tier of the reason, the CDQ is negative.

Based on the tier of answers and the tier of reason, some students experienced misconceptions. They assumed the position of the object will affect the shape of the image seen in the mirror and to see the image in the mirror the object must be placed at the focal point (answer B 36% and C 28%) even though the object's position only affects the size of the image that is visible, since the image formed is always upright because the object is always in the front area of the mirror. This is consistent with research conducted by Kaltakci-Gurel (2017) and the results of CDQ calculations. CDQ scores on answers and reasons are negative for both items. That is because students believed in the answers they thought were correct even though the answers were wrong. The choice of reason A has a percentage of 31%, B 21%, and E 21% means a significant misconception on that reason. Misconceptions found in students in this study were the same as the results of research conducted by Kaltakci-Gurel

(2017), where virtual shadows cannot be seen in a mirror / convex lens in contrast to real shadows and shadows can be seen if not at the focal point, there are no shadows formed / visible from an object at a focal distance in a mirror / convex lens. There were also students' misconceptions found about convex mirrors in the research of Fariyani (2015). According to students, convex mirrors have a positive focus. They considered objects placed in front of a convex mirror to be virtual so that the object's distance is negative. In addition, students also considered the shadow behind a convex mirror to be positive Fariyani (2015). The average level of confidence of students experiencing misconceptions in item 4 was lower than number 2, which was around 1.5-3.5.

In question number 6, it was found negative CDQ values only at the level of the answer. On the CDQ reason and CDQ both are positive. This means that students do not really know that shadows on the screen will be formed if it is adjusted to the distance of the object and the lens's focal point and the position of the object affects the nature of the shadow and the location of the shadow Kaltakci-Gurel (2017). In question number 6 also found that students who experienced misconceptions about option A as much as 39%, option B 33%, and option C as much as 19%. Thus the misconceptions that occurred in options A, B, and C were significant because they had a percentage value of $\geq 10\%$ of participants who chose the answer. The misconception found was that the image of shadows that are formed will get smaller if the screen is kept away from the converging lens and the real image can be seen from a different size / orientation if the screen is placed at a different location from the point of the shadow. The misconceptions found in students at Bandung High School and Jakarta High Schools were the same as

the misconceptions found by Kaltakci-Gurel (2017).

In item number 7 to 9, no CDQ values were found that were negative either CDQ_A , CDQ_R , and CDQ_B . The average level of confidence of students who answered correctly (CFC) was higher in value when compared to the average level of confidence of students who answered incorrectly (CFW). Because CDQ scores are positive, it can be said that no misconceptions were found in students who participated in the study. The misconception found by Munawaroh (2016) in his research, namely the strength of the loop is not influenced by the medium where the loop is used, meaning that the strength of loop in the air and in the water is not found in this study. Sheftyawan et al. (2018) found that the concept of light refraction on different mediums was found to be 67.86% of students thought that in a different medium, light was refracted away from the normal line if it moved from a less dense medium to a denser medium. This student assumption shows that students experience misconceptions. In this context, air has a lower density than water so that light is refracted closer to the normal line. Besides the misconception that Rahmadani (2018) discovered in her research, if a part of the lens is closed or divided into two parts, the image that is formed becomes incomplete or only half is also not found in this study. The same thing was also found in the research conducted by Sheftyawan et al. (2018) about the concept of forming real images, students assumed that in candles that were lit in front of a partly closed loop, the candle shadows that were formed would be incomplete because one of the three special rays was covered. The right concept is that the shadow of the candle will remain intact but fainter because there is less light entering. For other problems also apply analysis such as questions no. 1 to 9.

The Cause of Misconception

Processing the data of causes of student's misconceptions was the same as processing their misconceptions by using a CDQ (Confidence Discrimination Quotient) analysis, but only items that were identified by misconceptions were processed as causes or whose CDQ_B values (CDQ_B are both true/both wrong) were negative which were processed to identify the cause of misconception. Misconceptions can occur due to self-knowledge, school teachers, school textbooks, the internet, and tutoring places. The cause of misconception number 2, regarding the image on a plane mirror, if sorted from the largest to the smallest CDQ value, was coming from teachers, school books, internet, self-knowledge, and course places (based from CDQ calculation the causes of misconceptions). Saputri & Nurussaniah (2015) found the causes of misconception about plane mirror was associative and humanistic thinking and faulty intuition in their research. In item 14 regarding diffuse reflection, three sources of misconceptions were found in this research, namely teachers, school books, and the internet. Munawaroh (2016) also found the causes of misconceptions in the optical material in their research. The causes of the misconceptions that were found came from students who were divided into 8 specific reasons, namely preconception, associative thinking, humanistic thinking, incomplete reasons, wrong intuition, student cognitive development, student ability, and interest in learning. School teachers, school textbooks, and the internet were also among the reasons students experienced misconceptions in the world of education (Suparno, 2013).

CONCLUSION

In this study, 17 misconceptions were found out of 48 concepts tested in the Five-Tier geometrical optics test (FIGOT). Misconceptions can occur due

to self-knowledge, school teachers, school textbooks, the internet, and tutoring places. Sources of information that often cause misconceptions are school teachers, school textbooks, and the internet. validity and reliability are almost all feasible. In addition, in this study, the quality of the questions/instrument being tested was proper or good enough to identify misconceptions so it can provide information or a description of any concept in optical geometry material that needs to be optimized and provide information about the causes of misconceptions to students so that these sources can be given input so as not to make students experience misconceptions in the optical geometry material.

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