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# Developing a Four-Tier Diagnostic Test to identify students' conception on light and optic topic

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**Abstract.** Students' conception affects students' understanding, achievement, and how they relate the concept to others in science. The aim of this study is to develop a four-tier test to diagnose students' conception on light and optic topics. It is a multiple choice question consisting of the main question, certainty index for the answer, reason, and certainty index for the reason. Light and optic topic is chosen because it is very close to students daily life and is an essential topic at school. This study involves 114 students of grade 10. The instrument was developed from a list of indicators. Once the instrument was constructed, it was tested and analysed using SPSS. The instrument undergoes two stages of validity and reliability test. The first test showed there are 13 out of 19 questions that are valid and reliable with 0.740 Cronbach's Alpha. The remaining 6 questions were then revised and retested to 21 students of grade 10. The result showed the 6 questions are valid and reliable with 0.829 cronbach's alpha. Students has medium level misconceptions and they have more scientific knowledge than misconception. In conclusion, 19 questions that are feasible to diagnose students' conception on light and optic topic.

## 1. Introduction

Students' conception has become a very interesting topic to be studied. There are a lot of researches had been done and a lot more to come [1]. Students' conception can be defined as the way students making sense of a range of natural phenomena [2]. It could be ideas, explanations, or reasons on what is happening and what would happen related to natural phenomena. Students get their conception from their intuition and experiences [3].

There are several reasons which support the statement that diagnosing students conception is essential. The first is that a proper diagnostic leads to a more focuse teaching [4]. Being aware of students misconception is very essential so teachers can address it in class because when teachers neglect students misconception, the misconception will likely stay or even get worse [5]. It is added by the fact that it inhibits science learning [6]. Misconception also causing resistance of proposed development and it affects students' decision making [7]. Misconception also interfere with students' performance [8]. Students with misconception have lower performance. Researches then carried out to identify students' conception on biology, chemistry, and physics topics [9] [10] [11]. Besides identifying misconception, diagnostic tests are also used to prove if particular techniques, methods, and strategies are effective to eliminate students' misconception [12].

There are varous instruments that are used to diagnosed students conception such as interviews, open-ended questions, multiple choice tests, multiple tier test or even combinations of instruments



mentioned before. Each type of instrument has their own advantages and drawbacks [13]. In this research, four tier test is used because this instrument is more sensitive and effective to diagnose students' conception. With four tier test, students' conceptions are categorized into scientific knowledge, false positive, false negative, misconception, and lack of knowledge [14]. Related to the topic, Light and optic is chosen because this topic is considered as one of the essential topics at school. This topics are also closely related with students daily life. The topic is also chosen because there are findings that point to identification of the same misconception over time such as we see things without the light being reflected, light travels differently at night and day, and we can adjust to see in total darkness [15]. Those misconception had been identified since 1984 [16]. This facts supports that identifying students' conception in Light and Optic Topics is still essential. Therefore, in this research, a four tier test is developed to diagnose students' conception on Light and Optic Topics.

## 2. Method

This study involves 114 10th graders from one of the senior high schools in Cianjur, Indonesia. Ninety three students for the first test and twenty one students in the second test.. The first step of this study is analysing the curriculum and the light and optic topics. Researchers analyse the depth and the width of the topic in the 2013 curriculum. The existing instruments are also analysed. From that, researchers then adapt a list of indicators from the previous research as the guide for constructing the instrument [17]. Once the indicator is modified, authors construct the questions.

Once the instrument is constructed, it was administered to students through google form. The data then underwent several tests. Those tests are correlation and reliability tests. The result is then analysed for the correlation and reliability with SPSS. If there are any questions that are invalid, those question are revised and then it undergoes the same process all over again. The invalid questions will be administered again to students and be tested for correlation and reliability with SPSS.

## 3. Result and Discussion

In this study there are 19 sets of questions constructed as can be seen in Table 1. The 19 sets of questions are categorized into four subtopics which are the properties of light, image formation on mirrors, human eye, and optical instrument.

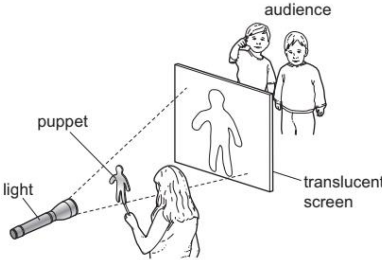




**Table 1. Distribution of questions**

Sub-Topic	Indicator of Question	Item
The properties of light	Definition of Light	Q1
	The relationship between light and vision	Q2
	Monochromatic and polychromatic light	Q3
	Light refraction	Q4
	Shadow formation	Q5
	Light travel in straight line	Q6
	The moon reflect light	Q13
The formation of image on mirrors	Distance of image in plane mirror	Q7
	Left right reverse in plane mirror image	Q8
	Angle between mirror, object, and image in plane mirror	Q9
	Formation of Image between two plane mirrors	Q10
	Convex mirror image characteristics	Q11
	Concave mirror image characteristics	Q12
Human Eye	Myopia	Q14
	Hypermetropia	Q15

Optical Instrument	Concave lens	Q16
	Convex lens	Q17
	What can be seen by microscope	Q18
	Type of mirror in microscope	Q19

Each set consists of four tiers. The first tier is the main question. The second tier is the confidence level of the main question. The third is the reason behind students' answer. The fourth is the confidence level of the reason as can be seen in Table 2. So in total, there are 38 questions that are being tested and analysed.

**Table 2.** Sample Question

Tier	No	Question
1	5a.	<div style="display: flex; align-items: center;">  <div style="margin-left: 20px;"> <p>Shadow puppets are figures that are placed between a light and a screen. Moving them creates the illusion of moving images on the screen. An experienced puppeteer can make figures appear to walk, talk, fight and dance. Shadow puppetry is a popular form of entertainment in countries all over the world. The woman use a thin, white fabric. What would the audience see if the screen were changed into white solid wood?</p> </div> </div> <div style="display: flex; justify-content: space-around; margin-top: 10px;"> <div style="text-align: center;">  <p>A.</p> </div> <div style="text-align: center;">  <p>B.</p> </div> <div style="text-align: center;">  <p>C.</p> </div> <div style="text-align: center;">  <p>D.</p> </div> </div>
2	b.	<p>Are you sure with your answer?</p> <p>A. Sure      B. Not sure</p>
3	c.	<p>Reason:</p> <p>a. All of the light rays goes through the wood</p> <p>b. Some of the light rays goes through the wood</p> <p>c. Some of the light rays bends and goes through the wood</p> <p>d. All of the light rays can not go through the wood</p>
4	d.	<p>Are you sure with your answer?</p> <p>A. Sure      B. Not sure</p>

### 3.1. Correlation and Reliability Test

The instrument constructed is then administered to students online with Google Formulir, Once it is done, the instrument undergoes correlation test and reliability test. Both tier two and tier three should be valid for the question to be considered valid [18]. The result of the correlation test is shown by Table 3. Correlation or validity test is done with Pearson Correlation test. It is to see the relation of two variables [19]. The pearson correlation coefficient for 93 respondent, 2 tailed test, in 0.05 significance level is  $r(91) = 0.207$  while for 21 respondent is  $r(19) = 0.433$  [20]. The question is valid and are able to measure the variable wanted when the coefficient is more than 0.207 for the first test

and 0.433 for the second test. From table 3, it can be concluded that all questions are valid except Q3, Q10, Q13, Q16, Q17, and Q18. The invalid questions from the previous test are then revised. There are improvements for the questions. some lines in the questions are changed, images are added, and some options are changed. After being re-administered to 21 students, the question items undergo correlation and reliability tests for the second time. All 12 questions are valid.

**Table 3.** The result of correlation test

Question	Tier	Test I			Test II		
		Pearson Correlation	Inter.	Decision	Pearson Correlation	Inter.	Decision
Q1	1	0.249*	Valid	Directly			
	3	0.349**	Valid	Used			
Q2	1	0.361**	Valid	Directly			
	3	0.288**	Valid	Used			
Q3	1	0.319**	Valid	Retest	0.655**	Valid	Directly
	3	0.106	Not Valid		0.630**	Valid	Used
Q4	1	0.274**	Valid	Directly			
	3	0.257*	Valid	Used			
Q5	1	0.510**	Valid	Directly			
	3	0.414**	Valid	Used			
Q6	1	0.499**	Valid	Directly			
	3	0.375**	Valid	Used			
Q7	1	0.376**	Valid	Directly			
	3	0.361**	Valid	Used			
Q8	1	0.360**	Valid	Directly			
	3	0.401**	Valid	Used			
Q9	1	0.324**	Valid	Directly			
	3	0.311**	Valid	Used			
Q10	1	0.154	Not Valid	Retest	0.638**	Valid	Directly Used
	3	0.209*	Valid		0.638**	Valid	
Q11	1	0.252*	Valid	Directly			
	3	0.325**	Valid	Used			
Q12	1	0.351**	Valid	Directly			
	3	0.305**	Valid	Used			
Q13	1	0.243*	Valid	Retest	0.696**	Valid	Directly
	3	0.200	Not Valid		0.623**	Valid	Used
Q14	1	0.240*	Valid	Directly			
	3	0.304**	Valid	Used			
Q15	1	0.406**	Valid	Directly			
	3	0.338**	Valid	Used			
Q16	1	0.341**	Valid	Retest	0.576**	Valid	Directly
	3	0.150	Not Valid		0.498*	Valid	Used
Q17	1	0.088	Not Valid	Retest	0.642**	Valid	Directly Used
	3	0.106	Not Valid		0.555**	Valid	
Q18	1	0.245*	Valid	Retest	0.589**	Valid	Directly
	3	-0.090	Not Valid		0.589**	Valid	Used

Q19	1	0.250*	Valid	Directly
	3	0.252*	Valid	Used

The valid questions from the first test then underwent reliability test. The 26 questions are reliable with 0.740 Cronbach's Alpha Score. With that score, the instrument is considered as acceptable [21]. The second reliability test was done for the revised questions. The 12 questions are also reliable with 0.829 Cronbach's Alpha value. This score is considered as fairly high [21]. The Cronbach's Alpha score can be seen in Table 4. In total, there are 19 sets of questions that are feasible to diagnose students' conception on light and optic topics.

**Table 4.** The result of reliability test

Test	N of Items	Cronbach's Alpha
I	26	0.740
II	12	0.829

### 3.2. Students Conception on Light and Optic Topics

Students' conceptions on light and optic topics are categorized into scientific knowledge, false positive, false negative, misconception, and lack of knowledge. It can be seen in Table 5. There are three points need to be noticed. The first is that in average, the percentage of FP and FN is less than 10%. This means the data collected here is good [14]. The second is that students have more scientific knowledge than misconception. The third is that students' conception in average is in medium level [22].

**Table 5.** Students' Conception on Light and Optic Topics

Subtopics	SK (%)	FP (%)	FN (%)	M (%)	LK (%)
The properties of Light	44.0	8.8	9.8	32.1	10.3
Image Formations on Mirrors	49.4	11.1	8.1	31.6	8.5
Human Eye	29.0	8.6	8.1	35.5	18.8
Optical Instruments	22.4	7.7	7.1	51.9	10.9
Average	39.9	9.2	8.1	32.5	10.3

The results might be caused by various reasons such as online learning, unconfident misconception, and unfamiliarity. The pandemic situation forces Indonesia to use an emergency curriculum. The method used is online learning. This method alone is causing more misconception [23]. Integrating technology to learning activities is good. However when the method used consists of mostly asynchronous or complete asynchronous, students will lose the immediate feedback from teachers. Moreover during lesson teachers are likely don't confront students' misconception or do not inform students the common misconception related to the topics. Unconfronted misconception might stay or even causing more misconception [5]. Online lesson also caused students to lose access to their school laboratory. This reduces students' chance to get familiar with the light concepts and also optical instruments at the laboratory. Those conditions then causing low level of scientific understanding and high level of misconception. When students are unfamiliar to objects or particular situation, it leads to misconception [24]. The idea proposed to overcome misconception is to facilitate students to have conceptual change [25]. Conceptual change can be done by hands-on activity [26], emphasizing misconception during class [27] or conceptual change-curriculum [28].

## 4. Conclusion

From this study there are 19 questions that are feasible to diagnose students' conception on light and optic topic. All questions are valid and reliable. Thirteen questions with 0.740 Cronbach's Alpha and 6 questions with 0.829 Cronbach's Alpha. Students have more scientific knowledge than misconception. However, their misconception is categorized as medium level. The medium level misconception might be caused by online learning, students' unfamiliarity to the topics learnt, and unconfident misconception. However this can be eliminated by giving students more hands-on activity [29].

With this result, Authors wish that this instrument can be used for future research to diagnose students' conception on light and optic topic. The result can also be used to develop strategies on strengthening students' conception as well as eliminating students' misconception or mapping students' conception before the lesson so teachers can adapt the learning method and strategies to the students' need.

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## 6. References

- [1] Neidorf T, Arora A, Erberber A, Tsokodayi Y and Mai T 2020 *Student Misconceptions and Errors in Physics and Mathematics Exploring Data from TIMSS and TIMSS Advanced* (Washington: IEA Research for Education)
- [2] Taber K S and Akpan B 2017 *Science Education* (Rotterdam: Sense Publishers) 119.
- [3] Lin J W 2015 *Int. J. Sci. Math. Educ*
- [4] Romine W L, Schaffer D L and Barrow L 2015 *Int J Sci Educ*, **37**, 16, 2740
- [5] I. W. Redhana, I. B. N. Sudria, I. Hidayat and L. M. Merta 2017 *J. Pendidik. IPA Indones.*, **6**, 2, 356
- [6] Ozmen H 2004 *J Sci Educ Technol*, **13**, 2, 147
- [7] Lee R P *Int J Sci Educ*, **1036**, 2016
- [8] Sinatra G M and Heddy B C 2013 *Sci Educ*
- [9] Amase A, Siahaan P and Fitriani A 2019 *J Phys Conf Ser*
- [10] Fenditasari K, Istiyono J E 2020 *J Phys Conf Ser*
- [11] Putri S S and Rusyati L 2021 *J Phys Conf Ser*
- [12] Berek F X and M. 2016 *J. Pendidik. IPA Indones.*, **5**, 2, 230
- [13] Kaltakci-Gurel D, Eryilmaz A and McDermott L C 2016 *Eur J Phys*, **37**, 4
- [14] Kiray S A and Simsek S 2020 *Int J Scie*
- [15] Susanti M A N, Effrita A and T 2021 *J Phys Conf Ser*
- [16] Eaton J F, Anderson C W and Smith E L 1984 *Elem Sch J*, **84**, 4, 365
- [17] Widiyatmoko A and Shimizu K 2018 *J. Pendidik. IPA Indones*, **7**, 491
- [18] Caleon I S and Subramaniam R 2010 *Rese Sci Educ*, **313**
- [19] Cooksey R W 2020 *Illustrating Statistical Procedures: Finding Meaning in Quantitative Data*, Springer Nature Singapore Pte Ltd
- [20] Pearson Education 2017 *Pearson Edexcel Level 3 Advanced GCE and Advanced Subsidiary in Statistics* (Pearson Education Ltd)
- [21] Taber K S 2018 *Res Sci Edu.*, **48**, 1273
- [22] Sundaygara C, Gusi L A R P, Pratiwi H Y, Ayu H D 2021 *J Phys Conf Ser*
- [23] Wendt J L and Rockinson-Szapkiw A 2014 *J Res Sci Teach*
- [24] Yen C, Yao T and Mintzes J J 2007 *Int J of Sci Educ*, **29**, 2, 535
- [25] Duit R, Treagust D F and Widodo A 2013 *Teaching Science for Conceptual Change," in International Handbook of Research on Conceptual Change* (London, Routledge)
- [26] Ribeiro J L P 2016 *Phys Educ*
- [27] Haagen-Schützenhöfer C 2017 *Phys Educ*
- [28] Kaewkhong K 2020 *J Phys Conf Ser*
- [29] Rohmanasari F and Ermawati F U 2020 *J Phys Conf Ser*