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THE DEVELOPMENT OF TWO-TIER MULTIPLE CHOICE TEST TO ASSESS STUDENTS' CONCEPTUAL UNDERSTANDING ABOUT LIGHT AND OPTICAL INSTRUMENTS

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ABSTRACT

This study aimed to develop a two-tier multiple choice test about the concept of "light and optical instruments" in the 8th grade of the Indonesian science curriculum. The test development procedure had three general steps: (1) defining the content area of the test; (2) identification on students' conceptions; and (3) developing the two-tier multiple choice test. The final version of two-tier multiple choice test consisted of 25 items question. This test was administered to 95 junior high school students. The students had completed a unit on light and optical instruments. The reliability of the test was 0.76. Based on the data analysis, twenty-two alternative conceptions were identified. The results of the study showed that the two-tier multiple choice test was effective in determining the students' misconceptions and also it might be used as an alternative to the traditional multiple choice test. In conclusion, two-tier multiple choice test could be used to assess students' conceptual understanding as well as students' misconceptions on light and optical instruments concept.

Keywords: two-tier multiple choice test, conceptual understanding, misconceptions, light and optical instruments

INTRODUCTION

Conceptual understanding in science learning has been the main concern of the researchers in the science education field. Students' conceptual understanding could not be easily observed or measured. Teachers have to investigate students' understanding before and after instruction. In order to measure students' conceptual understanding of several concepts in a science subject, various diagnostic tools have been developed and used such as open-ended tests, interviews, and multiple choice tests. Those are found to be the ones commonly employed in science education research (Gurel et al., 2015).

Multiple choice tests have been employed for measuring students' understanding of concepts since they allow a large number of students to be sampled in a provided amount of time as compared to time-consuming interviews. These tests are easy to administer and score; moreover, the results obtained are also easily processed and analyzed (Petersonn et al., 1989; Tan et al., 2008; Tan & Treagust, 1999). However, multiple-choice questions may not always indicate students' understanding or detect students' misunderstanding for a certain concept (Adodo,

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2013). The use of a two-tier diagnostic test (Treagust, 1988) has examined a better way to evaluate students' conceptions.

A two-tier diagnostic test was first developed with items precisely designed to identify auxiliary conceptions and misunderstandings in a defined content area of science. Since that time, a number of two-tier tests have been developed and reported in the literature (Treagust & Chandrasegaran, 2007). Two-tier diagnostic tests have been considered as an effective assessment tool to establish students' conceptual understanding (Treagust, 1988; Odom & Barrow, 1995; Chen et al., 2002; Lin, 2004; Cengiz, 2009; Sesli & Kara, 2012; Adadan & Savasci, 2012).

One of the factors affecting students' conceptual understanding is misconceptions. Misconceptions occur if a student's understanding of a concept differs from the scientific concept (Nakhleh, 1992). Misconceptions are stable cognitive structures to change, affect students' conceptual understanding, and must be overcome so that students learn scientific concepts effectively (Hammer, 1996). Misconceptions have become a part in the science education area. Previous researchers have done lots of studies to investigate the students' misconceptions, particularly in light and optical instruments concept.

Light and optical instruments is an important science concept included in the curriculum of many countries (Jones & Zollman, 2014). Although everyday experience with light and optical instruments concept, understanding of this concept turn out to be difficult for students. According to Ling (2017), light is a complex concept in science learning. Due to the complexity of the concept and difficulty of the subject, students have a various misunderstanding and hence have developed misconceptions about light and optical instruments concept. According to the national curriculum in Indonesia, light and optical instruments concept are taught at the 8th-grade student in junior high school (Krisno, 2008). This concept is expanded and taught in the upper grade in senior high school. If the students' misconceptions about light and optical instruments concept are not corrected, students will carry these misconceptions to the upper grades. Dealing with this issue, the development of two-tier multiple choice test for evaluating students' conceptual understanding of light and optical instrument may lead to more meaningful learning. Therefore, the purpose of this study was to develop a two-tier multiple choice test to assess students' conceptual understanding, as well as to explore students' misconceptions of light and optical instruments concept.

METHODS

This study was a mixed method with incorporating both quantitative and qualitative methods. The Two-Tier Mulitple Choice Test (TTMCT) was developed in three stages adopting procedures by Treagust's (1988, 1995). The procedure was divided into three stages as shown in Figure 1. Stage 1 was defining the content area of the study. Stage 2 was the identification of students' conceptions from previous literature and students' responses. Stage 3 was several steps in the designing of the test items and the validation of the final version of the two-tier multiple choice test.

The first stage was defining the content area. Based on the science textbooks, the content area of light and optical concept were identified. The concept can be defined into five concepts boundaries the content area of the properties of light, the formation of images in mirrors and lenses, the formation of images in lenses, optical instruments, and the human eye. The content area was encapsulated in concept maps. Then, the relationship between the concept maps was checked. The concept maps were validated by two expert science teachers and three science lecturers. Table 1 shows the distribution of the content area of light and optical instruments concept in the TTMCT.

Table 1. The Content Area of Two-Tier Multiple Choice Tests

Content Area	Items
The properties of light	Q1, Q2, Q3, Q4, Q5
The formation of images in mirrors and lenses	Q6, Q7, Q8, Q9, Q12, Q13
Optical instruments	Q18, Q20, Q21, Q22
Human eyes	Q10, Q11, Q19, Q23, Q24
Human eye disorders	Q14, Q15, Q16, Q17, Q25

The second stage was the identification of students' conceptions. The students described and explained the light and optical instruments concept using multiple levels of representations. The students' conceptions were identified using semi-structured and free response questions. These questions were administered to 40 students in grade 8th junior high school, which are chosen by using purposive random sampling. For more information and deeper perspective of students'

conceptions, semi-structured interviews were conducted. The interviews endured 20 to 30 minutes. Finally, the students' conceptions were identified by structured protocols.

The third stage was the development of two-tier multiple choice test. This stage focused on developing the two-tier multiple choice test. Based on the specification grid, 25 items two-tier multiple choice tests were developed. Each item of the instrument consists of two sections. In a TTMCT, the first tier asked students to choose about some specific concept related with light and optical instruments concept; and the second tier questioned students about the reason or explanation for choice in the first tier. There were four choices for both tiers. The instrument of the first version was validated by three science lecturer and two science teachers. Then, the final draft of TTMCT was developed. The final version of TTMCT consisted of 25 items question. The example of the TTMCT items can be seen in Figure 2.

Figure 1. The Flowchart of Instrument Development Based on Treagust (1988,1955)

RESULTS AND DISCUSSION

In order to validate the two-tier multiple choice test (TTMCT), a pilot study was conducted. The final version of the TTMCT was administered to 95 students in grade 9th Junior High School. All of them had studied light and optical instruments in grade 8th. The fundamental purpose of the pilot study was to evaluate the effectiveness of the TTMCT regarding its content coverage and language appropriateness. Based on the pilot test, it was identified that the students needed about 80 minutes to complete the TTMCT which consisted of 25 items question related to the concept of light and optical instruments. Item 1, 2, 3, 4, and 5 concerned with the properties of light. The formation of images in mirrors and lenses represented in item 6, 7, 8, 9, 12, and 13. Item 18, 20, 21, and 22 involved the concept of optical instruments. The concept of the human eye was demonstrated in item 10, 11, 19, 23, and 24. Finally, the concept of eye disorders was available in item 14, 15,16, 17, and 25. Details indicator of items in TTMCT can be seen in Table 2.

Table 2. Distribution of Items to the Contexts on the TTMCT

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
	Light as a transversal wave	Q5
The formation of an image in mirrors and lenses	Image formation in a plane mirror	Q6
	The law of reflection	Q7
	The relation between incident and reflection ray	Q8
	Image formation between two plane mirror	Q9
	Image formation in a concave mirror	Q12
	Analyzing the focus of the concave mirror	Q13
Optical instruments	The image formation in the convex lens	Q18
	The parts of microscope	Q20
	The image formation of eye and camera	Q21
	Similarities of human eye and camera	Q22
Human eye	Part of the human eye (retina)	Q10
	Part of the human eye (eye lens)	Q11
	Definition of human eye accommodation	Q19
	The relationship between presbyopia and eye lens	Q23
	Part of the human eye (aqueous humor)	Q24
Eye disorders	Eye disorders (myopia)	Q14
	The eyeglasses for myopia	Q15
	Eye disorders (hypermetropia)	Q16
	The characteristic of nearsighted eyes	Q17
	The solution for myopia	Q25

Two experienced science teachers and three science lecturers validated the questions' content. The validator was provided with a task description and a concept outline to evaluate the validity of the instruments. The validator commented that the content of the instruments included almost 95% of the syllabus and suitable to be used. The language used in the TTMCT was easily understood by the students. The reliability test is essential to examine the consistency of the items measured using the instruments. The reliability of the TTMCT was 0.76. Hence, it can be concluded that the items in the TTMCT were reliable in assessing the understanding of light and optical instruments concept.

In a traditional multiple choice test with four possible choices, the chance of predicting the correct answer is 25 percent. Nevertheless, in a TTMCT, the chance of predicting is 6.25 percent. By lessening the predicting chance from 25 percent to 6.25 percent, the arithmetic means of the students might decrease. Treagust (1988) stated that the development of the two-tier diagnostic test to reveal students' conceptions. The first tier of each item test is a multiple choice question dealing with proportional statements, and the second tier of each item is a composed of multiple choice set of reasons for the first tier's answer. The set of reasons includes students' scientific answer and possible misconceptions. A student's answer to an item was declared correct if the student selected both the correct answer and reason. Items of the TTMCT were evaluated for both correct and incorrect response combinations chosen by the students. Figure 2 shows the example of the response combinations picked by the students for item number 1 and number 2 dealing with the properties of light.

1. What is the definition of light? A. Light is an electromagnetic wave B. Light is a mechanical wave C. Light travels unlimited distance D. Light is a longitudinal wave Reason: a. Light has an infinite speed b. Light can travel through a vacuum c. Light can pass through all object d. Light can propagate if there is a medium	2. We can see the fish in the aquarium. The fact about the relationship between light and the ability of the eye to see objects is .... A. The eye can see objects because the object can absorb the received light B. The eye can see objects because the objects reflected light, so that light enters the eye C. The eye can see objects because the object refracted light, so that light enters the eye D. The eye can see objects because the eye nerves can see objects, so the ability of the eye to see the object has no relationship with light Reason: a. Eyes can see even without light b. Eyes can produce light, so the eyes can see objects c. Light coming from a light source directly enters to our eyes d. If there is no light to reflect at an object, no object can be seen

Item	Answer Option	Reason Option					Total
		a	b	c	d	Blank	
Q1	A	*23,16*	**56,84***	3,16	0,00	0,00	83,16
	B	1,05	4,21	2,11	0,00	0,00	7,37
	C	1,05	3,16	1,05	0,00	0,00	5,26
	D	2,11	2,11	0,00	0,00	0,00	4,21
	blank	0,00	0,00	0,00	0,00	0,00	0,00
Q2	A	3,16	1,05	2,11	0,00	0,00	6,32
	B	12,63	8,42	12,63	**35,79***	0,00	69,47
	C	4,21	2,11	4,21	3,16	0,00	13,68
	D	2,11	3,16	2,11	3,16	0,00	10,53
	Blank	0,00	0,00	0,00	0,00	0,00	0,00

Note : Figure in bold and with an asterik indicates the correct answer. texts in italics indicate a major alternative conception (>15%).

Figure 2. The Example of TTMCT Item and Percentage of Students Selecting Each Response Combination for Item Number 1 and Number 2 Dealing with the Properties of the Light

The Analysis of Alternative Conceptions Using Two-tier Multiple Choice Test

Alternative conceptions are considered significant and conventional if they were found in more than 10% of the students' sample (Peterson, 1986; Tan et al., 2005). Table 3 shows the summarize of significant common alternative conceptions of students in light and optical instruments concept using two-tier multiple choice tests. Twenty-two alternative conceptions were identified and grouped under the headings of 'the properties of light', 'the formation of the image in mirrors and lenses', 'optical instruments', 'human eye', and 'eye disorders'.

Table 3. The Students' Alternative Conceptions from the Administration of TTMCT

Alternative Conceptions	Choice Combination	Percentage
The Properties of Light		
Light is an electromagnetic wave and has an infinite speed	Q1 (A-a)	23%
White light bulb is the type of monochromatic light and can be broken down into other colors through the process of light diffraction	Q3 (A-a)	28%
White light bulb is the type of monochromatic light and can be broken down into other colors through the process of light dispersion	Q3 (B-c)	39%
Light can refract towards the normal when light ray directly refracted by the rarer medium	Q4 (B-c)	25%

The Formation of an Image in Mirrors and Lenses		
The height of an image is the same as the height of the object, while the distance of an image is two times the distance from the object	Q6 (B-a)	17%
The distance of the object affects the magnitude of the incidence angle and reflection angle	Q7 (B-b)	17%
The magnification of an image is the result of the height of the object with the height of the image	Q12 (A-a)	25%
The magnification of an image is the result of the height of the object with the distance of the image	Q12 (A-b)	16%
Optical Instruments		
In a convex lens, if the object position in closer to the lens then characteristic image are virtual, upright and enlarge	Q18 (A-a)	21%
Microscope consists of two convex lenses, the ocular lens (near the object) and the objective lens (near the eye)	Q20 (A-a)	26%
The similarities between human eyes and camera are both of them have concave-convex lens	Q21 (B-d)	17%
The lens in a camera has function to controls the accommodating power that same function with iris in the human eye	Q22 (C-a)	24%
Human Eye		
The eye lens is a part of the eye which serves as an image catcher	Q10 (B-b)	19%
The eye lens is a part of the eye that refracts the light so that it can give the impression of seeing.	Q10 (B-c)	22%
The pupil is a part of the human eye that has function to focuses the light onto the retina	Q11 (C-a)	18%
Eye accommodating happen when the object is far, the lens of the eye is flattened; while when the object is close, the muscle in the eye relaxing and the lens of the eye is bulging	Q19 (D-b)	18%
Presbyopia caused by the cornea is not working properly	Q23 (B-a)	18%
Presbyopia caused by the pupil is not working properly	Q23 (C-a)	18%
The aqueous humor is located in the iris	Q24 (A-d)	21%
Eye Disorders		
Myopia can help using positive eyeglasses	Q15 (B-a)	16%
The characteristic of nearsighted (hypermetropia) is formed image behind the retina and caused by the shape of the eyeball is too convex	Q17 (D-b)	18%
Myopia can be helped by the concave lens which is a positive lens	Q25 (C-b)	21%

The finding from Table 3 illustrates that students hold misconceptions of light and optical instruments concept. Based on the data analysis, twenty-two alternative conceptions were identified. These alternative conceptions in light and optical instruments concept were arisen because of the difficulty and complexity of the concept, daily life experiences, textbooks, language used, and teachers' misconceptions. Students come to school with different knowledge about this concept based on their daily experiences.

In light and optical instruments concept, Indonesian students have been provided an example of the properties of light based on their daily experiences. For instance, in Table 3 showed that 23% of the students held the misconceptions about "light is an electromagnetic wave and has infinite speed." Based on this conception, the students think that light is an electromagnetic wave and has infinite speed because they taught that the sun is shining every second. The fact is the light needs 8 minutes 20 seconds to reach on the earth from the sun.

Another example of misconception was eye accommodation process. Based on the analysis, 23% of the students held the misconceptions about "eye accommodation happens when the object is far, the lens of the eye is flattened; while when the object is close, the muscles in the eyes are relaxing and the lens of the eye are bulging." Students in Indonesia are difficult to explain the process of the eye's accommodation. Eyes accommodation is a reflex action as a response to focusing on a near object, then looking at a faraway object and vice versa. This process

is achieved through the changing of the eye lens. The process of the eyes accommodation is too abstract for students and tends to cause the misconceptions.

To determine the students' understanding in light and optical instruments concept using TTMCT instrument, the first tier asks a student to choose about some specific concept, and the second tier asks the student about the reason or explanation for choice in the first tier. The scoring method of TTMCT considered each item to be correctly answered if a student's choice of either the first tier (content knowledge) or the second tier (reason for the first tier) were both correct. Table 4 shows analysis of the percentage correct answer and correct reason of the TTMCT.

Table 4. The Percentage of Correct Answer-Correct Reason from the Administration of the TTMCT

Topic	Indicator of Question	Item	Total	
			N	Percentage
The properties of light	Definition of light	1	54	57%
	The relationship between light and vision	2	34	36%
	Monochromatic and polychromatic light	3	3	3%
	Light refraction	4	13	14%
	Light as a transversal wave	5	6	6%
The formation of image on mirrors and lenses	Image formation in a plane mirror	6	24	25%
	The law of reflection	7	45	47%
	Relation between incident and reflection ray	8	14	15%
	Image formation between two plane mirror	9	24	25%
	Image formation in a concave mirror	12	16	17%
	Analyzing the focus of the concave mirror	13	29	29%
Optical instruments	The image formation in the convex lens	18	13	14%
	The parts of microscope	20	41	43%
	The image formation of eye and camera	21	9	9%
	Similarities of human eye and camera	22	17	18%
Human eye	Part of the human eye (retina)	10	20	21%
	Part of the human eye (eye lens)	11	25	26%
	Definition of human eye accommodation	19	22	23%
	The relationship between presbyopia and eye lens	23	14	15%
	Part of the human eye (aqueous humor)	24	12	13%
Eye disorders	Eye disorders (myopia)	14	28	29%
	The eyeglasses for myopia	15	9	9%
	Eye disorders (hypermetropia)	16	31	33%
	The characteristic of nearsighted eyes	17	24	25%
	The solution for myopia	25	5	5%

Science curriculum in Indonesia stated that the assessment directed to measure students' conceptual understanding (Widiyatmoko & Shimizu, 2018). The TTMCT in this research addressed conceptual understanding in five topics: (1) The properties of light (definition of light, relationship between light and vision, monochromatic and polychromatic light, light refraction and light as a transversal wave); (2) The formation of image in mirrors and lenses (the image formation in a plane mirror, the law of reflection and refraction, and image formation in a mirror); (3) Optical instruments (the image formation in the convex lens, the image formation of microscope, and similarities of human eye and camera); (4) Human eye (the parts of human eye and the accommodation of human eye); (5) Eye disorders (the type of eye disorders and the solution for each eye disorders).

To show students' conceptual comprehension of the properties of light, students were expected to understand the definition of light, the relationship between light and vision, monochromatic and polychromatic light, light refraction, and light as a transversal wave. As seen from Table 4, 57% of the students have grasped the defini-

tion of light while 36% of the students showed an understanding of relationship between light and vision, and only 3% of the students understood the concept of monochromatic and polychromatic light. Moreover, 14% of the students showed an understanding of light refraction, and 6% of the students showed understanding of light as a transversal wave. Based on Table 1, the lowest percentage of the properties of the light was monochromatic, polychromatic, and light as a transversal wave. The factors that impeded understanding of this concept are light is abstract for the students, and the characteristic of light (its speed, wavelength, color, etc.) are beyond the perception of students' senses. Furthermore, many terms in light topic like reflection, refraction, and dispersion are difficult for students.

To know students' conceptual understanding of the image formation on mirrors and lenses, the students were expected to understand the image formation in a plane mirror, the law of refraction and reflection, and image formation in a mirror. Stand on Table 4, 25% of the students comprehended the image formation in a plane mirror, 47% of the students showed an understanding of the law of reflection, 15% of the students indicated an understanding of relation between incident and reflection ray, 25% of the students got the image formation in between two plane mirror, 17% of the students showed an understanding of image formation in a concave mirror, and 29% of the students showed an understanding of analyzing focus of the concave mirror. The image formation on mirrors and lenses are difficult for students due to several reasons. First, they were confused about the law of reflection (incident angle and reflection angle). Second, the students found it difficult to determine real image and virtual image. Third, the students did not have any experience with the number of images which generated from two plane mirrors, and fourth, they considered it difficult to measure image distance, object distance, focal length and image magnification.

To show the students' conceptual understanding of the optical instruments, they were expected to understand the image formation in the convex lens, the parts of microscope, and similarities of human eye and camera. As appeared in Table 4, 14% of the students showed an understanding of the image formation in the convex lens, 43% students indicated an understanding of the parts of microscope, 9% of the students showed an understanding of the image formation of human eye and camera, and 18% of the students revealed an understanding of the similarities of human eye and camera. The optical instruments topic were difficult for students because it was difficult to explain the similarities between human eye and camera about the process of image formation. Moreover, they found it hard to explain the similarities between parts of human eye and camera; further, the students hardly used microscope in order to find the image ude to their lack of knowledge about the parts of microscope.

To reveal the students' conceptual understanding of the human eye, they were expected to understand the parts and function of human eye. On the basis of Table 4, 21% of the students explained an understanding of the retina as a part of human eye, 26% of the students showed an understanding of the eye lens as a part of human eye, 23% of the students showed an understanding of the definition of accommodation human eye, 15% students indicated an understanding of the relationship between presbyopia and eye lens, and 13% of the students showed an understanding of the aqueous humor as a part of human eye. Human eyes topic was difficult for the students because they faced difficulties to mention the parts of the human eye and its function, the complex concept of how image formation process in the human eye, and the process of eye accommodation as those are too abstract.

To know the students' conceptual understanding of the eye disorders, they were expected to comprehend the type of eye disorders and the solutions. Based on the above Table 4, 29% of the students understood of the eye disorder myopia, 9% of the students grasped the eyeglasses for myopia, 33% of the students comprehended eye disorders of hypermetropia, 25% of the students showed an understanding of the characteristic of nearsighted eyes, and 5% of the students showed an understanding of the solution for myopia. Eye disorders topic was hard for the students as myopia, presbyopia, and hypermetropia are difficult to explain and they felt it difficult to visualize the process on how convex lens and concave lens can help someone who has eye disorders.

The analysis results elucidated that the students' conceptual understanding of light and optical instruments were low. The percentage of the indicator achievement in light and optical instruments concept below 50%. The highest percentage in Table 4 is 57% of the students showed an understanding of the definition of light. On the other hand, the lowest percentage is 3% of the students showed an understanding of monochromatic and polychromatic light. These results were indicating that a number of students did not know the correct answer and hold misconcep-

tions about light and optical instruments concept. Two-tier multiple choice test in this study can assess students' conceptual understanding as well as analyzing students' misconceptions.

Two-tier tests have been used by previous researchers to identify students' misconceptions in science learning (Treagust & Haslam, 1986; Treagust, 1988; Adodo, 2013; Kanli, 2015; Yusrizal & Halim, 2017), and particularly in light and optical instruments concept (Chen et al., 2002; Chu et al., 2009; Haagen-Schützenhöfer & Hopf, 2014). A two-tier diagnostic test, as Treagust (1988) reported, was first developed with items specifically designed to identify alternative conceptions and misunderstandings in clearly defined content areas of science. Since that time, a number of two-tier tests have been developed and reported in the literature (Treagust & Chandrasegaran, 2007).

The use of two-tier multiple choice tests allows teachers to achieve students' conceptual understanding, and also to explore students' reasoning behind these ideas (Tsai & Chou, 2002). Moreover, it facilitates the assessment of misconceptions of a larger sample of students in an effective way in science education research (Voska &Heikkinen, 2000). Misconceptions are stable, unscientific conceptions that obstacle the real learning of individuals Peşman & Eryılmaz (2010) and Hammer (1996) listed the properties of misconceptions as follows: (1) strong and stable cognitive structures; (2) Differ from scientific conception; (3) Affecting how students understand scientific explanations; and (4) Must be overcome, avoided and eliminated to achieve the scientific conceptions.

Research in overcoming students' misconceptions involves three main steps, namely developing diagnostic test instruments, analyzing the causes of misconceptions, and remediation of misconceptions (Allen, 2014). Misconceptions are difficult to replace with new, correct understandings; they consistently influence the effectiveness of further learning (Özmen, 2004; Tan et al., 2008). This condition happens because of misconceptions was difficult to change (Widarti et al., 2016). Students' misconceptions interfere with students' learning of scientific concepts (Sreypouv & Shimizu, 2017). Overcoming students' misconceptions require teaching methods which provide chances for students to reveal their pre-concepts and dissatisfaction with their concepts, particularly in light and optical instruments concept. According to Indonesian's national curriculum, the beginning of eighth grade in junior high school is the stage prior to receiving formal instruction about light and optical instruments concept, and this concept is expanded and taught in the upper grade in senior high school. If the students' misconceptions about light and optical instruments concept are not corrected, students will carry these misconceptions to the upper grades.

The previous literature indicated that there are various advantages of using two-tier multiple choice tests. Chen et al. (2002) found that the two-tier multiple choice test provided a reliable and valid pencil-and-paper, easy to score instruments for the teacher to evaluate students' idea better. Furthermore, this test has been used to evaluate students' misconceptions (Treagust, 1988) and very useful as the instruments that provide the teachers with students' understanding of particular science concept (Treagust & Chandrasegaran, 2007). The test is more readily administered and scored than the other method (Tan & Treagust, 1999, Adadan & Savasci, 2012). The TTMCT is relatively convenient for students to respond and more practical and valuable for teachers to use regarding reducing guesswork, allowing for large-scale administration and offering insight students' reasoning (Adadan & Savasci, 2012).

The complexity and difficulty of the light and optical instruments concept can cause the students' misconceptions. In the learning process, students will try to link the new knowledge to their cognitive structures. If the students have misconceptions, these will interfere with their learning and they will difficult to connect new knowledge with their existing knowledge. Because of this condition, students will difficult to achieve conceptual understanding in a learning process. Thus, the teacher should guide prerequisite concepts for the students as the bridging between students prior knowledge and the understanding of the concept being learning (Tsui & Treagust, 2010).

CONCLUSION

Based on this study, TTMCT is comfortably used to assess students' conceptual understanding as well as students' misconceptions on light and optical instruments concept. The TTMCT could help teachers to enhance students' knowledge level and prevent students' misconceptions. Thus, TTMCT help to improve teaching- learning process in the science classroom. This study exhibits several limitations. One of the limitations is that it lacks generalizability. Since the study involving a small number of participants, the findings from this study may not be generalized to the other contexts.

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