

Thai pre-service physics teachers' understanding of seeing an object

K Kaewkhong^{1,2}

¹Department of Curriculum, Teaching and Learning, Faculty of Education, Chiang Mai University, Thailand

²Thailand Center of Excellence in Physics, Commission on Higher Education, 328 Si Ayutthaya Road, Bangkok 10400, Thailand

kreetha.ka@cmu.ac.th

Abstract. The important role of Faculty of Education, Chiang Mai University, Thailand, is to prepare smart teachers in the future of Thailand. In 2018, the 50 Thai pre-service physics teachers had been trained by a workshop on active learning in optics and exposed to the concept of light as early as the primary level of training. A set of 4 conceptual questions on seeing objects in different situations was presented to these pre-service physics teachers. They were asked to draw a ray diagram and explain how they see 1) an object which can illuminate light by itself, 2) an object reflecting light from other light sources, 3) an object in a dark room (light cannot pass through) and 4) a beam of LASER.. Pre-service physics teachers' understandings were classified by determining their explanations and ray diagrams. Misconceptions about light propagation and human eyes were also approached. Surprisingly, we found that most of them confused in using a ray diagram to explain how objects are seen and how light propagate into eyes. Most of them still have some misconceptions about seeing, they believe eyes can adjust to see objects in a completely dark room.

Developing basic physics concepts for Thai pre-service physics teachers is the one of important responsibilities of the academic lecturers. In 2018, we design a workshop on active learning in optics based on concepts that secondary students were expected to have learnt for training the pre-service physics teachers, to help them have better understanding in basic optics concepts. The concepts we trained in the workshop are seeing, reflection, refraction, shadow and colour mixing, but this article we focus only the pre-service physics teachers understanding investigation on the topic of seeing which is the first topic in optics content of the Thai science core curriculum. Students usually enter a class with their conceptions related to their experiences [1-4], at the beginning of the workshop, the subjects were investigated their understanding by asking to answer a set of conceptual tests related to seeing concepts.

The research questions for the study are: (1) How do the pre-service physics teachers explain seeing? (2) How do the pre-service physics teachers draw a ray diagram to explain seeing? (3) How do the pre-service physics teachers explain factors which make objects visible? and (4) What are the students' misconceptions or difficulties of light?

1. Method

1.1. Samples

The subjects of this study are 50 Thai pre-service physics teachers, Faculty of Education, Chiang Mai University, Thailand, who came to a workshop on active learning in optics, selected by purposive sampling method. They are 26 first year students, 20 second year student and 4 third year students, respectively.

1.2 The instruments

We used a set of 4 conceptual questions to investigate the pre-service physics teachers understanding about seeing. This article highlights only two concepts on seeing that secondary students were expected to have learnt, firstly, objects are seen because light propagates from the objects, enter eyes lens, refract and project on a retina, secondly, eyes cannot adjust to see objects in a completely darkroom. The research questions for this study are: (1) How do the pre-service physics teachers explain seeing? (2) How do the pre-service physics teachers draw a ray diagram to explain seeing? (3) How do the pre-service physics teachers explain factors which make objects visible? and (4) What are the students' misconceptions or difficulties of light?

Question 1 and 2 are constructed based on the previous researches [1, 5-9]. Both questions are used to investigate the ideas about seeing and a ray diagram representing how objects are seen (in case of self-illuminated and non-self-illuminated objects). The analysis of subjects' responses of these two questions provide the answers of the research questions (1), (2) and (4). All 4 questions in this article, other two questions will be discussed later, are modified from the previous researches by placing the human eyes structure instead of using only picture of human eyes because we would like to approach the ideas of light propagation when light pass through the eyes to form an image on a retina. Question 1 and 2 are followings;

Question 1: How does an observer see a light bulb, figure 1(a), and a Fluorescent lamp, figure 1(b)? Explain and draw a ray diagram.

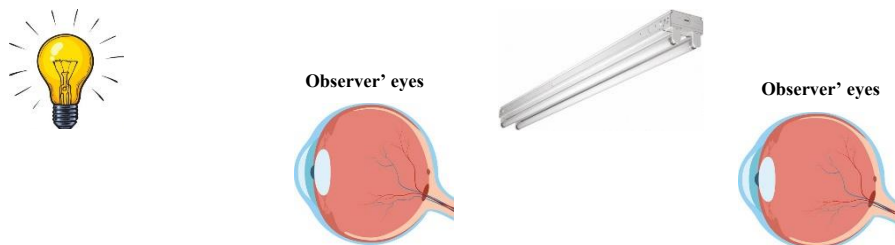


Figure 1(a).

Figure 1(b).

Answers

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Question 2: How does an observer see a bicycle, figure 2(a), and water glass, figure 2(b)? Explain and draw a ray diagram.



Figure 2(a).

Figure 2(b).

Answers

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The question 3 is constructed based on [5] used for detecting the participants ideas about factors that make objects can be seen. The analysis of the participants responses for this question provides the answers of the research questions (3) and (4). The results of this questions are such a surprising, we will discuss later in the results section.

Question 3: Can an observer see the object in a completed dark room, see figure 3? Why? Explain. If the observer closes his eyes about 1 minutes and opens slowly, will he see the object? Why? Explain.

A completed dark room



Answers

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Figure 3.

The question 4 is constructed based on our teaching experiences, we know that light exists and propagates in space, but we cannot see light directly, our eyes response to visible light when it reflects on the object's surface and propagate into our eyes. Most students in our class cannot explain how they see a laser beam based on reflection. The analysis of the participants responses for this question provides the answers of the research questions (1) (3) and (4), respectively.

Question 4, Which conditions make a laser beam can be noticed? Why? Explain.

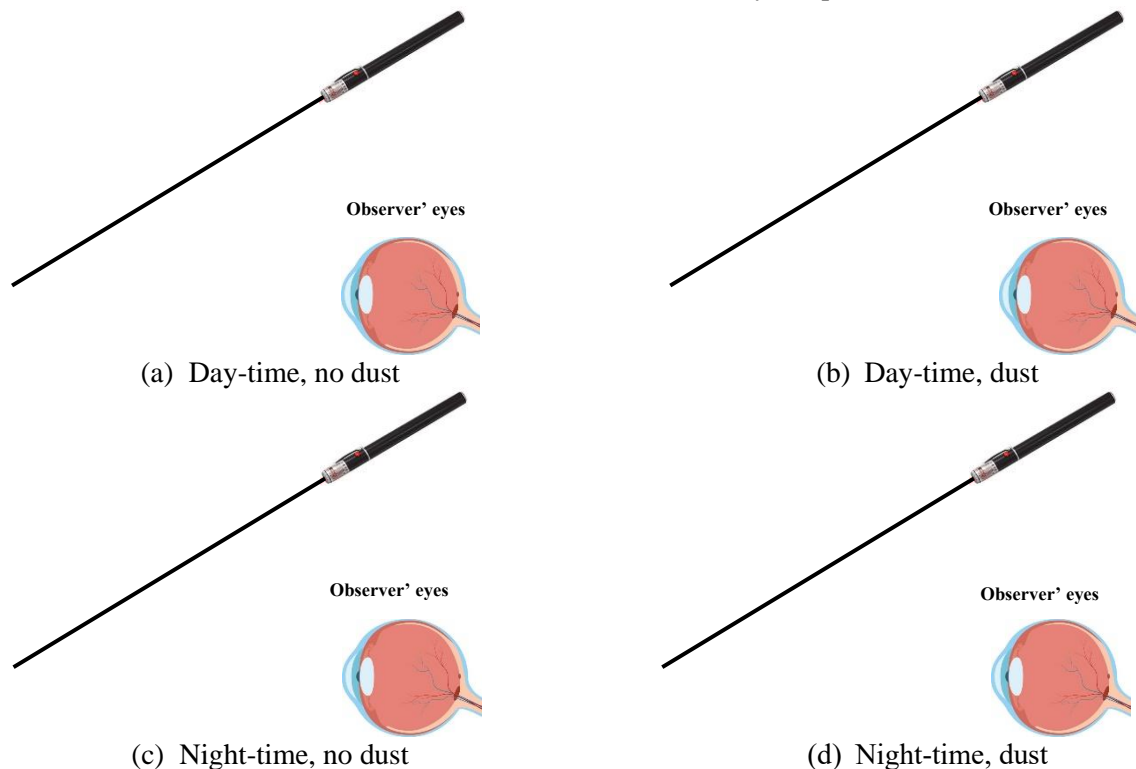


Figure 4. The 4 situations, the laser beam is shined pass the observer.

Answers.....

2. Data Analysis and Discussions

There were many misconceptions and difficulties used by subjects in trying to answer the four questions, and many subjects had multiple misconceptions and difficulties. These misconceptions and difficulties can be categorized into four main areas:


1. Difficulties about the direction of light that allows the object are seen by the observer.
2. Difficulties about how light refract at the interface of different two media.
3. Difficulties about how the human eyes form an image.
4. Misconceptions about how the human eyes work.


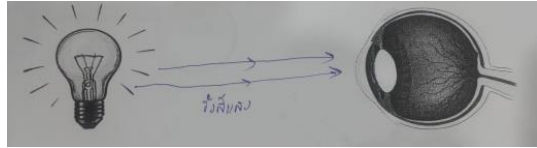
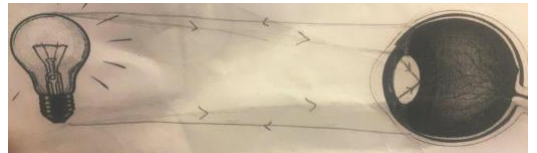
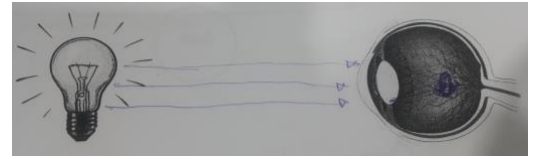
Each response in each question is categorized by the researchers' team, by considering a ray diagram and explanations, the misconceptions or difficulties are detected and shown in percentage of all subjects who give the responses in each question. The response analysed from question 1 and 2 can represent the first three main difficulties by determining a ray diagram they draw to show how the object are seen, the misconceptions about how the human eyes work are found clearly from the responses of 3 and 4. Some subjects are interviewed to make a data more correctly.

2.1 Data analysis of responses in question 1

There are 40 responses, from all 50 subjects, of question 1(a). This question, we expect that the subject should draw a ray diagram to show the direction of light propagation that allows the object are seen by the observer, they have to realize that the object are seen because light from the object propagate through space and reach the observer's eyes, light refracts between the interface of air and eyes lens then enter on a retina to make an image real and have inverted direction. We classified the responses of each subject into groups of three main difficulties, direction of light, refraction and an image formation on a retina by considering a ray diagram and their explanations. The results of question 1(a) and 1(b) and are summarized in table 1 and table 2 as followings.

Table 1. The results of question 1(a); note that each subject can have more than one difficulty.

Main difficulties	Characteristics	Percentage of all responses (40)	Examples of the response
1. Difficulties about the direction of light that allows the object are seen by the observer.	Directions of light are not indicated	18%	



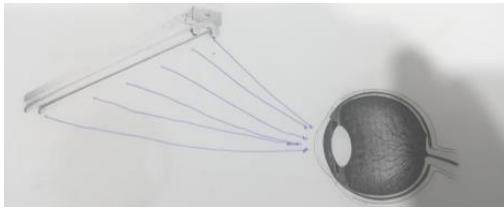
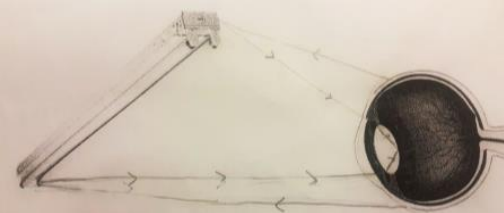
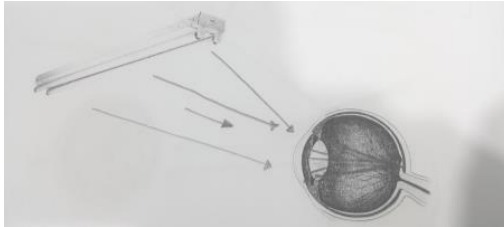
Main difficulties	Characteristics	Percentage of all responses (40)	Examples of the response
2. Difficulties about how light refract at the interface of different two media.	-Light pass through the human eyes without refraction	64%	
	-Light does not pass through the observer's eyes	54%	
3. Difficulties about how the human eyes form an image	-A position of light ray intersection in the eyes is not on a retina	2%	
	-Light rays did not pass through an observers' eyes, but a position of an image is indicated	6%	

For question 1(a), the responses are analysed and summarized in table 1, there are 18% of 40 pre-service physics teachers who give responses draw a ray diagram without indicating a direction of the light. Some of them were interviewed, we found that they try to draw a ray diagram by using a principle of reflection which is the same as indicating a position of an image formed by a plane mirror, they still looked confused about the direction of light when we asked them to tell steps when they draw a ray diagram. Besides, 64% of them draw rays pass through the observer eyes but did not represent refraction of light between the eye's lens and air. In this case, we found that most of them did not understand how light ray refract at the interface of two media, some subjects can draw a refractive ray only in case of an incident ray is parallel to an optical axis, they confused when a light ray incident on a lens in other angles. There are 54% of them did not draw a light ray pass through an observers' eyes, we found that most of them understand that the object are seen because light coming from the object enters the observer's eyes but they did not have ideas about image formation in the observer's eyes and refraction of light , the diagram they drew just only represent traveling of light from the objects to eyes. Surprisingly, 2% of them try to indicate the position of an image formed on a retina but they did not understand the structure of human eyes, they cannot indicate the position of a retina. About 6% of them indicate a position of an image formed on a retina but cannot explain how light propagate when it pass through the observer's eyes, most of them understand only that light coming from objects enters the observer 'eyes to make the objects can be seen at the retina.

For question 1(b), there are only 36 of all 50 subjects who gave responses, the analysis of responses is summarized in table 2. Noticeably, the responses of each subject in question 1(a) is related to the responses in question 1(b). Most of them still use the same ideas in question 1(a) to answer in question 1(b). There are 22% of them draw a ray diagram without indicating a direction of the light, 50% of them draw rays pass through the observer eyes but did not represent refraction of light between the eye's lens and air, 42% of them did not draw a light ray pass through an observers' eyes, 8%

of them try to indicate the position of an image formed on a retina but they did not understand the structure of human eyes, they cannot indicate the position of a retina and 4% of them indicate a position of an image formed on a retina but cannot explain how light propagate when it pass through the observer's eyes, respectively. From the results, we found that only few subjects realized that light propagate from a point source in a straight line all directions, and most of them cannot use a refraction principle to explain how light refract between air and observer's eyes, they draw ray diagrams just only representing light propagation from objects to the observer's eyes. .

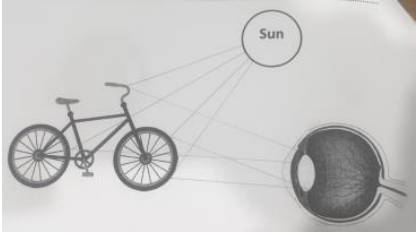
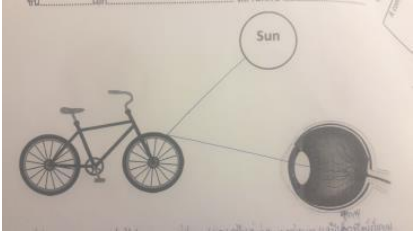
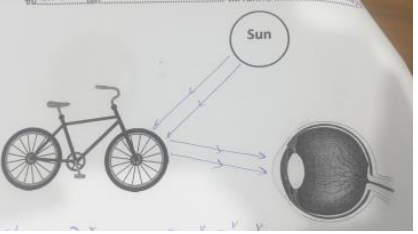
Table 2. The results of question 1(b); note that each subject can have more than one difficulty.

Main difficulties	Characteristics	Percentage of all responses (36)	Examples of the response
1. Difficulties about the direction of light that allows the object are seen by the observer.	Directions of light are not indicated	22%	
2. Difficulties about how light refract at the interface of different two media	-Light pass through the human eyes without refraction	50%	
	-Light does not pass through the observer's eyes	42%	
3. Difficulties about how the human eyes form an image	-A position of light ray intersection in the eyes is not on a retina	8%	
	-Light rays did not pass through the observers' eyes, but the image is indicated	4%	

2.2 Data analysis of responses in question 2

There are only 41 of the 50 pre-service physics teachers who give responses in question 2(a), we found that there are 18% of them did not indicate a direction of light, 52% of them draw rays pass through the observer eyes but did not represent refraction of light between the eye's lens and air. There are 46% of them did not draw a light ray pass through an observers' eyes, 10% of them try to indicate the position of an image formed by the observer's eyes lenses but it is not on a retina. Some of them did not indicate a direction of light coming from a light source and did not represent reflection of light on the object surface. For question 2(b), there are only 40 of the 50 pre-service physics teachers who give responses in this question, we found that there are 18% of them did not indicate a direction of light, 52% of them draw rays pass through the observer eyes but did not represent refraction of light between the eye's lens and air. There are 46% of them did not draw a light ray pass through an observers' eyes, 10% of them tried to indicate the position of an image formed by the observer's eyes lenses but it was not on a retina, respectively.

Table 3. The results of question 2(a); note that each subject can have more than one difficulty

Main difficulties	Characteristics	Percentage of all responses (41)	Examples of the response
1. Difficulties about the direction of light that allows the object are seen by the observer.	Directions of light are not indicated	18%	
2. Difficulties about how light refract at the interface of different two media	-Light pass through the human eyes without refraction	52%	
	-Light does not pass through the observer's eyes	46%	

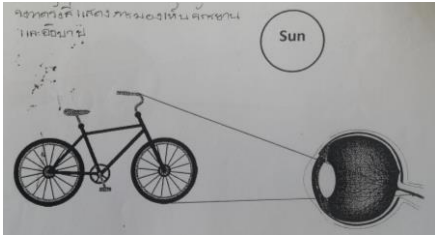
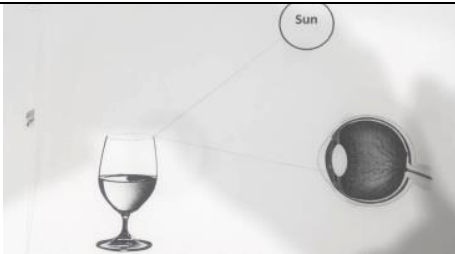
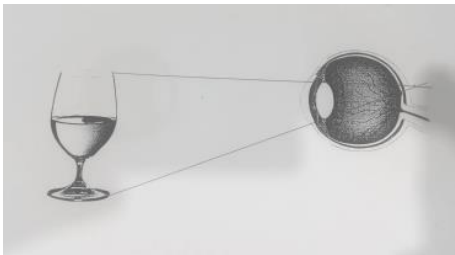
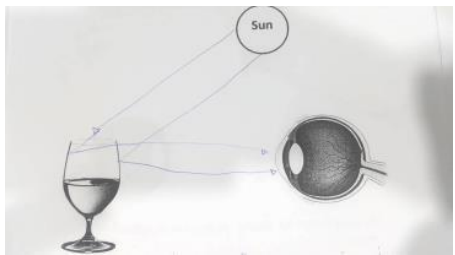
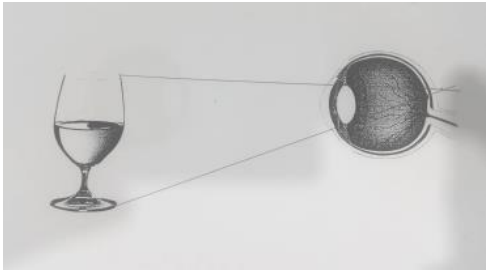
Main difficulties	Characteristics	Percentage of all responses (41)	Examples of the response
3. Difficulties about how the human eyes form an image.	An image is not forming on a retina	10%	

Table 4. The results of question 2(b); note that each subject can have more than one difficulty.

Main difficulties	Sub- difficulties	Percentage of all responses (40)	Examples of the response
1. Difficulties about the direction of light that allows the object are seen by the observer.	Directions of light are not indicated	18%	
2. Difficulties about how light refract at the interface of different two media	-Light pass through the human eyes without refraction	52%	
	-Light does not pass through the observer's eyes	46%	

Main difficulties	Sub- difficulties	Percentage of all responses (40)	Examples of the response
3. Difficulties about how the human eyes form an image	An image is not forming on a retina	10%	

2.3 Data analysis of responses in question 3

The answers of the pre-service physics teachers in question 3 can be classified into 5 groups of answers as shown in table 5. Surprisingly, we found that although most of them (60% of all) mention that an object cannot be seen in a completely dark room, but they still have some misconceptions that the human eyes can adjust themselves for seeing the object placed in a completely dark room if the observer close their eyes and open slowly. Each subject has different experiences that make they think that are situations like a completely darkroom such as seeing object when the electricity power is failed, seeing objects in a dark cave seeing objects in a dark forest or etc. These misconceptions have been discussed and reported in a little detail in [10].

Table 5. The results of question 3

No.	The answers of question 3(a) and 3(b)	Percentage of all responses (50)
1	-No, we cannot see an object in a completely dark room -No, we cannot see an object in a completely dark room, even we close our eyes in a minute and open slowly	60%
2	-Yes, we can see an object in a completely dark room - Yes, we can see an object in a completely dark room, when we close our eyes in a minute and open slowly	10%
3	-No, we cannot see an object in a completely dark room - Yes, we can see an object in a completely dark room, when we close our eyes in a minute and open slowly	26%
4	-Yes, we can see an object in a completely dark room -No, we cannot see an object in a completely dark room, even we close our eyes in a minute and open slowly	2%
5	No responses	2%

We know that a laser beam in space can be noticed when it reflects on the particles of dust in air, we found that there are 36% of all subjects (No.1 and No.3 in table 6) who believe that the laser beam can be noticed in a day-time and a night time without a particle of dust, respectively. Most of them understand the principle of light that allows the laser beam are seen. Some of them try to use a principle of scattering to explain but they still have some misconception about light scattering.

Table 6. The results of question 4

No	Situation	Percentage of all response (50)		
		Yes, the beam can be noticed	No, the beam cannot be noticed	No response
1	Day- time without dust 4(a)	16%	62%	22%
2	Day- time with dust 4(b)	56%	24%	20%
3	Night-time without dust 4(c)	20%	52%	28%
4	Night-time with dust 4(d)	78%	6%	16%

4. Conclusion

As the research questions for this study, we can summarize that; most pre-service physics teachers explain that we can see objects because light from the objects reaches the observers' eyes, they usually draw a ray diagram of light which propagates from the objects to enter the observer's eyes and a laser beam can be seen when it reflects on a particle of dust to enter the observer's eyes. However, the highlight of this research are the misconceptions and difficulties detected as followings;

- (1) The subject cannot apply a principle of refraction to draw a ray diagram at the interface of two media, between air and eyes.
- (2) The subjects do not understand the structure of human eyes and how an image form on a retina.
- (3) The subjects do not understand how the human eyes work in a completely dark room.
- (4) Eyes can adjust themselves for seeing object in a completely dark room.
- (5) A laser beam can be seen in the area where has no dust.
- (6) At night-time without particles of dust, we can see a laser beam clearer than during daytime.

All results from this research can guide for us to develop the curriculum that help them to have better understanding in optics concepts in a future.

Acknowledgements

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References

- [1] Goldberg F and Bendall S 1995 Making the invisible: a teaching/learning environment that builds on a new view of the physics learner *Am. J. Phys.* 63(11) 978-991
- [2] Halloun I A and Hestenes D 1985 The initial knowledge state of college physics students *Am. J. Phys.* 53(11) 1043-48
- [3] Hammer D 1994 Epistemological beliefs in introductory physics *Cog. Instruc.* 12(2) 151-183
- [4] Prosser M T and Sutton R A 1978 Understanding concepts *Phys. Educ.* 13 206.
- [5] Langley D, Ronen M and Eylon B S 1997 Light propagation and visual patterns: preinstruction learners' conceptions. *J. Res. Sci. Teach.* 34(4), 399-424.
- [6] Andersson B and Karrqvist C 1983 How Swedish pupils, age 12-15 years, understand light and its properties. *Eur. J. Sci edu.* 5(4), 387-402.
- [7] Osborne J et al. 1993 Young children's (7-11) ideas about light and their development. *Int. J. Sci. Edu.* 15(1), 83-93.
- [8] Saxena A B 1991 The understanding of properties of light by students in India. *Int. J. Sci. Edu.* 13(3), 283-89.
- [9] Shapiro B 1989 What children bring to light: giving high status to learners' view and action in science. *Sci. Edu.*, 73(6), 711-733.
- [10] Fetherstonhaugh T and Treagust D F 1992 Students' understanding of light and its properties: teaching to engender conceptual change. *Science Education*, 76(6), 653-672.