

What do the prospective science teachers know about human eye?

Çiğdem ŞAHİN

Giresun University, Education Faculty, Department of Science Education
28200, Giresun/TURKEY

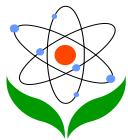
E-mail: hcsahin38@gmail.com

Received 22 Jan., 2013

Revised 22 May, 2014

Contents

- [Abstract](#)
 - [Introduction](#)
 - [Method](#)
 - [The sample](#)
 - [In Turkey, human eye in the Science Education Programs](#)
 - [Data collection tools](#)
 - [Data analysis](#)
 - [Findings](#)
 - [The findings obtained from the word associated test](#)
 - [The finding of the obtained from the open ended questions](#)
 - [The findings obtained from the PSTs' drawings](#)
 - [The findings obtained from the one two tiered-question](#)
 - [The findings obtained from the interview about concepts](#)
 - [Results and discussion](#)
 - [Suggestions](#)
 - [References](#)
 - [Appendix](#)
-



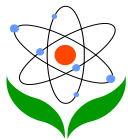
Abstract

In this study, the views of the Prospective Science Teacher (PST)s about human eye were examined. The following data collection tools were used: the Word Association Test (WAT), open ended questions, drawing technique, two tiered question item and an interview about concepts. The data of the study whose sample consisted of 34 PSTs were analyzed qualitatively and calculated repetition frequencies of their statements. Although most of the PSTs had taken an undergraduate course which included the subject of human eye, it was determined that they possessed insufficient knowledge-background and alternative concepts about the structure of human eye, the eye defects, its' treatment and vision. Having discussed these reasons for the lack of sufficient knowledge background, suggestions were presented to promote effective teaching.

Keywords: human eye, human eye defects, treatment of human eye defects, prospective science teachers, probing understanding

Introduction

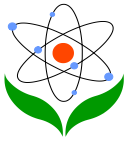
Students learn the concepts in informal and formal learning environments. Students get into the formal learning environments either with or without having prior knowledge. The students construct the concepts in their minds with their daily experiences (Ünal & Coştu, 2005), observations (Erginer, 2006) and intuitive perceptions (Seiger-Ehrenberg, 1981; Havu-Nuutinen, 2005). While the children are constructing the concepts, they may be developing alternative concepts which are not scientifically correct (Driver & Easley, 1978). It is not easy for the students to exchange these alternative concepts. In the teaching process, determining of the students' alternative concepts is important and essential for preparing effective teaching activities, environments and providing meaningful learning (Novak, 1988; Dekkers & Thijs, 1998; Erginer, 2006). Researches indicate that students have alternative conceptions related to various biology concepts in the literature (Cerrah-Özsevgeç, 2007; Köse, 2008; Mutlu & Özel, 2008; Özgür & Çıldır Pelitoğlu, 2008; Parker et al., 2012; Oztas & Oztas, 2012; Ozay Kose & Hasenekoglu, 2011). The structure of human eye, human eye defects, its treatment methods, vision and image formation concepts are among the biology topics in which understanding difficulties and alternative concepts are experienced.



The research available in the literature on human eye is limited. These researches are about material development to teach the structure of human eye (Mauser, 2011; Rule & Welch, 2008), vision and the formation of images (Ahçı, 2012; Çiftçi & Çökelez, 2012; Kara, Erduran Avcı & Çekbaş, 2008; Saka, Akdeniz & Enginar, 2002) and human eye defects (Güneş, 2006). Human eye defects and its treatment methods, vision and the image concepts are directly related to biology and physics courses (Ahçı, 2012; Dilek & Sahin, 2013).

It is not known whether the Prospective Science Teachers (PSTs) know human eye sufficiently or not. PSTs will teach human eye to the primary school students in the future. Therefore it is necessary for them to have domain knowledge consistent with scientific facts and the capability to transfer that knowledge correctly to their students. It is considered that teachers who have poor domain knowledge can cause misconceptions rather than meaningful information in their students' minds (Kara et al., 2008; Sezen & Çimer, 2009). So, as a necessity is seen that investigating of both teachers' and prospective teachers' understanding difficulties and domain knowledge proficiency.

When individuals relate knowledge to their everyday life concept, they can learn meaningfully (Özay Köse & Çam Tosun, 2011). In the physics course, human eye is an example from daily life that covers issues such as lenses, light refraction and vision (Mullin, 1996; Dilek & Sahin, 2013). Furthermore, one of the fundamental purposes of Science and Technology education is to increase the number of individuals who are literate in science and technology (MNE, 2006a). The science and technology knowledge of individuals involves their understanding of the nature of the science, knowing science and using this knowledge for their own benefits by relating it to their daily life. Therefore, the solution is to propose alternative concepts which will contribute to the students' literacy in science. So firstly, alternative concepts for students should be determined. An individual, who is shortsighted in other words he/she cannot see far but not aware that he has myopia, might not know which lens he should use. This is a worrisome indicator that the individual has insufficient science knowledge. When PSTs have knowledge about the structure of human eye, this can support their teaching activities in other science subjects. Determining the background knowledge of the PSTs about human eye will draw attention to learning and teaching of "human eye" concept. This study examined the views of the PSTs about human eye with different probing understanding techniques in depth. It is believed that the results of this study will be encouraging to use the concept probing understanding techniques. The purpose



of this study was to investigate the alternative concepts and background knowledge of the PSTs' about human eye.

Method

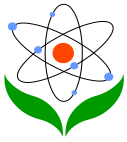
The research was conducted according to the case study methodology that aimed to investigate the PSTs' knowledge about human eye in detail. In the study, the PSTs' knowledge about human eye was researched with data collection tools such as the Word Association Test (WAT), open ended questions, drawing technique, two tiered question item and an interview about concepts.

The Sample

The sample of this study consists of 34 PSTs who were the 3rd year bachelor students of Primary School Science Education (Giresun University). The PSTs participated to this study voluntarily. The WAT, open ended questions, one two-tiered test question and drawing questions were applied to all of the PSTs. The interview about concepts were applied to 10 PSTs who are selected from the PSTs are having true knowledge, alternative concepts and confusing concept according to their drawings.

In Turkey, Human Eye in the Science Education Programs

The levels of education progressively, the concepts are taught to the students with more and more deepening content and from simple to complex (MNE, 2006a). The subjects of the structure of human eye, vision, human eye defects and its treatment are taught to the students in different levels of education with different contents in view of the quality of education levels in Turkey (MNE, 2006a; MNE, 2011). Teaching activities related to the role of lightning on vision and the effects of wrong lighting on human eye health are presented in the primary school 4th grade science and technology curriculum about human eye in "the light and sound" unit in the subject field of the physical events (MNE, 2006a). In addition, the students learn the structure of human eye, its defects, information related to the treatment of human eye defects, how lenses were used during the treatment of human eye defects, the features of the lenses and refraction by lenses via illustrations in practice in the 7th grade science and technology program (MNE, 2006b). In the 12th grade biology curriculum of the secondary education, a mammalian eye dissection activity (see URL-1, 2013) is suggested within the subject of endocrine and nervous system in parallel with the gain which says "it explains the impulses taken in human sensory organs, transfer of stimulus and their responses on the



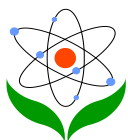
diagram” (MNE, 2011). The students study the structure of human eye, vision and human eye defects and its treatment within the content of the laboratory applications of the science and technology course in the general biology course at the university level (URL-2, 2013).

Data Collection Tools

In this study, to investigate the PSTs’ understanding on human eye were benefited from probing understanding methods and techniques which are both traditional open ended questions and contemporary the WAT, two tiered test, drawings technique and interview about concepts. To provide the validity of the data collection tools was consulted to the expert views. The pilot study was conducted to 10 PSTs for the validity of the data collection tools. Also the triangulation of methods was used for the validity of the data (Cohen & Manion, 1994). Furthermore quotations from the PSTs’ answers were presented in the findings.

One of the techniques is the WAT which is used to determine of the students' cognitive structure and between these concepts bonds, in other words networks of the PSTs to display and whether relationships between concepts is sufficient in the long-term memory also whether it is meaningful to determine (White & Gunstone, 1992; Bahar, Johnstone & Sutcliffe, 1999; Sezen & Çimer, 2009). The firstly, the WAT was applied to the sample of this study. After than respectively; open-ended questions, drawing questions, two-tiered test and the interview about concepts questions were applied:

1. Before the application of the WAT has been described to teachers and a pilot application has been made. After than the papers which are human eye concept is written 15 times sub-sub was given to PSTs. Writing of themselves words evoking “human eye” word were asked to the PSTs.
2. The WAT was used to determine words of the PSTs related to human eye. Following four keywords were asked to the PSTs: “human eye”, “human eye defects”, “its treatments” and “the vision”. The each of the words was completed in 30 seconds by the PSTs. After the PSTs completed their sentences related to their words.
3. The secondly, the PSTs completed 15 open ended questions on the structure of human eye, 11 open ended questions about human eye defects. The thirdly, the PSTs completed 2 drawing questions related to human eye defects

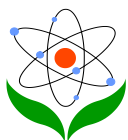


(hypermetropia and myopia) and 2 drawing questions related with its treatments and 1 two-tiered and drawing questions with vision in the lens and mirror. Two tiered question was selected from previous study done (Chen, Lin & Lin, 2002; cited by. Şahin, İpek & Ayas, 2008) and then adapted by Şahin, İpek and Ayas (2008) for a Turkish context.

4. The PSTs completed the open ended, drawing and two tiered questions in 40 minutes.
5. After reviewing of the PSTs' drawings, were interviewed about the concepts with 10 PSTs who have true, alternative drawings and no drawings. After the PSTs experienced mammalian eye dissection, interviewed about the concepts with 10 PSTs. The PSTs examined the structure of human eye, but the knowledge about human eye defects and its treatments were not given to the PSTs. The interview about concepts questions were carried out at 15-20 minutes with each of the PSTs. In the interview about concepts, human eye defects, the cause of human eye defects, its treatments, learning difficulties and suggestions for facilitating learning of the PSTs were asked to the PSTs.

Data Analysis

1. The result of the WAT, the frequency of the PSTs' words were grouped based on the just true propositions of the PSTs from highest to lowest frequency notwithstanding the wrong propositions of the PSTs. Preparing the networks cut-off point was taken as 0-7 below of the maximum number of the words were established correct link for the keywords (Bahar et al., 1999). The networks were used to comment about the understanding of related to the topic of the PSTs. The WAT data was analyzed qualitatively. The networks were composed of the data obtained from the WAT. The repetition frequencies of the PSTs' words were calculated.
2. The data obtained from open ended questions with structure of human eye were analyzed descriptively, coded as True (T), Partial True (PT), Alternative Concepts (AC) and Blank (B) and its frequencies were calculated. The data obtained from open ended questions with the description and treatment of human eye defects were coded as True (T), Alternative Concepts (AC) and Blank (B) and its frequencies were calculated.



3. The data obtained from PSTs' drawings on human eye defects and its treatments were analyzed descriptively. The data were coded as True Drawing (TD), Alternative Drawing (AD) and No Drawing (ND) themes and its frequencies were calculated. The quotations referring to the insufficient knowledge or alternative drawings of the PSTs were cited for the validity of the data.
4. The data obtained from the interview about concepts were analyzed contently. The PSTs' statements were coded and these statements describing excerpts were presented. The PSTs who participated in the interviews about concepts were coded as A, B, C, D, E, F, G, H, I and J.

Findings

The findings obtained from the word associated test

According to the result of the WAT, the detailed frequency table of the created networks is presented in the Appendix 1. The PSTs' numbers of answer words about keywords "human eye, human eye defects, its treatments, vision are presented in the Table 1:

Table 1. The numbers of the PSTs' first three answer words according to cut-off points and their total answer words

The keywords	Numbers of the total answer words (N=34)	The PSTs' the answer keywords					
		14-up Cut-off point		7-14 Cut-off point		0-7 Cut-off point	
Human eye	42	Fovea	30	Myopia	21	Hypermetropia	19
Human eye defects	13	Myopia	22	Hypermetropia	21	Astigmatism	18
The treatment of human eye defects	15	Operation	19	The concave lens	17	The convex lens	16
Vision	27	Fovea	11	Human eye	8	Optic nerves	8

In the Table 1 it is seen that the PSTs stated the most often the fovea, myopia, hypermetropia for human eye keyword in the first three. The PSTs stated the most often the myopia, hypermetropia and astigmatism words for human eye defects keyword. According to cut-off point 14-up, the PSTs stated the most often fovea word for both human eye and vision keywords. The PST stated as answer "human eye" keyword for "vision" keyword. They associated human eye with vision words.

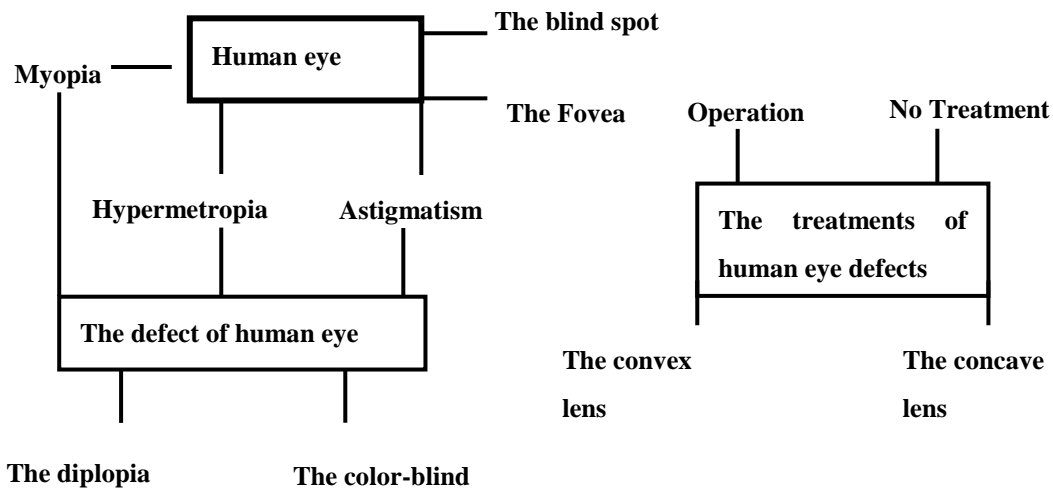
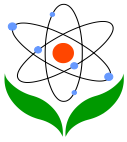


Figure 1. According to the results of the WAT is first and maximum connection, preparing the networks (Cut off point 14-)

When Figure 1 was examined it is seen that the PSTs associated human eye and its defects keywords. The PSTs stated words are operation, the convex and concave lenses and no treatment for “the treatments of human eye defects” keyword. It is seen that the PSTs did not stated any word for “vision” keyword at the 14-up cut-off point.

When Figure 2 was examined it is seen that the PSTs associated “human eye” and “vision” keywords. The PSTs stated word is cylinder lens for “the treatments of human eye defects” keyword. PSTs stated words are the presbyopia, cataract and glaucoma for “human eye defect” keyword among 7-14 cut-off point.

In the Figure 2, repeated words in the first cut-off point (14-up) was symbolized with black, repeated words in the second cut-off point (7-14) was symbolized with red.

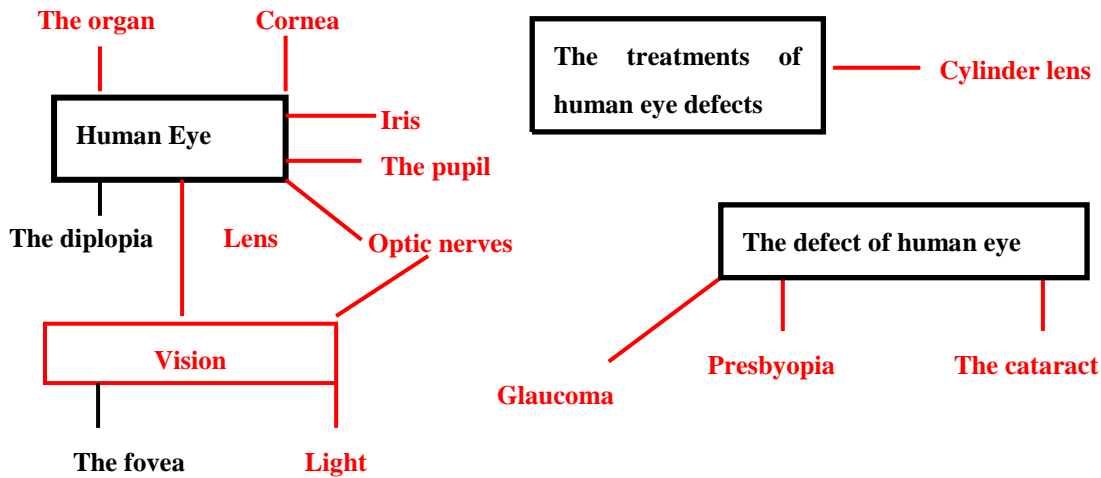
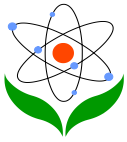


Figure 2. According to the results of the WAT is second and medium connection, preparing the networks (Cut off point 7-14)

In the Figure 3, repeated words in the first cut-off point (14-up) was symbolized with black, repeated words in the second cut-off point (7-14) was symbolize with red and repeated words in the third cut-off point (0-7) was symbolized with green.

When the third cut-off point was examined it is seen that the PSTs stated the mostly words related to the structure of human eye, vision, the auxiliary bodies, human eye defects and its treatments words in the third cut-off point. Also in the third cut-off point it is seen that the PSTs associated all of the keywords with each other.

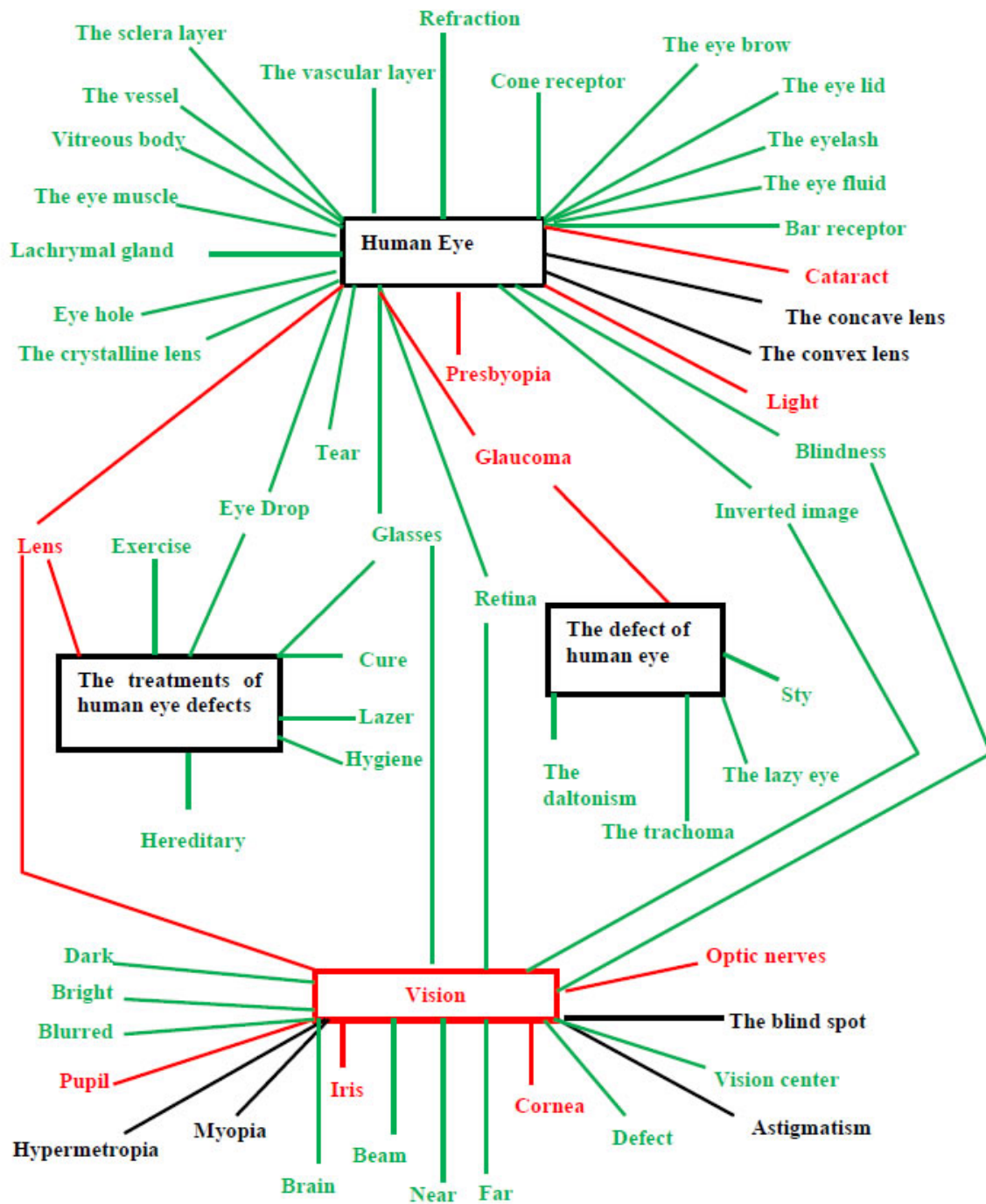
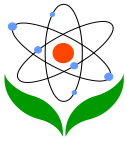
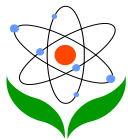


Figure 3. According to the results of the WAT is the lowest connection, preparing the networks (Cut-off point 0-7)

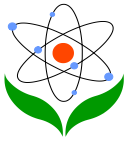


The findings obtained from the open ended questions

Table 2. The frequencies of the findings obtained from the responses of the PSTs about the structure of human eye and the quotes from their views

Questions	T	PT	AC	B	The quotes from expressions of the PSTs which consisted of Alternative Concepts (AC)
Q1. Which are layers in the structure of human eye?	23	2	9	-	Front, middle, rear layers.
Q2. What is the function of these layers?	3	11	9	11	It has a function such as refracting light. The nervous layer nourishes the eye.
Q3. Where is cornea? What is the function of the cornea?	14	3	9	8	The cornea allows seeing.
Q4. Which layer underwent a change and formed cornea?	8	-	17	9	Occurs by a change of the nervous layer.
Q5. Where is iris located? What is the function of iris?	5	10	14	5	It is located in the outermost layer. It is found in nervous layer. It is below the nervous layer. Iris gives color to human eye.
Q6. Which layer underwent a change and formed iris?	6	-	19	9	It was formed with the change of the cornea. It was formed with the change of the outermost layer. It was formed with the change of the nervous layer.
Q7. Where is the pupil located? What is the structure of the pupil like?	2	13	11	8	It is behind the ocular lens. It is in the nervous layer.
Q8. What is the reason for the pupil's being black with everyone?	4	10	5	15	Black absorbs light better. To differentiate dark and light colors
Q9. What is the factor which is effective for the pupil to be sometimes small and sometimes large?	24	7	2	1	It expands when you get a fright.
Q10. In what area of human eye is the crystalline lens located?	4	4	19	7	It is between the iris and the pupil. It is located in the outer layer. It is found on the pupil. It is between the cornea and the iris.
Q11. What kind of lens is crystalline lens? Why? Please explain.	18	-	9	7	It is a concave lens.
Q12. What is the function of crystalline lens? Please explain.	8	15	5	6	It absorbs light and it enables its transfer to the fibrous-nervous-vascular layer and blind spot.
Q13. Where is blind spot located?	23	-	4	7	It is behind the eye, above the fibrous layer.
Q14. Where is fovea located?	11	9	9	5	It is located in the posterior chamber of human eye.
Q15. How does vision occur? Which way is light follow when light entered human eye?	7	2	21	4	"Cornea, iris, crystalline lens, pupil, blind spot" "Cornea, crystalline lens, pupil, yellow spot, blind spot"

In Table 2 are shown that the frequencies of the responses of the PSTs about the structure of human eye, the functions of these parts and the way the light follows during vision. It was revealed from the quotations of the PSTs that their explanations consisted of insufficient knowledge in the each question. The PSTs



mostly could not answer the questions which were about the reason why the pupil is black with everybody, and what kind of lens is crystalline lens.

Table 3. The frequencies of the findings obtained from the responses of the PSTs about human eye defects and its treatment

The defects of human eye	Description of human eye defects (N=34)			The treatment of human eye defect (N=34)		
	T	AC	B	T	AC	B
Hypermetropia	22	10	2	20	12	2
Myopia	22	11	1	22	12	-
Astigmatism	23	4	7	9	6	19
Diplopia	20	8	6	15	3	16
Presbyopia	15	4	15	8	6	20
Color blindness	31	2	1	25	2	7
Cataract	4	14	16	18	3	13
Lazy eye	4	14	16	18	3	13
Daltonism	3	-	31	1	-	33
Glaucoma	2	1	31	-	-	34
Trachoma	-	1	33	-	-	34

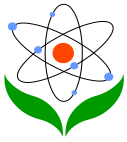
When Table 3 is examined, while the PSTs were describing human defects as myopia, hypermetropia in this parallel they could answer the treatment methods of human eye defects at the same rate. But they could not answer the question about human eye defects such as trachoma and glaucoma.

The findings obtained from the PSTs' drawings

The findings obtained from the PSTs' drawings were presented at below.

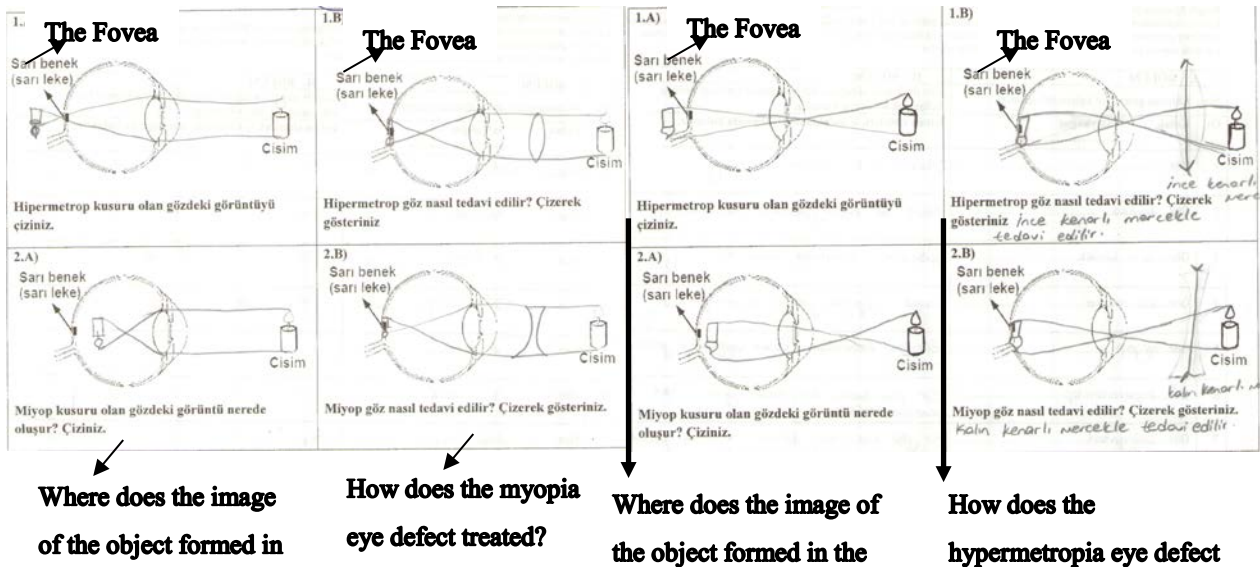
Table 4. The findings obtained from the PSTs' drawings about human eye defects and its treatment

The defects of human eye	Description of human eye defects (N=34)			The treatment of human eye defect (N=34)		
	T	AC	B	T	AC	B
Hypermetropia	22	10	2	20	12	2
Myopia	22	11	1	22	12	-
Astigmatism	23	4	7	9	6	19
Diplopia	20	8	6	15	3	16
Presbyopia	15	4	15	8	6	20
Color blindness	31	2	1	25	2	7
Cataract	4	14	16	18	3	13
Lazy eye	4	14	16	18	3	13
Daltonism	3	-	31	1	-	33
Glaucoma	2	1	31	-	-	34
Trachoma	-	1	33	-	-	34



Just 10 PSTs could draw myopia, hypermetropia eye defects and its treatments correctly. The drawings exemplifying statements were presented at the Figure 4:

Figure 4. The true drawing of the PSTs



When was examined in the Figure 5, it is seen that the some PSTs confused hypermetropia and myopia eye defects. They drew instead of myopia hypermetropia. The quotations of the PSTs' drawings were presented at the Figure 5.

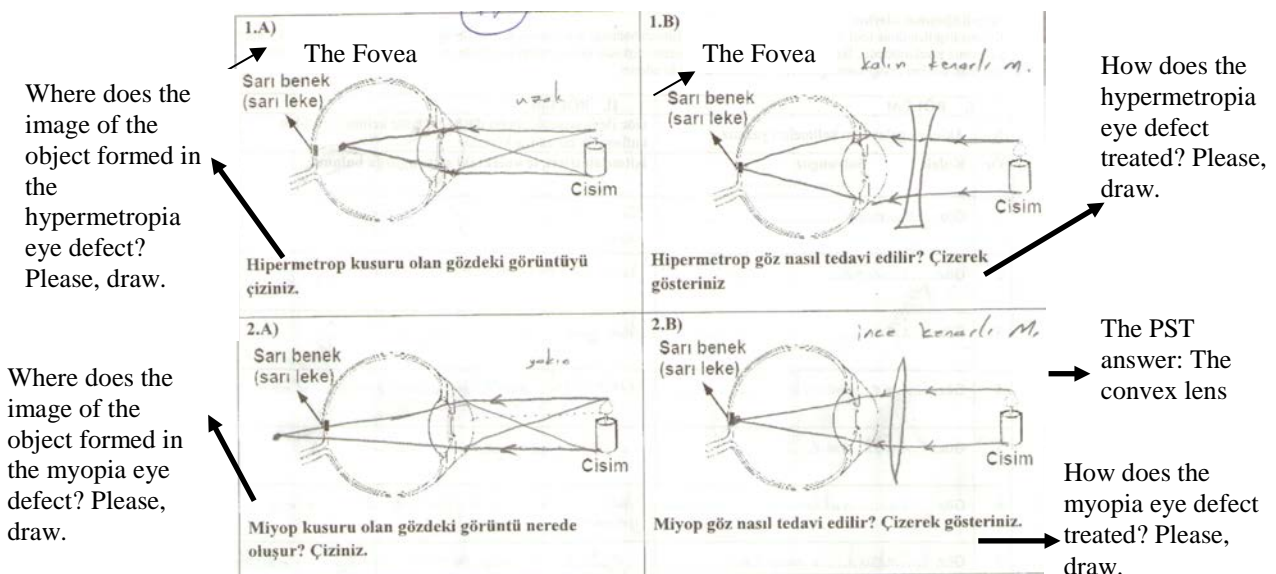
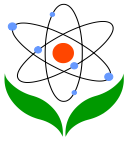


Figure 5. The false drawing which the PSTs confused the hypermetropia, myopia eye defects and its treatments



In the Figure 6 is seen that the mistakes in the PSTs' human eye defects drawings stems from not only the location of the image according to fovea but also drawing of the lenses and do not knowing of the refraction laws in the lenses. These findings related with an example of drawing are presented at the Figure 6:

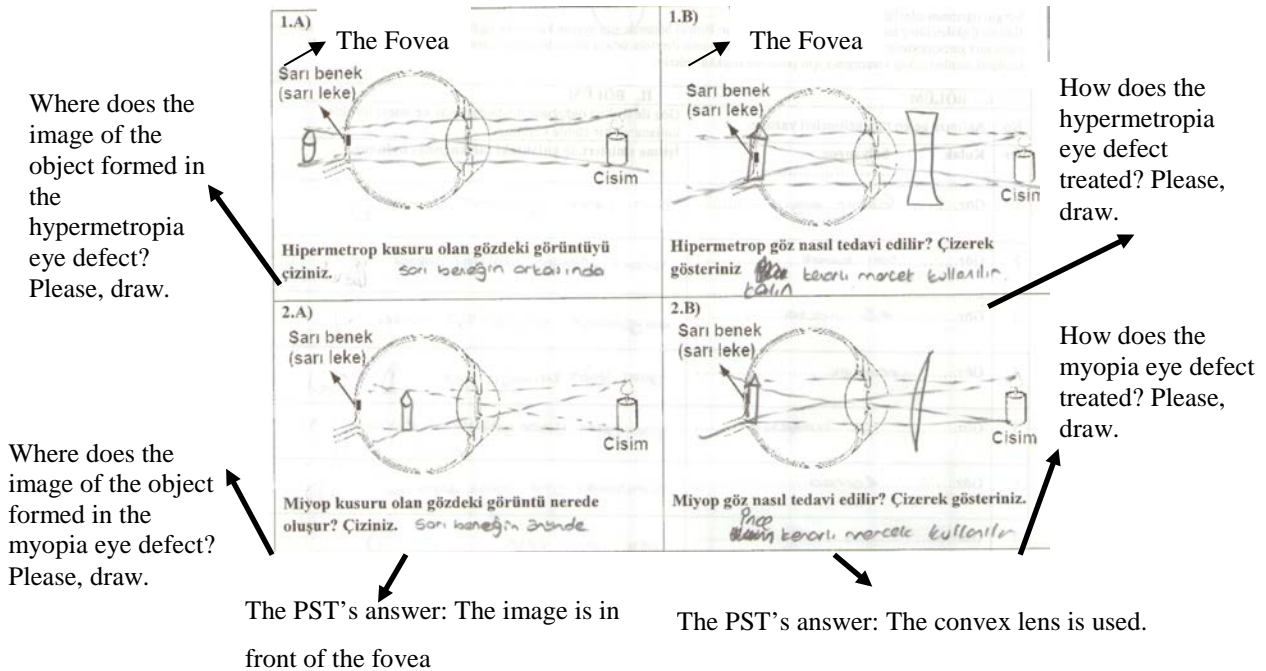


Figure 6. The image is straight and the usage of these lenses is incorrect for the treatment of the eye defects

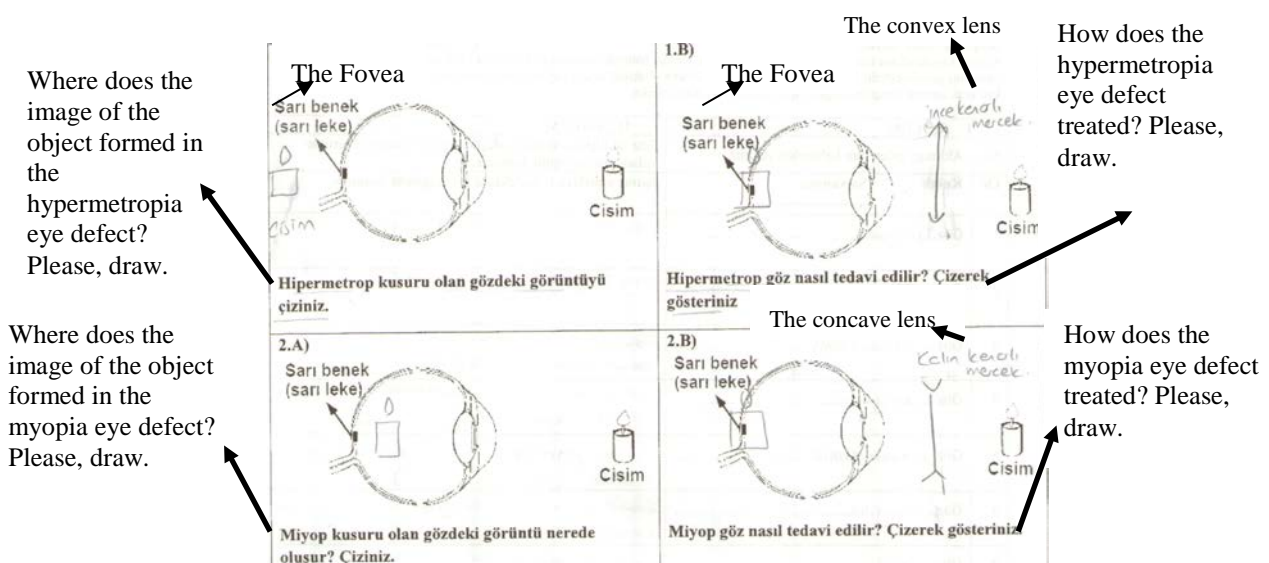
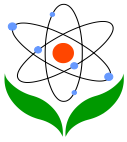


Figure 7. The alternative drawing of the PSTs



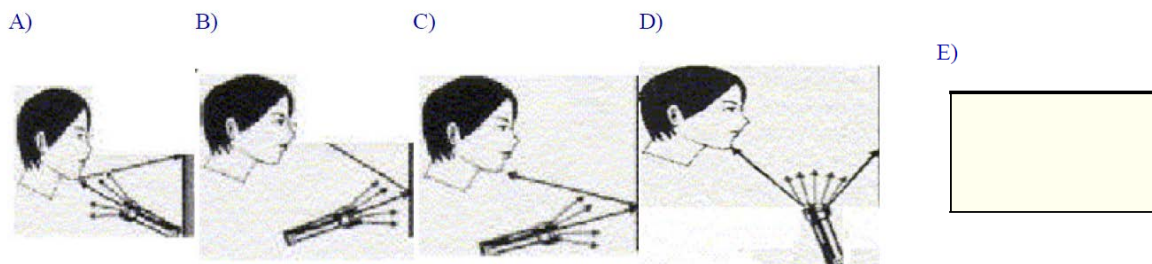
In the Figure 7 is seen that image is straight in the behind and in front of the fovea, whereas the image must be inverse. For the treatments of human eye defects, the lenses were selected correctly but light beams were not drawn. Although the image of object is straight, the location of image is correct.

The findings obtained from the one two tiered-question

The findings obtained from the PSTs' answers to the two-tiered question were presented at below. Question: A mosquito bites Ahmet's chin at midnight. Ahmet wants to see where the mosquito has bitten. Ahmet immediately finds a flashlight and mirror. If he wants to see his chin in the mirror very clearly. How should he hold the flashlight?

- A) He should hold the flashlight to the mirror.
- B) He should hold the flashlight to his chin.
- C) He should hold the flashlight parallel to the mirror.
- D) He should hold the flashlight straight to the mirror.
- E).....

Qii. Which one of the diagrams below perfectly explains your idea? If none of the diagrams explains your ideas. Draw your diagram in the box E.



When were examined answers of the PSTs related with two-tiered question, 13 PSTs stated that it is necessity Ahmet should hold the flashlight to his chin for seeing where the mosquito has bitten. But only 2 PSTs could draw the second phase of the question correctly. The drawings exemplifying statements were presented at below:

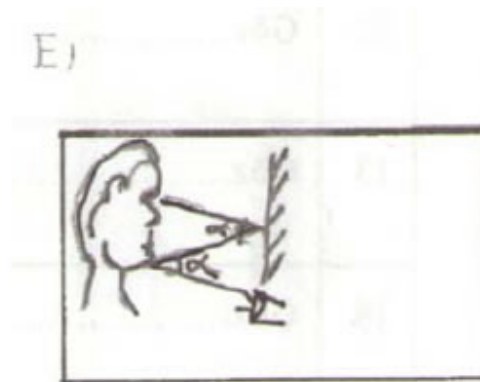
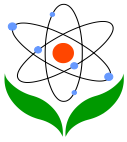


Figure 8. The true drawing of the PST

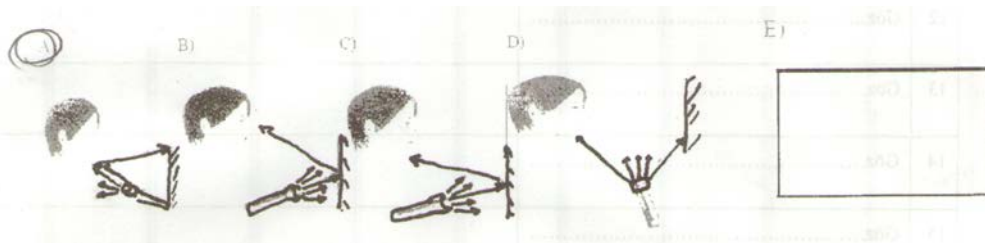


Figure 9. The selection of the other PSTs

Twenty one PSTs stated that these statements are incorrect such as Ahmet should hold the flashlight to the mirror, the flashlight parallel to the mirror, the flashlight straight to the mirror for seeing where mosquito has bitten. In parallel of this case, they marked false to the second phase of this question.

“How the image of the object is formed among focus of peak in the convex lens? Please draw.” drawing question only 1 PST could draw correctly. But he stated that image of object formed at infinity we cannot see it. Also he did not draw vision, he could draw image in the convex lens. The other PSTs drew the image of object incorrectly. The examples of the PSTs’ drawings were presented at the Figure 10 and 11.

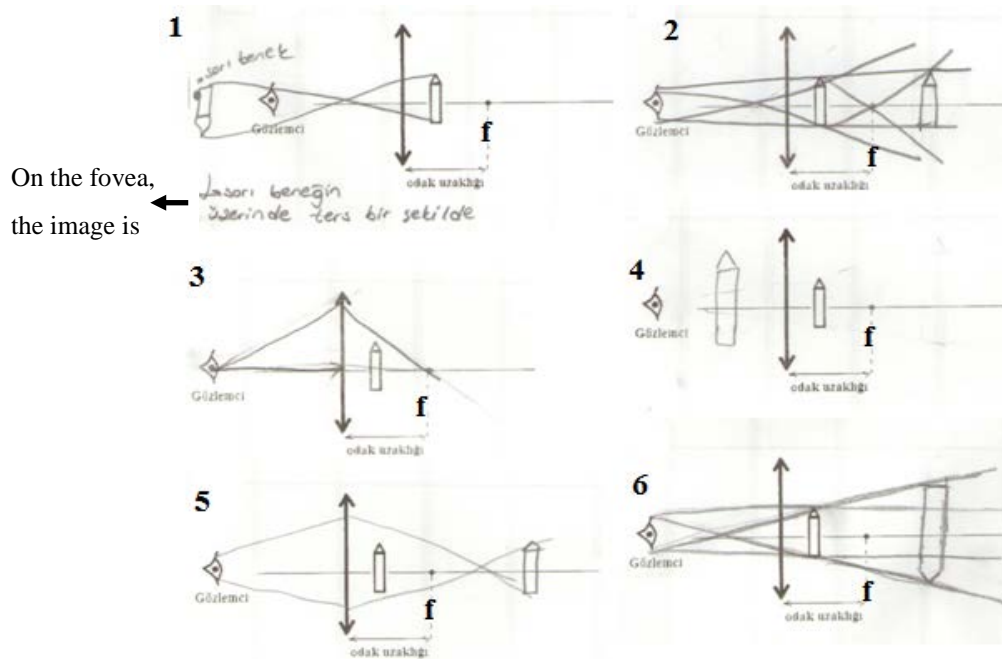
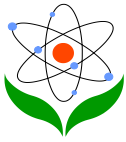


Figure 10. The alternative drawings of the PSTs The selection of the other PSTs

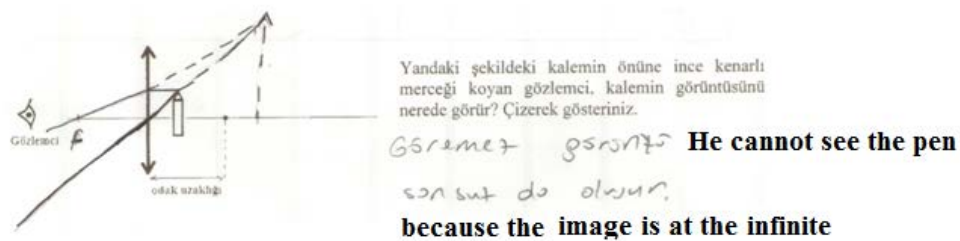


Figure 11.The drawing is insufficient and the explanation of the PST is false

The findings obtained from the interview about concepts

The findings obtained from the interviews conducted with the selected 10 PSTs with were presented at below:

When Table 5 was examined is seen; although A coded PST stated the location of the image and using lens for treatment of the eye defect correctly, but he stated the cause of the eye defect and vision problem which myopia cannot see near incorrectly.

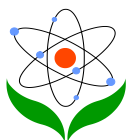
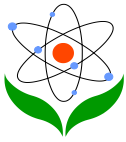


Table 5. The findings obtained from the interview about human eye concept

Themes	The PSTs and categories of their answers			The Alternative concepts of the PSTs
	T	PT	AC	
The vision in the Myopia and Hypermetropia	D, E, F, G, H, I, J	-	A, B, C	1. “Someone has hypermetropia cannot see distant clearly. Someone has myopia cannot see near clearly” (A,B,C)
				2. “The crystalline lens acts as a concave lens.” (A,I)
According to the fovea, the location of the image	A, D, E, F, G, H, J	-	B, C, I	3. “The concave lens was used for treatment of the hypermetropia and the convex lens was used for the treatment of the myopia.” (B,I,J)
The selection of the lens for treatment of human eye defects	A, D, E, F, G, H, J	-	B, I	4. “The cause of the hypermetropia and myopia may be caused from the problem in the pupil.” (C)
				5. “The myopia can be caused from contraction of the eye muscle at the behind. If the eye muscle in the behind is long may cause to hypermetropia.” (D)
The causes of the myopia and hypermetropia eye defects	-	F, G, H	A, B, C, D, E, I, J	6. “The cause of the hypermetropia and myopia may be caused from the problem in the cornea.” (E)
				7. “The eye is swollen in the myopia and principal axis is extended, in the hypermetropia principal axis is extended.” (I)
				8. “In my opinion the pupil is a structure as head of fastener. I surprised when saw the pupil is space in the middle of the iris.” (D,F,H,I,J)

I coded PST stated the problem of the eye defect which cannot see near/distance correctly, but he stated the location of the image, using lens for treatment of the eye defect and the cause of the eye defect incorrectly.

F, G, H coded PSTs stated the eye defect, the vision problem, the location of the image and using lens for its treatments correctly. They explained the causes of the eye defects partially correct. The statement of G coded PST “...*the refractive index of the crystalline lens is disrupted and the image occurs in different places from the fovea. The flexibility of muscles in the crystalline lens may be disturbed. It may*

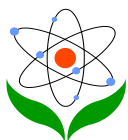


cause from congenital. The crystalline lens swells and its refractive increases...” is example to the partial correct explanation.

PSTs stated 1 and 3 numbered alternative concepts often in the Table 5. The PSTs confused myopia with hypermetropia each other. For example; B coded PST stated as *“Someone has hypermetropia cannot see distant. The image form in front of the fovea, for reaching to the fovea of the image is necessity the light beams must be fracture with concave lens removing. The cause of the hypermetropia is that refractive index of the crystalline lens is higher than normal. Someone has myopia cannot see near. The image form in the behind of the fovea, for focusing to the fovea of the image must be used convex lens. The cause of the myopia is that refractive index of the crystalline lens is thinner than normal. So refractive index of the crystalline lens is lower than normal.”*

Table 6. The learning difficulties of the PSTs obtained from the interview about human eye concept

Themes	According to the PSTs, The Understanding Difficulties of the PSTs	The PSTs
To confuse	“I confused because Latin is called myopia and hypermetropia, I'm drawing the first shape I remembered.”	A, E, I
To Memorize	“I do not memorize the names of its”	B, C, I
	" I forget what I memorized because I do not repeat continuously"	C
	“I do not memorize the vision, the ray of the light follow”	H
To be unrelated	“I have no interest in physic. I'm trying to memorize how refracting occur in lenses, but then I forget it”	C
To associate interdisciplinary		C,
To draw	“I know that the image occur in front of the fovea, image is reverse, but I do not draw to image. I have problem in the drawing.”	D, I
To establish cause-effect relationship	“I know the eye defects, but I do not know the cause of the eye defects. So I'm having trouble, I do not associate to different case.”	F, I
To use language	“The words are different in daily usage of language life may cause to learning disability.”	G
To understand human eye structure	“I do not distinguish the fovea, blind spot and vitreous body.”	B
	“I confused which layer underwent a change and formed cornea, retina or fibrous layers”	B

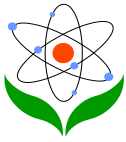


	“Although the crystalline lens is same objects, how it perceives different objects at different distances? This I do not understand.”	B
	“We say the vision of the objects is related to the pupil, the pupil grows and shrinks it adjusts the amount of light. What is the task or relevance of the lens for occurring of the image? I do not understand”	B
	“I confuse and use instead iris of retina.”	H
	“I do not memorize the vision, ray of the light follow”.	H
	“I do not know human eye structure exactly.”	H, I
	“Do not anything in the pupil? What is anything else in the blind spot? Only do nerves walk out form the blind spot?”	J

G coded PST stated that he has no problem with his statement as “I have no problem I’m learning associating with lenses. Also I have the myopia defects, so I do not forget it...” J coded PST stated that she has no any problem with her statement as “Before I do not remember which lens used for treatment of the eye defects. But my brother told a codification “KUM” (Turkish means of KUM is sand in English) code are “K” the concave lens (concave lens is read as Konkav lens in Turkish), “U” cannot see distance (means of distance is as Uzak in Turkish), “M” Myopia eye defect (myopia is read as miyop in Turkish). Also, the name of hypermetropia is long and the image occurs in the behind of the fovea. I coded as that.”

Table 7. The suggestions of the PSTs obtained from the interview about human eye concept

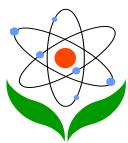
Themes	The suggestions of the PSTs	The PSTs
To associate	“Using from lenses I am trying to detect the eye defect.”	B
	“I have myopia and I associate myopia with myself.”	G, I
	“I do not confuse when I associated with my friends’ the eye defect”	
To understand	“In fact, if I find a clue may be permanent”	E
	“Latin names must be learned with Turkish means.”	G
	“Make coding facilitates learning.”	J
To memorize	“After the interview I’ll be gone thoroughly memorized, too embarrassed”	D
	“Eye defects should be repeated once a year.”	G
To take care	“I wish I am interest in it at that time I do not forget”	C



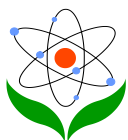
The PSTs' proposals to overcome learning challenges are presented in Table 7. The PSTs offered suggestions such as to associate, understand, memorize and take care in the various themes.

Results and Discussion

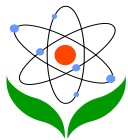
When words in the networks are examined it has been seen that PSTs usually used interrelated concepts such as human eye (fovea, blind spot, myopia, hypermetropia, astigmatism), human eye defects (myopia, hypermetropia, astigmatism), treatments of the eye defects (operation, concave and convex lenses, no treatment), vision keywords (the fovea, human eye, optic nerves, light). But they used words related to human eye structure as the sclera and vascular layers, vitreous body slightly. Also in the open ended questions, it was seen that the PSTs knew the location of the sclera very well but they had difficulties in determining the location of the fibrous and the vascular layers. Although the PSTs responded about the location of these layers correctly, the responses of them about the functions of the layers do not show parallelism. This situation can be explained by the fact that the PSTs do not have sufficient knowledge about the functions of the layers of human eye. Also in the interview about concepts that is determined the PSTs stated that do not know the structure of human eye exactly. They explained the cause of that as they are trying memorizing learning. When the responses of the PSTs about the cornea are examined, nearly half of the PSTs know the location of the cornea both in the WAT and open ended question. But, they do not possess the knowledge that the cornea formed when the sclera layer underwent a change. Although some PSTs know the features and the location of the iris, it is revealed that they do not possess the knowledge that the iris formed with the changes in the vascular layer. They explain function of the iris color give to human eye. They don't aware of iris provides growth and shrinkage of the pupil depending on the amount of light. Although the PSTs repeated medium frequencies in the WAT, the PSTs' lack of information about the structure of the pupil draws attention in the open ended questions. Only 2 PSTs stated that the pupil is hole in the middle of the iris. The other PSTs stated as pupil is in the middle of the iris superficially. Unfortunately, PSTs stated that they surprised when they saw that the pupil is hole in the middle of the iris in the interview. These findings supported to each other. The most of the PSTs having alternative concepts about the pupil state that the pupil is on the lens, behind the iris etc. Nearly most of the PSTs could not answer this question correctly. Similarly, in the interview the PSTs stated that they confused the ranking of organs in the eye. However, the PSTs could answer the question about pupil's getting sometimes



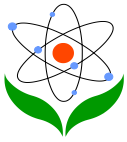
wider or sometimes narrower correctly with the light factor entering the pupil. The PSTs' explanation of the pupil's getting sometimes wider or sometimes narrower can be explained with the fact that the expansion and contraction of the pupil is frequently used in daily life because associating science concepts to daily life and their use in daily life is quite effective to learn the concept (Saka et al., 2002; Ünal & Coştu, 2005). In the interview, some PSTs stated learned associating and some PSTs stated that do not understand because they do not adapt to different cases. Similarly, nearly the half of the PSTs could not know that the crystalline lens is a convex lens. They also could not explain the function and location of the crystalline lens. In the WAT, is seen that the PSTs answered the crystalline lens word in the lowest cut-off point. Also the results of the interview are supported to this case. Rule and Welch (2008), benefited from analogy to teach the theoretical underpinning of the activities, to support elementary student learning about the structure and function of the eye. B coded PST stated that they could not understand the relationship between the lens and vision. The PSTs do not know to the refractive index of the crystalline lens can be changeable. This case is interpreted that the some PSTs possessed poor background and lack of knowledge on the crystalline lens. The some PSTs stated that the crystalline lens acts as concave lens and the some PSTs believed that the sometimes the crystalline lens acts as concave lens, the sometimes acts as convex lens. This situation can be explained with the fact that the PSTs could not construct the refraction of light through lenses in their minds. In this case is explained that the PSTs do not know the focal length of the crystalline lens can be changeable. Moreover, this situation can be interpreted as the result of the PSTs did not associate the lenses subject to the daily life while learning them in the physic course. There are realistic models elucidating the changing the focal length of the crystalline lens in the literature (Mullin, 1996). Also Dilek and Sahin (2013) suggested a teaching activity provides a context for the basic principles of image formation in thin converging lenses. So, in their class activity concerned with real image formation by a converging lens in the context of accommodation in human eyes is described. In the first part of the activity, students are encouraged to experience the accommodation of their eyes in a prescribed way using simple materials. In the second part, the accommodation function of human eye is illustrated by means of a simple demonstration. Dilek and Sahin (2013) associated geometric optic with working of human eye in their study. Ahçı (2012) in his study determined that the university students could not draw the formation of the image through convex lens, and they possessed insufficient knowledge such as the individual who is farsighted should use concave lens and the individual who is short-sighted should use convex lens. Thus, the PSTs take optics



course in the undergraduate 2nd grade, as well as they acquire the theoretical knowledge about the refraction of light through lenses and practice skills (URL-2, 2013). Half of the PSTs stated correctly in what area of human eye are the macular area (fovea) and the blind spot located. Similarly, in the WAT the PSTs answered the fovea and blind spot at high frequency. Most of the PSTs could not answer the question about the route the ray follows when entering human eye and again. This situation results from the fact that the PSTs do not know the structure of human eye very well. Even though the PSTs acquired some similar knowledge about human eye from the primary education to university education, they were not able to answer these questions correctly. The reason for their not being able to answer them could be that either learning was not attained or the students memorized the knowledge without constructing it in their minds (Koray & Tatar, 2003). Already the PSTs stated that do not know structure of human eye exactly and they learned memorizing. Similarly, Glynn and Duit (1995) stated that students may think one thing but verbalize another because of memorized facts (cited by Rule & Welch, 2008). “*Student ideas that differ from scientific explanations may reappear after instruction if the teacher does not directly address them. These mental models are unique and individual, but often they have inconsistencies*” (Rule & Welch, 2008). In this context, the teachers are vital to provide meaningful teaching. When the PSTs’ responses to the questions about human eye defects and its treatment were examined, it is revealed that they possessed a higher rate of correct information about human eye defects and its treatment such as hypermetropia, myopia, astigmatism and diplopia which are commonly known among the public. However, they do not know human eye defects such as *amblyopia (lazy eye)*, presbyopia, glaucoma, and trachoma very well. In parallel with this, only 3 PSTs could answer the question “what is eye defect which is also expressed as daltonism?” correctly but 31 PSTs could not answer it. However, when this question is asked using the term “color blindness”, commonly used in the socio-linguistic perspective, nearly all of them could explain the causes of the color blindness correctly. The socio-linguistic perspective in education has led to a wide recognition of the role of language in learning science (Kaur, 2012). The daltonism eye defect (the color blindness) must be taught formally in the 7th grade Science and Technology course curriculum in the primary education (MNE, 2006b). So, that the PSTs’ knowing that daltonism is color blindness is important and essential for their future careers. This condition can be explained with the PSTs’ perceptions concepts and events encountering in their daily life (Cerrah Özsevgeç, 2007; Şahin, 2013; Ünal & Coştu, 2005). Similarly the PSTs answered hypermetropia, myopia, astigmatism and diplopia defects as answer word the most often. They answered



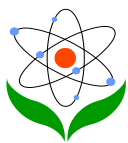
the other eye defects as daltonism, trachoma the lowest often. Rule and Welch (2008), emphasis on analogy and words with multiple meanings provides opportunities for integration with reading and language arts. Because is very important addressing students' misconceptions, the roles of analogy and vocabulary in science learning, the theoretical underpinning of the activities, and national standards that support elementary student learning about the structure and function of the eye. Also the PSTs could answer treatments of the hypermetropia, myopia, astigmatism defects correctly in the open ended questions. But they could not answer treatments of the other eye defects. Although the PSTs stated treatments of the hypermetropia and myopia defects in the open ended questions, most of the PSTs could not draw its. The PSTs drew instead hypermetropia of myopia defect and its' treatments. Although some PSTs could draw the eye defects correctly some PSTs could not draw its' treatments. These results are consistent with the research results of Ahçı (2012). Even though the image was drawn hypermetropia defect in the behind of the fovea, was drawn the concave lens for treatment (see Figure 5). These findings indicate the PSTs do not know the usage aims of the lens they memorize without establishing cause and effect relationships between concepts. It is possible students do not draw because they have not sufficient knowledge (Kara et al., 2008). In the interview about concepts, the PSTs stated that they could not associated interdisciplinary their physics and biology and could not adapted to different cases. Thus D coded PST stated that she embarrassed and after then interview she'll go home and memorize thoroughly. In interview about concepts, although 6 PSTs could explain the eye defects and its' treatments correctly, only 3 PSTs could explain the cause of the eye defect partial correctly. These PSTs explained the cause of the eye defect with "disrupting of the structure of the crystalline lens". But they did not stated change in the structure of the major axis of the eye. Although J coded PST explained the eye defects and its' treatments correctly, they stated the cause of the eye defects with the crystalline lens acts as concave lens. This alternative concept indicates that the PST does not know factors which affect the focal length of the lens. F, G and H coded PSTs constructed associating the eye defects with the feature of the lenses in their minds. G and H coded PSTs stated that they understood the eye defects and its treatments because of associating with themselves eye defect. J coded PST sad that he do not forget because of coding of the eye defects and treatments as KUM. It is seen that to make sense concept is very important to code, associate and establish cause and effect relationships. Similarly, Rule and Welch (2008) used object boxes to teach the form, function, and vocabulary of the parts of human eye and investigated the role of analogy and vocabulary in alleviating science misconceptions. Rule and Welch



(2008) determined that students learned better through analogies the form, function, and vocabulary of the parts of human eye in their study. Answers of the PSTs were examined in the two tiered question it is determined that they have problem on how is seeing. Even though PSTs aware of light must be to see any object they do not aware of the reflected light from the object must come to eye. Furthermore only one PST could draw accordance with refraction law of light in lens correctly. But he did not draw vision, he just could draw image in the convex lens. As well as elementary school 6th grade students' explanations in studies of Çiftçi & Çökelez (2012), the PST described "vision concept" with "image concept". Similarly, it is determined that to see and look are perceived as the same concept in some other studies (Galili & Hazzan, 2000; Heywood, 2005, Şahin, İpek & Çepni, 2008). That PSTs do not know refraction of light in the convex lens caused they do not answer to where and how the image is formed in the between focus and peak of convex lens. Similarly, Ahçı (2012) determined that university students did not draw the image of the object between the lens and the focus in his research. This case is interpreted that the PSTs' lack of knowledge in a discipline would be affected to learn another discipline directly. But learner with a specified prior knowledge with the subject matter and these knowledge may not be easily transferable to a different setting (Kaur, 2012). Saka et al., (2002) determined that high school students do not have sufficient knowledge on forming of image in human eye. In this context, when teaching geometric optics, human eye has great potential as a relevant context to engage students' interest (Dilek & Sahin, 2013). The results of this study support Kaur's results of her/his studies (2012), which "students even at the level of teacher preparation courses may not always be able to clearly articulate and analyze their own thought processes and need help to be able to do so".

Consequently the PSTs;

1. Do not know the structure human eye in detail. And they have lack of knowledge on human eye.
2. Memorize without understanding the structure of human eye (Human eye layers, the pupil, the fovea, the blind spot etc.), human eye defects and its treatments.
3. Have confusing between concepts such as the hypermetropia-myopia, the fovea-blind spot, the vascular-nervous-fibrous layers, location of the iris-pupil-cornea, the function of the vascular-nervous-fibrous layers, the function the pupil-iris, the function of the pupil- crystalline lens, followed way of light when light entered human eye etc.

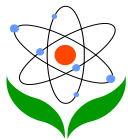


4. Do not know the cause of human eye defects and do not associate the cause of human eye defects and vision with refracting in the lens is studied at the optic course.
5. Could explain human eye defect and its treatments verbally, but they have the problem drawing.
6. The PSTs to be unrelated to physics course will affect their achievement in biology course negatively.
7. Not only the PSTs emphasis as the solution to overcome their learning difficulties, associating between concepts and learning meaningful but also memorizing.

This study draws attention on the potential lack of knowledge and insufficient knowledge encountered while teaching human eye. The result of this study is believed to contribute to the PSTs' probing understanding on human eye and their learning and offer discernment to the teaching process of teachers and researchers.

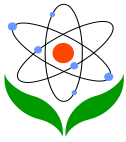
Suggestions

1. Before teaching the structure of human eye to the PSTs or dissection of the mammalian eye, the questions used in this study can be asked and curiosity can be raised to examine and learn the eye with the PSTs and their motivation can be ensured.
2. In this study was used different probing understanding methods and techniques could be used for investigating alternative concepts or background of the students related to another science concepts.
3. Within the teaching process, it is suggested that the teachers and lecturer should enable the students to make associations between the different disciplines. Moreover, while teaching human eye, an attention must be paid to associate it with the science and technology, society and environment. Therefore, the PSTs and students can be encouraged to learn knowledge about the treatment of human eye defects.
4. However, the study has some limitations in providing concrete evidence about any teaching activity the paper is a survey. For this reason, to investigate effects of any teaching methods or techniques in a comparative manner (experimental research design), further research should be undertaken. When such studies are prepared, lack of knowledge and alternative concepts of the PSTs determined in this research might be taken into consideration.

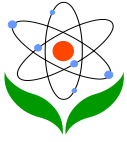


References

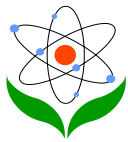
- Ahçı, M. (2012). *University students' conceptual understanding about the subjects of light and optics*. MSc Thesis, Balıkesir University Institute of Science Secondary Science and Mathematics Education, Balıkesir. (In Turkish).
- Bahar, M., Johnstone, A.H. & Sutcliffe, R.G. (1999). Investigation of students' cognitive structure in elementary genetics through word association tests. *Journal of Biological Education*, 33, 134-141.
- Cerrah Özsevgeç, L. (2007). What do Turkish students at different ages know about their internal body parts both visually and verbally? *Journal of Turkish Science Education*, 4(2), 31-44.
- Cohen, L. & Manion, L. (1994). *Research Methods in Education*, 4th Edition. Routledge, London, England.
- Çiftçi, S. & Çökelez, A. (2012). *İlköğretim 6. sınıf öğrencilerinin 'görüntü kavramı' ile ilgili kavramsal öğrenmelerinin incelenmesi*. Presented Paper in the X. National Science and Mathematics Education Congress. (In Turkish).
- Dekkers, P. J. J. M. & Thijs, G. D. (1998). Making productive use of students' initial conceptions in developing the concept of force. *Science Education*, 82(1), 31-51.
- Dilek, U. & Sahin, M. (2013). Investigating accommodation using eyes and lenses. *Physics Education*, 48(2), 193-198.
- Driver, R. & Easley, J. (1978). Pupils and paradigms: a review of literature related to concept development in adolescent science students. *Studies in Science Education*, 5, 61-84.
- Erginer, E. (2006). Yeni İlköğretim Programları Gerçekten Yapılandırmacı mı? Bir Fikir Taraması, *İlköğretmen Eğitimci Dergisi*, 4, 46- 47. (In Turkish).
- Galili, I. & Hazzan, A. (2000). Learners' knowledge in optic: interpretation, structure and analysis. *International Journal of Science Education*, 22(1), 57-88.
- Güneş, R.S. (2006). *Multiple intelligence basis education's effect on student's success, permanence and attitude of learned knowledge in primary school's 6th class students understanding the issue of five senses*. Master Thesis, Gazi University Institute of Educations Sciences, Ankara. (In Turkish).
- Havu- Nuutinen, S., 2005. Examining young children's conceptual change process in floating and sinking from a social constructivist perspective. *International Journal of Science Education*, 27(3), 259- 279.
- Heywood, D.S. (2005). Primary trainee teachers' learning and teaching about light: Some pedagogic implications for initial teacher training. *International Journal of Science Education*, 27(12), 1447-1475.
- Kara, İ., Erduran Avcı, D. & Çekbaş, Y. (2008). Fen bilgisi öğretmen adaylarının ışık kavramı ile ilgili bilgi düzeylerinin araştırılması. *Mehmet Akif Ersoy Üniversitesi Eğitim Fakültesi Dergisi*, 46-57. (In Turkish).
- Kaur, G. (2012). Drawing insights from cognitive science for a strengthened teacher preparation: Learnings from optics. *International Journal for Cross-Disciplinary Subjects in Education (IJCDSE)*, 3(2), 741-749.
- Koray, Ö. & Tatar, N. (2003). İlköğretim öğrencilerinin kütle ve ağırlık ile ilgili kavram yanılgıları ve bu yanılgıların 6.,7. ve 8. sınıf düzeylerine göre dağılımı, *Pamukkale Üniversitesi Eğitim Fakültesi Dergisi*, 1(13), 187-198. (In Turkish).
- Köse, S. (2008). Diagnosing Student Misconceptions: Using Drawings as a Research Method. *World Appl. Sci. J.*, 3(2), 283-293.
- Mausser, M. W. (2011). How to do it exploring the anatomy of your own eye. *The American Biology Teacher*, 73(1), 28-33.



- Ministry of National Education of Turkey (MNE), (2006a). *T.C. MEB Talim ve Terbiye Kurulu Başkanlığı, İlköğretim Fen ve Teknoloji Dersi (4 ve 5. Sınıflar) Öğretim Programı*. Ankara. Retrieved November, 1, 2012, from http://ttkb.meb.gov.tr/program2.aspx/?width=900&height=530&TB_iframe=true. (In Turkish).
- Ministry of National Education of Turkey (MNE), (2006b). *T.C. MEB Talim ve Terbiye Kurulu Başkanlığı, İlköğretim Fen ve Teknoloji Dersi (6 ve 8. Sınıflar) Öğretim Programı*. Ankara. Retrieved November, 1, 2012, from http://ttkb.meb.gov.tr/program2.aspx/?width=900&height=530&TB_iframe=true. (In Turkish).
- Ministry of National Education of Turkey (MNE), (2011). *T.C. MEB Talim ve Terbiye Kurulu Başkanlığı, Ortaöğretim 12. Sınıf biyoloji Dersi Öğretim Programı (3 Ders Saati)*, Ankara. http://ttkb.meb.gov.tr/program2.aspx/?width=900&height=530&TB_iframe=true at the 01.11.12 date was taken from the internet. (In Turkish).
- Mullin, W. B. (1996). The working of human eye III. *Physic Education*, 1, 276-278.
- Mutlu, M. & Özel, M. (2008). Preservice elementary teachers' understanding levels and misconceptions related to the grow and development of flowering plants. *Kastamonu Eğitim Dergisi*, 16(1), 107-124. (In Turkish).
- Novak, D. J. (1988). Learning science and the science of learning. *Studies in Science Education*, 15, 77-101.
- Ozay Kose, E. & Hasenekoglu, I. (2011). Misconceptions and alternative concepts in biology textbooks: Nucleic acids and protein synthesis. *Energy Education Science and Technology Part B*, 3(4), 403-410.
- Özay Köse, E. & Çam Tosun, F. (2011). Effect of "context based learning" in students' achievement about nervous system. *Journal of Turkish Science Education*, 8(2), 91-106.
- Özgür, S. & Çıldır Pelitoğlu, F. (2008). The investigation of 6th grade student misconceptions originated from didactic about the 'digestive system' subject. *Educational Sciences: Theory & Practice*, 8(1), 597-606.
- Oztas, F. & Oztas, H. (2012). Biology teacher candidates' alternative conceptions about human respiration and source of metabolic energy. *Energy Education Science and Technology Part B*, 4(2), 749-756.
- Parker, J. M., Anderson, C. W., Merrill, M. J., Merritt, B., Richmond, G. & Urban-Lurain, M. (2012). Exploring undergraduates' understanding of photosynthesis using diagnostic question clusters. *CBE Life Sci Educ.*, 11(1), 47-57.
- Rule, A.C & Welch, G. (2008). Using object boxes to teach the form, function, and vocabulary of the parts of human eye. *Science Activities*, 45(2).
- Şahin, Ç. (2013). Biology teachers' drawings about the place of the organs on human body: Afghanistan case. *Mediterranean Journal of Educational Research*, 14, 201-206.
- Şahin, Ç., İpek, H. & Ayas, A. (2008). Students' understanding of light concepts primary school: A cross- age study. *Asia Pasific Forum on Science Learning and Teaching*, 9(1), Article 7.
- Saka, A., Akdeniz, A.R. & Enginar, İ. (2002). Biyoloji öğretiminde duyularımız konusunda çalışma yapraklarının geliştirilmesi ve uygulanması. http://www.fedu.metu.edu.tr/ufbmek-5/b_kitabi/PDF/Biyoloji/bildiri/t29d.pdf at the 10.09.2012 date was taken from the internet. (in Turkish).
- Seiger-Ehrenberg, S., (1981). Concept development. concept learning: How to make it happen in the classroom. *Educational Leadership*, 39(1), 36- 43.



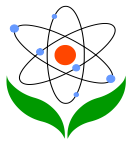
- Sezen, G. & Çimer, A. (2009). *Identification of student teachers' comprehension level of concepts about human circulation system through concept maps and vocabulary association tests*, The first International Congress of Educational Research "Trends and Issues of Educational Research" Presentations, Çanakkale On Sekiz Mart University, Çanakkale. <<http://oc.eab.org.tr/egtconf/pdfkitap/pdf/231.pdf>> 25.03.2014
- Ünal, S. & Coştu, B. (2005). Problematic issue for students: Does it sink or float? *Asia-Pacific Forum on Science Learning and Teaching*, 6(1), 1.
- URL-1, (2013). Eyeball Dissection-Youtube, retrieved June, 26, 2013, from <<http://www.youtube.com/watch?v=VNIOTKNNHJY>>.
- URL-2, (2013). Retrieved January, 15, 2013, from <http://egitim.giresun.edu.tr/fileadmin/user_upload/ders_icerikleri/fen_bil._ders_icerikleri.pdf>.
- White, R.T. & Gunstone, R.F. (1992). *Probing Understanding*. The Falmer Press: London.



Appendix

Table 1. According to cut off points, the PSTs' number of answer words about keywords

Keywords	Cut of point 14- up		Cut of point 7-14			
	The PSTs' words	Repetition of the word (N=34)	The PSTs' words	Repetition of the word (N=34)	The PSTs' words	Repetition of the word (N=34)
Human Eye	Fovea	30	Cornea	13	Pupil	11
	Myopia	21	Iris	13	Organ	10
	Hypermetropia	19	Lens	12	Diplopia	9
	Astigmatism	15	Optic nerves	12	Vision	7
	Blind spot	14				
Human eye defects	Myopia	22	Presbyopia	13	-	-
	Hypermetropia	21	Cataract	9		
	Astigmatism	18	Glaucoma	7		
	Diplopia	17				
	Color blind	15				
The Treatments of human eye defects	Operation	19	Cylindrical lens	11	-	-
	Concave lens	17				
	Convex lens	16				
	No treatment	14				
Vision	-	-	Fovea	11	-	-
			Optic nerves	8		
			Human eye	8		
			Light	7		
Key words	KN 0-7					
	The PSTs' words	Repetition of the word (N=34)	The PSTs' words	Repetition of the word (N=34)	The PSTs' words	Repetition of the word (N=34)
Human eye	Retina	6	Glasses	3	Lachrymal gland	1
	The crystalline lens	5	Cataract	3	Inverted image	1



	Tear	5	Presbyopia	2	Vascular layer	1
	Eye lash	5	Cone receptor	2	Vitreous body	1
	Lens	4	Light	2	Blindness	1
	Eyelid	4	Eyebrow	2	Refraction	1
	Eye pressure	4	Vessel	1	Convex lens	1
	Color-blind	3	Eyehole	1	Concave lens	1
	Sclera layer	3	Eye drop	1	The eye muscle	1
	Bar receptor	3	The eye fluid	1		
Human eye defects	Daltonism	5	Glaucoma	3	Sty	1
	Lazy eye	3	Trachoma	1		
The treatment of human eye defects	Lens	6	Hygiene	4	Heredity	1
	Glasses	5	Laser	3	Cure	1
	Exercise	5	Eye drop	2		
Vision	Blind spot	6	Brain	2	Dark	1
	Retina	3	Myopia	1	Bright	1
	Pupil	2	Hypermetropia	1	Optic nerves	1
	Inverted image	2	Glasses	1	The beam	1
	Cornea	2	Blindness	1	Blurred	1
	Vision centre	2	Astigmatism	1	Far	1
	Lens	2	Iris	1	Near	1