

Students' understanding of light concepts primary school: A cross-age study

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Abstract

In this article we investigated 4th, 6th, and 8th grade students' misconceptions about light, sight, vision, source of light and examined students' conceptual development of these concepts at different grade levels.

Data collection was done using five two-tiered test questions with one open-ended question, an interview about concepts and a drawing exercise. Questions were selected from previous



studies done by different researchers and were adapted to Turkish. An experienced researcher and a lecturer commented on readability and comprehensibility of the examined test questions. Two- tiered test questions are used to find students explanations. The data frequencies are calculated and formed on tables. Collected data showed some distinguished and similar misconceptions among students' grade levels. These findings showed that light concept is constructed hierarchically in students' minds related to their ages; students' concepts were affected by their daily life experiences. It is suggested that teachers should be aware of students' misconceptions and daily life experiences in order to provide effective teaching.

Keywords: Misconception, conceptual development, light, cross-age study.

Introduction

In science and technology education, students come to the formal learning environment with various misconceptions (Gilbert & Watts, 1983). Daily used phrases (Eshach, 2003; Heywood, 2005), intuitional learning (Driver & Easley, 1978; Guesne, Driver & Tiberghien, 1985), misconceptions in textbooks (Ünsal & Güneş, 2003), and teachers explanations (Çalık & Ayas, 2005b) could cause misconceptions in students' minds. It won't be easy to change or to remove the misconceptions acquired from several sources (Osborne & Wittrock, 1983; Akdeniz, Yıldız & Yiğit, 2001). Misconceptions are believed to negatively effect students' conceptual development. Bodner, (1986) indicated that misconceptions would be an obstacle to constructing new knowledge regardless of the quality of teaching.

The conceptual development process starts when students are uncomfortable with their present knowledge or when they feel that their knowledge is insufficient in explaining certain situations they have encountered. To indicate the difference between correct and incorrect scientific knowledge is very important in conceptual development. Recently, various studies have been done to determine and remove misconceptions. Cross-age methodology is preferred in these studies, because this method looks at individuals' misconceptions developed at an earlier age and how they change are observed (Büyükkasap, Düzgün & Ertuğrul, 2001; Şen, 2003; Krnel, Glazar & Watson, 2003; Çalık, 2005; Çalık & Ayas, 2005a; Saka, Cerrah, Akdeniz & Ayas, 2006). But in many studies, misconceptions constructed at earlier ages are so strong that they are difficult to change (Çalık &Ayas, 2005a; Saka, Cerrah, Akdeniz & Ayas, 2006).

Light, in physics, often has many misconceptions. The literature reveals that a number of alternative concepts were found regarding: definition of light, source of light, speed of light, vision, spread out of light, reflection, images on mirror, etc. (Guesne, Driver & Tiberghien, 1985; Galili & Hazzan 2000; Yıldız, 2000; Cansüngü, 2000; Büyükkasap, Düzgün & Ertuğrul, 2001; Akdeniz, Yıldız and Yiğit, 2001; Cansüngü Koray and Bal 2002; Şen, 2003; Eshach, 2003; Kara, Kanlı & Yağbasan, 2003; Heywood, 2005; Sağlam, 2005; Valanides, & Angeli, 2008).

The purpose of this study is to determine 4th, 6th and 8th grade students' misconceptions about light, vision, and light sources as well as to investigate students' conceptual development at different levels of education.

Methodology



1. The Sample

The study sample was selected randomly from a primary school (year 1-8) with a population of nearly 1700 in Akçaabat, Trabzon during the 2005-2006 academic year. A total of 109 students from 4^{th} (N=34 out of 155), 6^{th} (N=36 out of 162) and 8^{th} (N=39 out of 227) grades formed the study group.

2. Instrument and Data-Collection Procedure

A cross-age study methodology was used in this study. Students from different ages were selected and their conceptual development about light concept was determined using five two-tiered test questions and one open-ended question, a drawing exercise and an interview about concepts; these techniques were used to collect data. The questions were selected from previous studies done by different researchers (Chen, Lin, & Lin, 2002; Heywood, 2005) and then adapted for a Turkish context. In addition, a researcher and a lecturer commented on the questions readability, comprehensibility and appropriateness. The commenter indicated that the questions could be used for the study. Many researchers involved in related literature (Novak, 1988; Büyükkasap, Düzgün & Ertuğrul, 2001; Çalık, & Ayas, 2005b) also used these kinds of questions.

The first question was asked to determine students' considerations about light. The second question was asked to determine what students knew about light sources. The third question was asked to determine how students have made the connection between light and seeing. The fourth question was asked to determine how students have made connections between vision and seeing. The sixth question was asked to determine how students have made connections between vision, sight, light and light source. Students were given 30 minutes to complete the test. Ten students were selected from each age group according to their answers on the test questions. Group interviews were conducted about different light sources and reflectors with these same students. Students' ideas about concepts, their propositions and learning strategies could be determined with interviews about concepts technique (White & Gunstone, 1992). Interviews about concept technique can be applied not only individually but also with groups. It is also suitable for young children (Tytler, 2000). At the end of the interviews, researchers wanted the students to draw a diagram of how they think about sight and vision; this exercise helped to support data.

Using drawings in studies gives students another opportunity to express their ideas and feelings and it also supports students' written explanations (White, Gunstone, 1992; Çalık & Ayas, 2005a; Sheppart, 2006). It is also possible to determine the relationship between students' daily life experiences and their scientific knowledge through drawings (Longden, Black & Solomon, 1991; Sheppart, 2006). In this study, various data collection tools were used in order to further investigate students' understanding at each level.

Data Analysis

Data collected from the test, concept interviews and the drawings were analyzed qualitatively and quantitatively. The data frequencies are calculated and formed into tables. Also, focus concepts, students' explanations and selected sample drawings are included in the tables.

Findings



1. Data Collected from Primary School Students using an Open- Ended Question

The open-ended question is as following:

1. According to you, what is light? How do you explain the concept of light?

Table I. 4th Grade Primary School Students' Light Concept Definitions

Focus on concept	Typical definitions	Percentages (%)
		(N= 34)*
illumination	"Light enlightens dark places."	35
	"We turn on the light when it is dark."	
Sun	"The Sun gives light to the World."	21
Electricity	"Light comes through electricity to us."	12
Lamp	"We use lamps when it is evening."	12
	"Light occurs in the lamp."	
To see	"We can see with light when it is evening."	9
Tool	"It's a tool, which provides sight."	6
Existence	"Existence is enlightens of The World."	3
Matter	"It's a matter, which enlightens us."	3

*The percentage is more than a hundred because *students' sometimes use more than one concept in their construction of a definition.*

Primary school 4th grade students' light concept definitions are given in Table I. 35% of students' defined light concept as illumination, 21% as sun; 12% as electric and 3% as existence and matter concepts.

Table II. 6 th	¹ Grade Primar	y School Students	' Light Concep	ot Definitions
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Focus	Typical definitions	Percentages
		(%)
concept		
		$(N=36)^*$
To see	"Providing sight is a source. If there weren't light, human	42
	couldn't see anything."	
	"Illuminates environment provides sight in dark."	
Illumination	"Light is light. If there weren't light, the World would be	11
	dark."	
	"Light illuminates some places and space."	
	There is light at luminousness. There isn't light in dark."	
The Sun	"The Sun gives light and heat to the World."	8
	"Sun is light."	



Energy	"Light is a source of energy. Light source illuminates every	8
	place at night."	
	"To provide illumination is energy."	
Subject	"Is a subject that provides to see?"	8
Reflection	"Light reflects matter."	8
	"Light is a reflector matter."	
	"Light come into existence with electricity and it reflects. It is	
	a colored, shined, abstracted source."	
Electric tool	"Our houses are illuminated with light which run to work with	6
	electricity."	
Beam	"Providing illumination is a ray of light."	3
Lamp	"We use lamp as light in our houses."	3
Matter	"It is a matter that provides to see."	3
Color source	"Light is a color source. We need light to see in dark."	3

*The percentage is more than a hundred because *students' sometimes use more than one concept in their construction of a definition.*

In Table II, 6th grade primary school students' light concept definitions are given. 41% of students' defined light concept as to see; 11% as illumination, 8% as energy, 6% as an electric tool, 3% as matter, beam and lamp concepts.

Table III. 8 th	Grade Pr	rimary Sch	ool Students	' Light Co	ncept Definitions
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Focus concept	Typical definitions	Percentages (%) (N=39)*
Energy	"Illuminated energy."	51
	"Illuminated darkness energy source."	
	"Light is energy, which provides to see matters, and to see each other."	
	"It is an energy that provides sight and is seen as energy."	
To see	"Light provides sight every thing we can't see before."	18
	"Illuminating dark places provides sight."	
Darkness and	"It illuminates darkness."	15
light	"It is a source that illuminates darkness."	
Matter	"Is a matter that illuminates our front?"	10



M.		
The speed of light	"Light spreads in an unknown way. It is very fast. It hits to objects and provides sight their colors."	8
	"Light spreads in an unknown way. Light is very fast."	
	"When matter gets warm it spreads heat and light. Light turns the World's surrounding seven times until we open and close our eyes."	
To see a tool	"Light illuminates our World. We can use it as a tool to see."	6
	"What we use the most important in daily life."	
Wave length	"Light turns the World's surrounding seven times until we open and close our eyes. Light is a word that symbolized withy."	3

*The percentage is more than a hundred because *students' sometimes use more than one concept in their construction of a definition.*

In Table III, 8th grade primary school students' light concept definitions are given. 51% of the students' defined light concept as energy, 10% as matter, 8% as light's speed, 6% as a tool and 3% defined as a wavelength.

2. Data Collected From Primary School Students With Two-Tiered Test Questions The first question of the two-tiered test is:

1. i. Which isn't a light source?a) Star b) Candle c) The Moon d) Firefly

1. ii. Write down your reasons for the choice you made.



Table IV. 4th Grade Students' Answers

Choice	Typical definitions	Percentages (%)
Firefly	"It isn't a tool that works with electricity and it doesn't reflect	85
	light."	
	"Firefly is an insect. Light source isn't related to it."	
	"It doesn't enlighten every place. We don't use it for our	
	houses and street illumination."	
	"Its light isn't sufficient. It produces less light than others. It	
	doesn't enlighten The World."	
	"We can't open and close its light."	
Moon	"It reflects the light that it has taken from the Sun".	3
Candle	"It ends when it burns".	6
	"Candle is a fire."	
Star	"Star can't be a light source".	6

In Table IV, 4th grade primary school students' choice of light sources and their reasoning are given. "The Moon" is the correct choice and only 3% of the students selected the correct answer.

 Table V. 6th Grade Students' Answers

Choice	Typical definitions	Percentages (%)
Firefly	"Its light isn't sufficient. It produces less light than others. It doesn't enlighten The World." (%5) "We can't pen and close its light." (%5) "Eirofly is an animal and an axistence." (%48)	58
Moon	"The Moon reflects the light that it takes from The Sun."	31
	"The Moon is a satellite."	
Candle	"Candle is a fire."	8
Star	-	3

In Table V, 6th grade primary school students' choice of light sources and reasoning are given. The Moon, again, is the correct choice, but only 31% of the students selected this choice.

Table VI. 8th Grade Students' Answers

Choice	Typical definitions	Percentages
		(%)



V		
Firefly	"It is an animal."	56
	"We couldn't open and close its light."	
	"It produces less light than the other light sources. It doesn't enlighten World."	
	We can't use it as a tool. It doesn't illuminate.	
Moon	"The Moon reflects the light that it takes from The Sun."	36
Candle	-	-
Star	-	-

In Table VI, 8th grade primary school students' choice of light sources and their rationale are given. The Moon is the correct choice and only 36% of the students selected correctly.

The second question of the two-tiered test is:

2.i. There are white and black colored papers in the dark room, but there is no light. Can you see these papers?

Table VII. Students' Answers to the Third Question

Students	4 th grade	6 th grade	8 th grade
Choices in percentages			
a)Yes. We can see them.	-	3	-
b) No. We can't see them	50	17	40
c) We can see black ones.	-	8	-
d) We can see white ones.	50	69	60

ii. Select your answer and write an explanation

50% of the 4th grade students said that they could see the white papers in the dark room, where 50% said that they couldn't see anything. Students think that color of the light and paper are the same. 68% of students said that light is necessary to see. Only 12% of students explained vision and sight in a correct way.

69% of 6^{th} grade students said that they could see white paper in the dark room, and 17% said that they couldn't see anything in the dark room. 8% of 6^{th} grade students said that when the room is dark everywhere is seen black. Thus, they said that they can see black papers better in dark. Moreover, 3% of 6^{th} grade students said that they could see both black and white papers.

60% of 8th grade students' said that they can see white papers in the dark room, where 40% said that they couldn't see anything in the dark. Some of their ideas were as follows: "White paper shines", "White light shines at darkness.", "White is the true color for light.", "If there is no light, we can't see and there won't be any vision.", "We can't see any matter at dark.

The third question of the two-tiered test is:



3.i. Six pictures about sight are below. In which picture can you see the tree?



Note: Arrows are showing the direction of light.

ii. Write your explanation for the choice that you think is correct.

Table VIII. Rates of Figures That Students Selected, about How They Can See a Tree

Students	Choices and Students' Answers Percentages							
	A(%)	B(%)	C(%)	D(%)	E(%)	F(%)		
4 th grade	3	9	15	38	12	18		
6 th grade	6	-	25	36	14	14		
8 th grade	-	-	8	62	13	10		

38% of the 4th grade students, 36% of the 6th grade students, 62% of the 8th grade students selected choice D. 3% of the 4th grade students selected choice A and 9% selected choice B. 25% of the 6th grade students selected choice C, but none of the 8th grade students selected choice A.

The forth question the two-tiered test is:

4.i. A mosquito bites Ahmet's chin at midnight. Ahmet wants to see where the mosquito has bitten. Ahmet immediately finds a flashlight and a 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)

ii. Which one of the diagrams below perfectly explains your ideas? If none of the diagrams explains your ideas, draw your diagram in box E.

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E)



Table IX.	Students	'Answers	about	Figures	Related	to.	Ahmet's Sight His Chir	1
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Students	Frequencies of students' answer choices						
	A (%)	B (%)	C (%)	D (%)			
4 th grade	44	32	18	3			
6 th grade	33	19	14	14			
8 th grade	33	21	13	15			

32% of the 4th grade students, 19% of the 6th grade students, 21% of the 8th grade students selected choice B. None of the students selected to write their own answer in box E.

Table X. Students' Explanations about Figures about Ahmet's Sight His Chin

	Frequencies of students' answer choices															
Students	A(%)			B(%)		C(%)				D(%)					
Students	A	В	С	D	Α	В	C	D	Α	В	С	D	Α	В	С	D
4 th	7	27	27	20	55	18	-	-	-	17	67	17	-	-	100	-
Grade																
6 th	8	8	75	-	71	-	-	-	-	-	60	20	-	-	-	100
Grade																
8 th	-	54	31	-	86	-	13	-	-	20	-	80	17	-	-	67
Grade																



55% of the 4th grade students, 71% of the 6th grade students, and 86% of the 8th grade students selected figure A for choice B. 17% of the 4th grade students, 20% of the 6th grade students, and 80% of the 8th grade students selected figure D for choice C.

The fifth question of the two-tiered test is:

5. Yıldız, Ali, Gül and Burak are talking about sight and light concepts. Gül confused as to whether the Moon is a light source or not? Which idea is correct Please write your explanations under your answers?



Three cartoons characters are talking about whether the Moon is a light source or not. Gül confused Ali's, Burak's and Yıldız's statements about the necessity of light for vision. We want students to select the ideas, for which they agree.

	Students' answer percentages								
Students grade	Ali (%)	Burak (%)	Yıldız (%)						
4 th grade	15	3	74						
6 th grade	19	6	56						
8 th grade	13	-	82						

Table XI. Students' answers about whether the Moon is a light source

3% of the 4^{th} grade students and 6% of the 6^{th} grade students selected Burak's statement. On the other hand, none of the 8^{th} grade students selected Burak's statement.

3. Data Collected from the Sample through Interviews about Concepts and Drawings

These interviews were conducted in order to learn the reasons behind students' responses for the two-tiered test's first (about light source) and fifth questions (about sight and light concepts).



Focus Concept	Typical definitions	Student (N=10)
Moon	"The Moon reflects light to us." "The moon reflects the light that it takes from The Sun to us. So we can see."	3 (agree)
Moon	"The Moon reflects the light that it takes from The Sun. It can't be a source." "If the Moon was a light source, it would be full moon. But, the Moon is sometimes The Full moon and sometimes First Moon."	7 (don't agree)
Firefly	"If a firefly is put into a lamp, it doesn't give light like electricity because it is an animal, it reflects light very little, and it can't be used at home".	7(don't agree)

In Table XII, 4th grade primary school students' answers to interview questions about light concept definitions are given. 3 students agreed that the Moon is a light source. The others did not agree that the Moon is a light source. Also, these students didn't agree that a firefly is a light source or not. When we asked students whether the moon or the firefly is light source, they stated that firefly isn't a light source. They showed evidence by saying that; "If firefly is put into lamp, it doesn't give light like electricity because it is an animal, it reflects light very little, and it can't be used in houses". Similar answers were given in the two- tiered test that took place beforehand.



Figure I. 4th grade student think that to see and to look have the same meaning.

Table XIII. 6th Grade Students' Interview Answers about Concepts

Focus Concept	Typical definitions	Student (N=10)
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Moon	"The Moon illumines at night."	4 (agree)
Moon	"The Moon reflects the light that takes from The Sun.	6 (didn't agree)
Metal spoon	"Metal spoon reflects the light; we can see it in dark kitchen."	1 (agree)
Firefly	"We can see its light.",	2 (agree)
	"If there were fireflies more than one, they would illumine us."	
Firefly	"Firefly doesn't spread light like The Sun."	8 (didn't
	"Firefly spreads enough light for itself to see."	agree)

In Table XIII, 6th grade primary school students' answers to interview questions about light concept definitions are given. 4 students agreed that the Moon is a light source. They explained their reasons as; "The Moon illumines at night." And a student stated that, a "Metal spoon reflects the light; we can see it in dark in kitchen". Students drew figures to further explain their statements.



Figure II. δ^{th} grade student agree the moon is light source



Figure III. 6th grade student agree metal spoons are light source

Table XIV. 8 th	Grade Students	Interview A	Inswers	about	Concepts	

Focus Concept	Typical definitions	Student (N=10)
Moon	"The moon reflects light that it takes from The Sun to us."	10 (agree)
Firefly	"We can see its light."	2 (agree)
	"If there were more fireflies they would illumine us."	

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 Firefly
 "Firefly doesn't spread light like The Sun."

 "Firefly spreads enough light for itself to see."
 8 (didn't agree)

In Table XIV, 8th grade primary students' answers to interview questions about light concept definitions are given. 10 students agreed that the Moon is a light source. They reasoned that, "The Moon illumines at night." And a student stated that "Metal spoon reflects the light, we can see it in dark in kitchen". Students drew figures to further explain their statements.



Figure IV: An 8th grade student's drawing reflecting the relationship between the concepts of sight with light.

Figure V gives a summary of the findings for the 4^{th} , 6^{th} and 8^{th} grade students' rates of correctly answered

open-ended and two-tiered questions.



Figure V. Rates of 4^{th} , 6^{th} and 8^{th} grade students' rates of answers to questions A, B, C, D, E and F

First open-ended question A: According to you what is light? How do you explain the concept of light?

First two-tiered question B: Which isn't a light source?



<u>Second two-tiered question C</u>: There are white and black colored papers in the dark room, and there is no light. Can you see these papers?

<u>Third two-tiered question D</u>: Six pictures about sight are given at the below. In which picture could you see the tree?

Fourth two-tiered question E: The mosquito bites Ahmet's chin at midnight. Ahmet wants to see where the mosquito has bitten. Ahmet immediately finds a flashlight and a mirror. If he wants to see his chin in the mirror very clearly, how should he hold the flashlight?

Fifth two-tiered question F: Yıldız, Ali, Gül and Burak are discussing sight and light concepts. Which idea do you think is correct? Please write an explanation for your answers.

As seen in Figure V, from 4^{th} grade to 8^{th} grade, the students' level of understanding improved except when looking at questions D and F. 6^{th} and 8^{th} grade students have lower levels of understanding than 4^{th} grade students regarding question D. Also, 6^{th} grade students have lower levels of understanding in comparison to 4th graders regarding question F.

Conclusions And Discussion

According to the data obtained, students' concepts showed consecutiveness. The 4th grade students didn't define light as energy. 51% of the 6^{th} grade students and 8% of the 8^{th} grade students defined light as reflection. The 4th and the 6th grade students didn't mention anything about the speed of the light or the wavelength of the light, whereas the 8th grade students mentioned the speed of the light and the wavelength in their definitions. Light concept and light source concept definitions change among the students. Learning circumstances change according to age groups (Sen, 2003). Knowledge is constructed hierarchically in students' mind and it relates to their age as they grow (Novak, 1988). The development of the concept of light in our research showed similarities with literature (Dedes, 2005). 4th, 6th and 8th grade students defined the effects of light as, "Light occurs from lamp.", "Light comes as electric to us", "Light enlightens dark places" (See Table I), "Sun is the light", "There is light in luminousness", "There isn't light at dark" (See Table II) and "Light illuminates darkness" (See Table III). This data can be explained by the impact of student's ideas from their daily life (Cansüngü, 2000; Pine, Messer & John, 2001). Eshach (2003), also have similar findings such as: "We throw a glance", "Give a look" and "If you get closer, you will see well". 4th, 6th and 8th grade students defined light relating to working with an electric tool. For example: "Light occurs from lamp", "Our houses illuminated with light to run to work with electricity" and "We can use light as a tool to see". Similar findings have been found in another study (Cansüngü Koray & Bal, 2002). Moreover, 4th, 6th and 8th grade students' definitions include concepts of matter and existence. The same concepts are used in other studies for the definition of light (Yıldız, 2000; Cansüngü, 2000; Akdeniz, Yıldız & Yiğit, 2001; Cansüngü Koray & Bal, 2002).

85% of the 4th grade students didn't agree that a firefly is a light source and 3% of them didn't agree that the Moon is a light source. 58% of the 6th grade students didn't agree that a firefly is a light source and 31% of them didn't agree that Moon is a light source. 56% of the 8th grade students didn't agree that firefly is a light source and 36% of them didn't agree that Moon is a light source.



"The Moon is a light source" misconceptions persist from 4th grade to 8th grade. The similar finding was determined in another study (Pine, Messer & John, 2001). Büyükkasap, Düzgün & Ertuğrul, (2001) found that student did not understand? Light sources.

To change children's conceptions seems to be quite difficult, as they understand events which happen around them intuitively. Furthermore, this consequence can be explained according to the interviews carried out with the sample. Students' defined light sources according to their understanding during their interviews. ("Firefly isn't a light source. Because, we can't use it as a tool. It doesn't illuminate").

Students were asked if the Moon, firefly, flashlight and star were light sources, and the results indicated that students' similarly. Students stated their explanations by comparing choices with the Sun's energy.

According to the students, everything that reflects light is a light source. In their light source definitions, "to reflect" is seen as a concept. Students considered that a "light source spreads light" and that a "light source reflects light" and gave these ideas the same meaning. Similar results are found in a previous study (Akdeniz, Yıldız & Yiğit, 2001).

Students could not distinguish between concepts like light source and light reflection. In the interviews that carried out with the 6th grade students, one of them stated that, a "Spoon reflects light; we can see it in dark kitchen." This finding demonstrates that students think that everything they see with light is a light source. This finding can also be seen in students' drawings (see Figure 3). This case showed similarities to the development of light history. Leucippus of Milletus proclaimed that every visible object is a light source (Guesne, Driver, & Tiberghien, 1985).

Students defined concepts according to their daily life experiences (Cansüngü Koray & Bal, 2002). However, students didn't agree that firefly is a light source, and they explained their reasoning by saying that a "Firefly can only show itself." This rationale shows that those concepts can't always be clearly understood by the students.

50% of the 4th grade, 69% of the 6th grade and 60% of the 8th grade students stated that they could see white papers in a dark room. Similarly, Şen (2003) found that in order to see matters, matters should be bright.

In the third question the 4th and the 6th grade students marked choices A and B, whereas the 8th grade students didn't mark any of these choices. This shows that the 4th and the 6th grade students felt sight and looking was the same thing (see Figure I). Again, similar findings were found in other studies (Cansüngü, 2000; Yıldız, 2000; Pine, Messer & John, 2001). This case showed similarity with the belief that Pythhagorean had - the eye should be active for sight. Archytos of Toroanto agreed with Pythhagorean's convictions. Also, in the 5th Century, Alcmaeon of Croton proclaimed the eye to be a light source (Guesne, Driver, & Tiberghien, 1985). To see and to look are found to be the same concept in some other studies, too (Galili & Hazzan, 2000; Şen, 2003; Heywood, 2005; Eshach, 2003). The first time in the history of development of light concept, Ibn-ul Heysem revealed the function of eye and light. Ibn-ul Heysem rejected the idea that the eye diffuses light. He also asserted that light beams come from the object and then to the eye (URL-1).



Choice E is correct, and was marked by the $4^{th}(12\%)$, $6^{th}(14\%)$ and $8^{th}(13\%)$ grade students at approximately the same rate. According to students' grade levels, concepts are developed hierarchically.

With the data obtained from the interviews and drawings, it is understood that students can relate sight and light (see Figure III and IV). But, they didn't draw or say anything about how sight comes into existence. These findings can be explained because students aren't aware of that when light falls on a matter the light should reflect on the eye so that sight occurs. 6th and 8th grade students have lower levels of understanding than 4th graders regarding the question about "Six pictures about sight are below. In which picture can you see the tree?" as seen in Figure V. Also, 6th grade students have a lower level of understanding than 4th graders have in question F. These findings show that misconceptions are resistant to change with scientific knowledge (Boo, 2007; Ekici, Ekici & Aydın, 2007).

Suggestions

Constructing abstract concepts in students' mind is rather difficult (Novak, 1988). New materials that support instructions should be improved (Akdeniz, Yiğit & Yıldız, 2001; Novak, 1988). These materials should have certain features in order to remove students' misconceptions. Furthermore, teachers have undertaken considerable challenges in order to remove these misconceptions. Teachers play an active role in the instruction process, and teachers have an important role in instruction (Gilbert & Watts, 1983; Hewson, 1992). Teachers should be able to facilitate students' conceptual change (Çalık & Ayas, 2005b). Therefore, a great importance should be given to teacher education, both in pre-service and during in-service training.

To further determine students' knowledge and to remove their misconceptions, other conceptual change techniques like drawings, concept mapping, word association, prediction-observation-explanation and interviews about concepts can be utilized (White & Gunstone, 1992) which are related to probing understanding should be used in new studies.

Teachers should be aware of science topics and students' misconceptions. To remove students' misconceptions, science topics should be related to examples from daily life. Abstract concepts should be connected with appropriate experiences. In particular, metacognitive materials should be developed to overcome students' misconceptions (Gilbert, & Watts, 1983). Thus, students can become aware of their own learning.

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