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The Effects of Instruction on 5th Grade Students' Conceptual Understandings about Light Concept

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Abstract

Students' preconceptions about the concept they will learn is very affective on the teaching. Students' ideas are not always compatible with scientific facts and such ideas are referred to as misconceptions in the literature. Teaching can be effective in changing students' ideas, even after teaching there are students who continue to pursue ideas that are incompatible with scientific facts. The aim of this study is determined fifth grade students' ideas related to the concept of light before and after teaching. To uncover students' ideas about the concept of light, a concept test consisting of five questions has been prepared by the researcher. The test reliability study conducted with sixty-five students and cronbach's α coefficient was calculated to be .783. Questions consist of four options and that students are asked to explain their ideas about select from the options. This test on the light concept has been applied before and after instruction. Descriptive analysis of the data obtained from tests was performed. Students' scientific idea about the concept of light encountered ratio is low and the majority of students' ideas are the nature of misconceptions. After instruction for students faced with scientific answers increased. Instruction caused an increase in the frequency of students' scientific response about the concept of light. In studies using different teaching techniques can be researched the changes in ideas of the students about the concept of light.

Key Words: Light concept, fifth grade students, misconception

Introduction

During the recent years, the number of studies carried out in the field of science education has increased rapidly. Studies that are particularly devoted to determine the students' opinions regarding the science concepts are carried out (Duit, 2009). These studies confirmed that students have opinions that are inconsistent with scientific knowledge regarding many science concepts. Although these opinions are denominated differently in many studies, they are named as "misconceptions" in this study. Misconceptions can be defined as the way a person comprehends a concept is significantly different from its commonly acknowledged scientific meaning. (Stepan, 1996; cited in Gülçiçek & Yağbasan, 2003). Misconceptions come up as learning obstacles. If the students come to the class environment with misconceptions, this situation prevents them from learning (Hewson & Hewson, 1983). Therefore, it is important to resolve these students' misconceptions as it is important to remove them. It is important to reveal misconceptions as much as it is important to change these opinions. The first step of conceptual change is to reveal the students' misconceptions. Once these misconceptions are revealed, the education can be organized so as to change these misconceptions. There are many studies that investigate the students' misconceptions regarding many science concepts and very few of them lay emphasis on changing these opinions. There have been studies intended at revealing the students' opinions regarding the concept of light. Anderson and Smith (1986) used multiple-choice tests that consist of 37 questions in order to reveal primary educations students' opinions regarding the concept of light which they have before education and after education. The test covers four objects; a) how people see, b) the nature of color vision, c) the interaction of light with various objects, d) the structure and functioning of human eyes. The misconception that says "light comes out of the lamp until it fills the room; then it stops moving" is encountered in questions about nature of light. The misconceptions that say "arrows sowing reflection at other angels" and "showing no arrows away from object" are encountered in questions about reflection of light. The misconception that says "eyes see objects directly" in encountered in the question about how people see. The misconception that says "people's eyes see colors of objects" is encountered in the question about the nature of color vision.

Barnett and Morran (2002) investigated seventeen fifth grade students' opinions before and after education regarding the phases of moon and moon and sun eclipses in their studies. It is stated that students confuse moon and sun eclipses before education, however, the education have an effect on the change in these opinions. The students formed correct cognitive structures regarding sun and moon eclipses after education.

Eaton, Anderson and Smith (1984) investigated fourteen fifth grade students' opinions on the concept of light before and after education in their studies. In the question that says "Draw arrows on the pictures below to show what would happen to light after it hits the objects", misconceptions such as

"goes all over the place", "soaks in" and "arrows scatter on the surface of the object" are encountered in students. The education caused a decrease in the frequency of encountering these misconceptions in students.

Gan (2008) investigated twenty two fourth grade university students' prior knowledge and misconceptions regarding the reflection of light. He stated that the students' drawings support idea improvement and conceptual change. The misconceptions that say "an inexact reflection of object", "belongs to object or come from it" and "everything has a shadow" are encountered in "What is shadow" question. The misconception that says "a shadow can exist underground" is encountered in "Why do shadows exist" question. The misconceptions that say "a shadow is bigger when an object is closer to light source", "a shadow is smaller than the object", "a shadow is bigger in the morning and smaller in the evening" and "the size of a shadow depends on the sun's brightness" are encountered in "Why shadows are big and small?" question.

Gölgeli and Saraçoğlu (2011) compared seventy seven sixth grade students' opinions regarding the concept of light before education and after education with concept caricatures. In this study, it is determined that the education performed by using concept caricatures about the concept of light is more effective than the traditional education method. Similarly, Pektaş, Çelik and Katrancı (2009) stated in their studies that computer-aided education about the concept of light has an effect on the students' success.

Şahin, İpek and Ayas (2008) compared 4th, 6th and 8th grade students' opinions on the concept of light. While 4th grade students do not define light as energy, light is identified as energy in other class levels. 6th grade students define light as reflection, while this definition is not encountered in 8th grade level. In this study, t is stated that the misconceptions on the concept of light decrease as the age increases.

Purpose of the Research

The purpose of this research is to determine the opinions of secondary school fifth grade students' regarding the concept of light before education and after student-centered education. The students' answers which are given before and after education, to questions regarding the concept of light are compared. The research aims to investigate whether there is an increase in students' scientific answer rates after student-centered education. The frequencies of encountering misconceptions after education and before education are compared. The effect of education on the change in students' opinions is discussed.

Importance of the Research

The recent amendments in Turkish education programmes took their place in middle-school fifth grade science programme of light concept. In this programme, the education of the concept of light will continue in further-classes' secondary school science lectures, according to spirality principle. What students learn at this class level will form a basis for further class levels.

Therefore, it is important that the students at this class level state their opinions on the concept of light, which is one of the main subjects of physics. It is important to determine the naive opinions about this concept before education as much as it is important to determine the change that occurs in students' opinions after education.

Method

Single group pretest posttest, which is one of the weak experimental designs, is used as a research design in this research. This study consists of three steps; pre-experimental, experimental period and post-experimental. In weak experimental research design, pretest is implemented on research group, then experimental study is made on the research group, and finally posttest is implemented on the same group (Cohen, Manion & Morrison, 2005). The effect of the experimental study on the difference between pretest and posttest is investigated in pre-experimental research model.

Participants

This study is carried out with one hundred fifty fifth grade students who study in three secondary schools in western region of Turkey. The schools and classes are randomized among other schools and classes. These students have received instruction on the concept of light in science lectures for three weeks.

Data Collection

A data collection tool that consists of five open-ended questions is developed by the researcher in order to determine the opinions of fifth grade students' opinions on the concept of light. The questions are multiple-choice and consist of four choices. Students are asked to explain their opinions on the choice they make for every question.

Four of five questions in data collection tool are developed by the researcher; the remaining question is taken from Gan (2008) study. These questions are written considering the gains in fifth grade science lecture schedule. Question 1 is about the propagation of light; question 2 is about the reflection of light; question 3 is about light's passing through the object; question 4 is about shadow length; question 5 is about eclipses.

The reliability study of data collection tool is carried out with sixty five fifth grade students from another secondary school. The reliability coefficient of the test is calculated as cronbach's α.783. As this reliability coefficient is above .70, it is adequate for the reliability of this test (Büyüköztürk, 2010).

Data Analysis

This test is implemented before and after education, regarding the concept of light. The descriptive analysis of the data obtained from the test is made. Data is summarized and interpreted according to predetermined themes in descriptive analysis (Yıldırım & Şimşek, 2005).

A rubric that consists of four categories is used in the analysis of data which is obtained from questions in data collection tool. Assessment categories and the answers in these categories are explained below.

Table 1. *The Categories used in analyzing the Students' Answers to the Concept Test, and their Explanations*

Kategoriler	Kategorilerin Açıklamaları
Understanding	Including the correct response with the explanation of correct response.
Partial Understanding	The reason being given the correct answer, but the answer is not disclosed.
Misunderstanding	Questions and answers about the wrong answers are wrong description.
No understanding	Students did not specify with the idea about question.

The frequencies of the students' answers in this category to five questions that are asked about the concept of light are calculated. In "misunderstanding" category, the misconceptions about the concept of light encountered in students are included.

Findings

The findings obtained by analyzing the first question before and after instruction via rubric are mentioned below in Table 2.

Table 2. *The Findings obtained from the Analysis of Question 1 via Rubric*

	Before Instruction	After Instruction
	n (%)	n (%)
Understanding	1 (0.7)	100 (66.7)
Partial understanding	57 (38)	18 (12)
Misunderstanding	92 (61.3)	32 (21.3)
No understanding	0 (0)	0 (0)

While one student takes part in "understanding" category in Question 1 about the propagation of light before education, this rate increases after instruction and one hundred students gave answers in this category. The instruction caused an increase in students' scientific answer rates. While thirty eight students are in "partial understanding" category before education, this rate is decreased after education, because the instruction enabled the students to explain the reasons of their right answers and these students take part in "understanding" category after education. Answers in "misunderstanding" category are the most encountered ones before education. The instruction has been effective on the decrease in students' misconceptions about the propagation of light. Answers in "no understanding" category are not encountered before or after instruction in this question.

Table 3. *Misconceptions encountered in Students for Question 1*

	Before Instruction	After Instruction
	n (%)	n (%)
Light continues to propagate only in the direction of the source it comes out.	39	16
Light propagates in circular orbits after it comes out from the source.	39	9
Light rays from light sources in different environments follow different paths.	14	7

The frequency of encountering misconceptions in students after instruction is decreased in this question. The misconception that says "light continues to propagate only in the direction of the source it comes out" is encountered in thirty nine students before instruction and in sixteen students after education. The instruction has an effect on the opinion change regarding this misconception. While the misconception that says "light propagates in circular orbits after it comes out from the source" is encountered in thirty nine students before education, it is encountered in nine students after education. The instruction caused a decrease in the frequency of encountering this misconception. The misconception that says "light rays from light sources in different environments follow different paths" is encountered in fourteen students before instruction and in seven students after instruction. The frequency of encountering these three misconceptions is decreased after instruction.

Table 4. *Findings obtained from the Analysis of Question 2 via Rubric*

	Before Instruction	After Instruction
	n (%)	n (%)
Understanding	0 (0)	63 (42)
Partial understanding	83 (55.4)	28 (18.7)
Misunderstanding	62 (41.3)	58 (38.6)
No understanding	5 (3.3)	1 (0.7)

While there were not any scientific answers before instruction about the reflection of light in Question 2, sixty three students gave scientific answers after education. The instruction enabled these students to give correct answers about the concept of light reflection and to make explanations of these answers. Eighty three students gave answers in "partial understanding" category before instruction and twenty eight students took part in this category after education. The instruction enabled these students to explain their correct answers. Misconceptions on this concept are encountered in sixty two students before education, while this rate slightly decreased after instruction and misconceptions are encountered in eight students. Five students did not state

opinions in this question before education, while one student did not give any answer after education.

Table 5. *Misconceptions encountered in Students for Question 2*

	Before Instruction	After Instruction
	n (%)	n (%)
Light rays pass through nontransparent objects.	29	20
Light rays randomly reflect from nontransparent objects.	10	11
Some of the light rays pass through nontransparent objects while some are reflected.	23	27

The frequency of encountering the misconception that says "Light rays pass through nontransparent objects" is decreased. The frequencies of encountering the misconceptions that say "Light rays randomly reflect from nontransparent objects" and "some of the light rays pass through nontransparent objects while some are reflected" slightly increased after education. Instruction could not be very effective in changing these misconceptions and even caused an increase in their frequencies.

Table 6. *Findings obtained from the Analysis of Question 3 via Rubric*

	Before Instruction	After Instruction
	n (%)	n (%)
Understanding	0 (0)	68 (45.3)
Partial understanding	61 (40.7)	39 (26)
Misunderstanding	88 (58.6)	40 (26.7)
No understanding	1 (0.7)	3 (2)

While there were no students that take part in "understanding" category before instruction in Question 3, sixty eight students took part in this category after education. The instruction enabled nearly half of the students to give scientific answers. Answers of sixty one students were in "partial understanding" category before education, whereas thirty nine students were included in this category after education. The instruction caused a decrease in the number of answers within this category because some of the students in this category made the explanations of the correct answers. While the answers of eighty eight students took part in "misunderstanding" category before education, the frequency of encountering misconceptions decreased after education. One student did not state his/her opinion in this question before education, while three students did not state their opinions after education.

Table 7. *Misconceptions encountered in Students for Question 3*

	Before Instruction	After Instruction
	n (%)	n (%)
The light can not proceed its way when it meets a transparent object.	33	14
Light can not pass through semitransparent objects.	20	7
Nontransparent objects are not light-proof.	35	19

The frequencies of encountering these three misconceptions seen in students' answers to this question decreased after education. The instruction has been effective in changing the opinions regarding the misconceptions that say "the light can not proceed its way when it meets a transparent object", "light can not pass through semitransparent objects" and "nontransparent objects are not light-proof". There have been very few students who maintain their opinions regarding these misconceptions after education.

Table 8. *Findings obtained from the Analysis of Question 4 via Rubric*

	Before Instruction	After Instruction
	n (%)	n (%)
Understanding	1 (0.7)	69 (46)
Partial understanding	58 (38.6)	18 (12)
Misunderstanding	90 (60)	61 (40.7)
No understanding	1 (0.7)	2 (1.3)

While only one student took part in "understanding" category before instruction regarding the length of shadow in Question 4, the answers of fourty six students are included in this category after education. The instruction provided an increase in students' scientific answer rates. Fifth eight students took part in "partial understanding" category before education, whereas this rate is decreased after instruction and eighteen students took part in this category. The instruction affected the opinions of other students and enabled them to give answers in scientific answer category. While the answers of ninety students took part in "misunderstanding" category before education, it is seen that sixty one students have misconceptions after education. The instruction caused a decrease in the frequency of encountering misconceptions regarding this concept, yet it could not be efficient in changing them completely. This is because misconceptions are maintained after instruction regarding this concept. While one student did not state opinion on this concept before education, two students did not state opinion on this concept after education.

Table 9. *Misconceptions encountered in Students for Question 4*

	Before Instruction	After Instruction
	n (%)	n (%)
The length of the shadow is always smaller than the object.	58	10
The length of the shadow does not change according to the size of the object.	12	36
The size of the shadow depends on the brightness of the Sun.	28	15

The frequencies of encountering the misconceptions, which are "the length of the shadow is always smaller than the object", "the size of the shadow depends on the brightness of the Sun" decreased after education. The instruction has been effective in changing the opinions regarding these misconceptions; however, it could not be effective in removing them completely. The misconception that says "the length of the shadow does not change according to the size of the object" is seen in more students after education. The instruction caused an increase in the opinions regarding this misconception.

Table 10. *Findings obtained from the Analysis of Question 5 via Rubric*

	Before Instruction	After Instruction
	n (%)	n (%)
Understanding	0 (0)	48 (32)
Partial understanding	43 (28.7)	11 (7.3)
Misunderstanding	98 (65.3)	88 (58.7)
No understanding	9 (6)	3 (2)

While there are no answers in "understanding" category before instruction regarding the eclipses in Question 5, fourty eight students gave scientific answers about this concept after education. The instruction enabled these students to form scientific answers about the concept of eclipses. The answers of forth three students took part in "partial understanding" category before education, whereas eleven students took part in this category after education. These students explained the reasons of their answers after instruction and took part in "understanding" category. The most common answers encountered before and after instruction about the concept of eclipses are within "misunderstanding" category. There were misconceptions in ninety eight students before education, whereas this number decreased to eighty eight after education. Nine students did not state their opinions before instruction; three students did not state their opinions regarding this concept after education.

Table 11. *Misconceptions encountered in Students for Question 5*

	Before Instruction	After Instruction
	n (%)	n (%)
Moon eclipse occurs when the Sun comes between the Earth and the Moon and the Moon can not reflect the sunlight.	34	33
Moon eclipse occurs when the Moon comes between the Earth and the Sun and the Moon can not be seen from the Earth.	27	32
Sun eclipse occurs when the Moon is behind the Earth.	37	23

The frequencies of encountering the misconceptions that say "moon eclipse occurs when the Sun comes between the Earth and the Moon and the Moon can not reflect the sunlight" and "Sun eclipse occurs when the Moon is behind the Earth" are decreased after education. The instruction has been effective in the decrease of these opinions regarding these misconceptions; however, it could not provide a complete change. The opinions on these misconceptions are maintained after education. The frequency of encountering the misconception that says "Moon eclipse occurs when the Moon comes between the Earth and the Sun and the Moon can not be seen from the Earth" increased after education. The instruction supported the opinions on this misconception.

Results and Conclusions

In the results of this study which investigates secondary school fifth grade students' opinions on the concept of light before and after education, it is seen that they can give correct answers to questions about the concept of light before education, whereas they can not explain their answer. The students' answers given before instruction are intuitional and they could not make accurate explanations to these answers. The frequencies of encountering scientific answers in students after instruction have increased. The instruction has an effect on the students' giving the correct answer and making the correct explanation. The most common answers encountered in students before instruction are in "misunderstanding" category. The instruction caused a decrease in the frequency of encountering misconceptions in students. The frequency of encountering many misconceptions encountered in students regarding the concept of light is decreased after education. The frequencies of encountering the misconceptions, which are "Light rays randomly reflect from the nontransparent object", "some of the light rays pass through a nontransparent object, whereas some light rays reflect", "the length of the shadow does not change according to the size of the object" and "Moon Eclipse occurs when the Moon is not seen from the Earth as Moon comes between the Earth and the Sun" slightly increased. The instruction could not be

very effective in the change of opinions on these misconceptions. We may call these misconceptions as misconceptions that are resistant to change.

The misconceptions, which are "The length of the shadow is always smaller than the object" and "the size of the shadow depends on the brightness of the Sun" is similarly encountered in Gan (2008) students. Eaton, Anderson and Smith (1984) encountered the misconception that says "Light rays reflect back from the nontransparent object" in secondary school fifth grade students. Barnett and Morran (2002) found out that students in secondary school fifth grade confuse moon and sun eclipses. The misconceptions encountered in the question about the path followed by the light when it meets the object" is seen for the first time in this study.

Recommendations

Studies intended at revealing the opinions of students from different age groups regarding the concept of light are carried out. As a result of this study, it is determined that students have various misconceptions regarding the concept of light. There are not many studies carried out in literature on students' misconceptions regarding the concept of light. The conceptual change that occurs in students can be investigated by performing studies where various conceptual change strategies are used. Studies that particularly investigate the opinions of students at secondary school level on the concept of light, and the change in these opinions. Similar studies on different science concepts can also be performed.

It is determined in the results of this study that the frequencies of encountering some misconceptions increase after education. The reason why the instruction causes an increase in students' opinions about misconceptions can be investigated.

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