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RESEARCH ARTICLE

REMEDIATION OF MISCONCEPTIONS ABOUT GEOMETRIC OPTICS USING CONCEPTUAL CHANGE TEXTS

Süleyman AYDIN

Ağrı İbrahim Çeçen University, Education Faculty, Elementary Education Department, Turkey

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ABSTRACT

By exploring the Science Teacher program students' misconceptions, this study is aimed to eliminate their misconceptions about geometric optics with conceptual change texts. At the first stage, the data were obtained by applying a three-tiered multiple choice test containing 19 questions, improved for Agri Education Faculty Science Teaching Department 90 sophomore students and a classic exam related to the subject in autumn season. To determine misconceptions concerning the geometric optics, randomly chosen 10 sophomore students were interviewed with 10 open-ended questions. Findings obtained from the test and interviews showed that students have misconceptions about "propagation of light", "reflection of light" and "refraction of light". At the second stage, the sample composed of 90 students was separated into two group as experimental group and control group. The conceptual change texts were prepared then to apply for instructional method in experimental group. By being parallel to each other conceptual change text method for experimental group and traditional lecturing method for control group were applied respectively. Later the test consisting 19 multiple choice test were applied as post-test in both experimental and control group. The data appearing coherent of 35 each of experimental and control group were taken into consideration. Reliability of the test that used as pre-test and post-tests were calculated by Cronbach-Alfa coefficient as 0,69 by using SPSS-11 for Windows. The study showed that the conceptual change texts are more effective than traditional method for instruction to eliminate students' misconceptions about geometric optics.

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INTRODUCTION

Many scientists have now come to recognize that the process of conceptual accommodation lies in the center of science teaching and learning. Therefore, it is suggested that science educators seriously consider the process of conceptual change in a serious manner. (Posner *et al.*, 1982). This model of conceptual change, a theory formulated by Posner *et al.* towards the end of the twentieth century, is considered as one of the most illuminating and elucidative models for the process of conceptual structuring (Demastes *et al* 1996; Tyson *et al.* 1997; Beeth 1998; Feldman 2000; Thorley and Stofflett 1996; Dagher 1994; Cobern 1996). Strike and Posner (1992) clarified the scope of the conceptual change theory in detail and stressed that it aims at bringing out situations that are necessary to restructure existing concepts. According to Posner *et al.* (1982) learning takes place in the light of a student's existing conceptions and previous experience. Whenever students face a new phenomenon, they need to refer to their existing conceptions to grasp the meaning of that phenomenon. Without existing concepts, it is impossible for a student to ask and answer questions about a new phenomenon and neither relate the features of this phenomenon to those of others nor differentiate from them. Aforementioned authors refer to two dimensions of learning in the learning process of which the first is called assimilation.

and represents the process of reconciling or incorporating a new conception with the existing one in the students, while the second is called conceptual change or accommodation, which indicates the efforts of a student to reorganize his/her existing conceptions that fall short of his/her grabbing a newly-introduced concept or replace them with new conceptions. With the conceptual change model, Posner *et al.* (1982) aimed to deal with this second dimension of learning.

One of the methods that would ensure permanent conceptual learning is to use conceptual change texts. Hynd and Alvermann (1986) define conceptual change texts as text which clearly reveal the inconsistencies between scientifically correct knowledge and misconceptions. In a conceptual change text, students are first asked a question to activate their misconceptions related with the subject concerned. Subsequently, subject related common misconceptions are pointed out and the reason of why this information is incorrect is explained, through which students question their existing misconceptions and realize the deficiencies in their knowledge. Next, new information is disclosed and students are provided with examples. Handing out the conceptual change texts to students is preferable to ensure a sustained and permanent conceptual change. To fulfill students' misconceptions, a number of instructional strategies based on Posner *et al.*'s (1982) conceptual change model have been proposed. For instance, an instructional model which was developed by Champagne and called ideational confrontation

is one of them. According to ideational confrontation model, teacher brings a situation that exemplifies some common misconceptions to the students' attention in a classroom environment. Having expressed their individual opinions about what will happen at the end, students discuss what they think and defend them in the classroom environment as well. Afterwards, the actual consequence is presented and then after pointing out inconsistencies among the students' opinions regarding the situation, the teacher makes correct explanations. (Wang and Andre 1991).

Another instructional model based Posner *et al.*'s conceptual change approach was developed by Roth (1985). In this model, the teacher is supposed to identify common misconceptions among the students. Thereafter, these misconceptions are activated by bringing forward situations that would trigger the student to explain based on their existing misconceptions. In the next stage, students' questioning their misconceptions is ensured through subject related common misconceptions and the evidences that would prove their incorrectness. Finally, scientific explanations with regard to correct form of the misconceptions should be made.. Roth reports that a greater success is achieved with students in the instructional process using the above-mentioned method than in a process using the traditional method. (Chambers and Andre 1997).

It is often emphasized that teacher–student and student–student interaction is important so as to promote effective conceptual change in instructional process. Such methods are particularly effective in small-sized classrooms, while they are more difficult to accomplish in larger classes with a larger number of students. Thus, in such larger classes, using texts with features that will promote conceptual change (conceptual change texts) may facilitate students' construction of their own conceptions, which will be more consistent with those considered as scientifically correct. Conceptual change texts may be used as supplementary material to improve teacher-centered classroom activities. Furthermore, using conceptual change texts in small-class situations may help teachers as a method to promote conceptual change and thus, enrich instruction (Chambers and Andre 1997).

Using conceptual change texts is considered to be one of the most effective instructional methods that have been designed to promote conceptual change (Guzzetti *et al.*, 1992). The present study also uses conceptual change texts to determine the effectiveness of the conceptual change approach on enhancing student understanding of the concepts related to resolution. Optics has become one of the subjects that cause common student misconceptions in science and particularly, physics education. The learning of optics is of crucial importance in that it constitutes base for learning many other subjects in the curriculum. Therefore, examining the scope and origins of misconceptions about optics plays an important role in developing instructional techniques to remediate such misconceptions. This is in conformity with the opinions of researchers such as Driver and Ausubel who put forward that in the making of development of methods on better understanding of the scientific concepts, existing knowledge of the students should be considered at the beginning (Prieto and Rodriguez 1989).

In science and particularly physics education, light has been one of the subjects in which misconceptions are most commonly observed. There are numerous studies which reveal various misconceptions on the subject of light. Being related with the diffusion, nature and reflection of light, these studies have provided such conclusions that students have misconceptions about these areas. In order to remediate such misconceptions, teachers must first attempt to identify them and then, focus on them to present new, plausible and useful concepts; to reinforce these new concepts through examples based on experience; and even to reorganize their curricula by considering student intuitions and opinions (Buyukkasap *et al.* 2001b; Buyukkasap and Samancı 1998; Kaya and Buyukkasap 2004; Akdeniz and Yigit 2000; Brown 1992; Cansungu and Bal 2002; Carmichael *et al.* 1990). In the studies which are designed to remediate misconceptions it is found out that the student misconceptions about the related physics and science areas can be eliminated by using conceptual change texts, activities, computer-supported in-class presentations, and analogies and be obtained more successful than traditional instruction methods (Canpolat 2002; Buyukkasap *et al.* 1998; Brown 1992).

It is well-known that students have previous knowledge on various subjects prior to the instructional process and this knowledge is considerably different from the scientific information contained in the curriculum. Hence, researches regarding assessment of teaching techniques that would help identification of reasons of incorrect knowledge of the students and removal of them are increasingly gaining prominence. Current science instruction related studies focus on identifying misconceptions, their origins and finding ways on how to eliminate them in the instructional process. They often reveal that certain part of the misconceptions persist in some students, even after an instructional process. The most common causes of misconceptions could be listed as misperception or lack of perception of previously acquired conceptions namely they are inconsistent with the scientific definitions; the difference in use of concepts between daily and scientific languages; the failure to provide appropriate environments to teach certain subjects and concepts; presenting concepts without establishing connections between them and mostly, without relating them to daily phenomena.

The results of the studies on misconceptions put increasing emphasis on the significance of concept teaching. From the elementary school stage to higher levels of education, “the nature, refraction and reflection of light”, which are among the basic subjects in science instruction continuing to present difficulties for students. Therefore, concept teaching will also be useful in getting students to better grasp these fundamental subjects. One of the most effective methods in concept teaching is using conceptual change texts and it is obvious that it will have a positive effect on the teaching of the subjects of geometric optics. Thus, the present study aims to identify the misconceptions about the diffusion, nature, reflection and refraction of light among sophomore students in the Department of Science Education, who are likely to be employed in the 2nd stage of primary education; and in the light of the obtained results, to prepare conceptual change texts; and to further determine the effectiveness of these texts in the remediation of misconceptions when compared to traditional instruction methods.

MATERIALS AND METHODS

The Problem and Hypothesis

Study purpose

The study aims to determine the conceptions and misconceptions of prospective science teachers about refraction and reflection, and to remediate misconceptions using conceptual texts. In addition, helping students acquire scientific thinking skills for the subjects of refraction and reflection, ensuring that they thoroughly learn the concepts they are supposed to know, remediating their misconceptions about the field of optics through conceptual texts, helping them establish connections between the basic concepts they know and the phenomena they encounter in daily life, keep them updated about the latest developments in technology and guiding them to science and optical technology, the study is intended to contribute in their education.

Sub-problems

In order to achieve the purposes states above, the study will also seek answers to the following sub-problems:

- 1- Do prospective science teachers have any misconceptions about the subjects of refraction and reflection in the optics course?
- 2- Do prospective science teachers possess scientific thinking skills for the subjects of refraction and reflection in the optics course?
- 3- Were prospective science teachers thoroughly taught the concepts they are supposed to know for the subjects of refraction and reflection in the optics course?
- 4- Is it possible to create accommodation texts based on the misconceptions of students?
- 5- Are conceptual change texts able to bring about a change in the misconceptions of prospective science teachers about optics?
- 6- Are prospective science teachers able to establish connections between the basic concepts they know about the subjects of refraction and reflection in the course of optics and the phenomena they encounter in daily life?
- 7- Do the scientific process skills of students have a significant contribution to the understanding of the concepts about refraction and reflection?

Hypotheses

The hypotheses of the research are as follows:

H₀₁- Should the scientific process skills of students be taken under control, it could be possible to prepare accommodation texts drawing upon their misconceptions.

H₀₂- Should the scientific process skills of students be kept under control, in the understanding of conceptions about refraction and reflection in geometric optics, their misconceptions could be eliminated or reduced using accommodation texts and through a teaching method based on the conceptual change approach.

H₀₃- It is possible to obtain the results of conceptual change strategy and a statistical analysis of the results reveals a significant difference.

H₀₄- The effects of conceptual change texts are important for students to acquire the scientific skills about refraction and reflection in geometric optics, and they could be statistically determined.

METHOD

In order to determine the effectiveness of the conceptual change approach and the traditional method, the "semi-experimental method", an experimental research model, was used. The semi-experimental method is an experimental research approach in which it is not possible to assign the persons to experiment and control groups through random distribution (Campbell & Stanley 1963). This method usually entails studying on multiple samples over a long period of time. The most striking difference between classical and semi-experimental methods is that the groups are not randomly formed but on the basis of measurements in the latter, while the former does that in a random manner. The reason why the present study prefers the semi-experimental method is that, as it is performed in a natural environment, it has a higher external validity compared to other methods. Furthermore, the experimental method could be employed in studies aiming to determine cause-and-effect relationship by examining a factor, and then to compare and measure the results. However, studies using the semi-experimental method do not have such limitations.

The semi-experimental method is summarized in the Table 1.

Table 1. Semi-experimental method

Groups	Pre-tests	Application	Post-tests
Experiment Group	T ₁ , T ₂	Conceptual change approach	T ₃
Control Group	T ₂	Traditional teaching method	T ₃

Where T₁ refers to the face-to-face interview questions administered to students in order to determine the misconceptions; and T₂ and T₃ indicate the pre-test and post-test, respectively.

In order to reveal the misconceptions of students about geometric optics, prior to the application, ten open-ended questions were addressed in face-to-face interviews to ten students who were selected from the sample group and an examination was administered to the entire sample. After performing the pre-test and application which were developed in the light of the misconceptions identified at the initial phase of the study, the post-test was administered to all the students within the scope of the study. While preparing the test (a three-stage misconception test), the available literature was used and five academics specialized in the field were consulted. The test consists of 19 questions, each with three stages.

Study sample

The study sample consists of 90 sophomore students taught by the same lecturer in two separate sections in the Department of Science Education of Agri Faculty of Education at Ataturk University. The application was performed in the spring semester of the 2004-2005 academic year.

In order to identify the misconceptions at the beginning of instruction, a three-stage pre-test, a classical exam and a ten-student interview was administered on the subjects of reflection, refraction and diffusion of light. One of the two groups was selected as the experiment group and the other as the control group. The experiment group was administered the teaching method through conceptual change texts, and the control group was taught using the traditional teaching method. The post-test application were implemented on a total of 90 students from the control and experiment groups, and the data of 35 students who were regarded as consistent from each group were taken into consideration.

Instruments used in the Study

Open ended, face-to-face interview questions about the diffusion and refraction of light. The questions consist of 10 open-ended questions. Drawing upon the available literature, the commonly observed misconceptions of students about "diffusion of light", "reflection of light" and "refraction of light" in geometric optics were taken into consideration while preparing the questions. The questions were addressed to 10 students not included in the sample group of the study and an analysis of the data demonstrated that misconceptions identified in the literature also exist among the students of the Department of Science Education of Agri Faculty of Education. Subsequently, the pre-test and the post-test were developed in the light of these identified misconceptions. All of the formulated questions are about geometric optics and although each of them were prepared to evaluate a single particular concept on the issue, other question types examining the same particular concept were also included. They were also organized in a such a way that allow to assess students' knowledge of geometric optics at basic level

Among ten questions addressed during the face-to-face interview, the first is about the diffusion of light, the second about refraction, and the third, fourth, fifth and sixth about the formation of image in a plane mirror pertaining to the subject of reflection. The seventh and eight questions are about drawing special rays during refraction of light on concave lenses and drawing special rays on convex mirror, respectively. The ninth question is about the properties of images formed by refraction, whereas the tenth question tests student knowledge of whether a dark object could reflect light.

The three-tiered misconception test

In this three-tiered test, the questions in the first stage were prepared in a written format, which were then represented on figures in the second stage, whereas the questions of the third stage were formulated so as to examine whether the respondents were certain of their answers. The motive behind organizing a three-stage test was to improve the validity of the data to be obtained. In the selection of questions, the test questions formulated by Chen *et al.* (2002) to identify the misconceptions of Taiwanese high school students about image on plane mirrors were used and specialists in the field were consulted by taking into consideration the misconceptions and target behaviors on the issue. The researcher initially prepared 30 multiple-choice test questions to determine students' level of comprehension and their

misconceptions about the diffusion, reflection and refraction of light. Upon the examination in terms of validity by 5 academics who are specialized in the field and employed in the Agri Education Faculty and Kazım Karabekir Education Faculty of Ataturk University, necessary corrections were done and, the number of questions was then reduced to 22. The test questions were prepared in multiple-choice format and each last choice was left as blank following the statement of "If you believe none of the above is true, please indicate the correct one with a written expression or a figure. In each test question, one of the choices was formulated as the correct answer and others formulated in a way that includes phrases with common misconceptions. In first stage of this three-stage test, the respondents were asked to indicate in which of the choices a given statement is found, or if not, to write down the correct form of the statement. In the second stage, students were asked to make geometric drawings of a particular phenomenon presented in the previous stage, and in the final stage they were asked whether they are certain of their answers. The pilot application of the test was made on 32 freshman students receiving education in the Department of Science Education of Agri Faculty of Education. At the end of the pilot application, it was realized that students could not properly understand 3 of the test questions, and, in addition to the clarification of some unclear concepts, these questions were then removed, which gave its final form to the test.

Reliability refers to the error-free measuring capability of a measurement instrument. Reliability coefficient denotes not the inaccuracy but the accuracy in measurements. Although reliability estimations based on the assumptions of the classical test theory are sound techniques, reliability estimations could prove to be inadequate in certain cases as its processes are based on two separate measurements conducted on a single individual. In order to avoid this deficiency, the present study uses "generalizable test theory" in measuring reliability. Cronbach alpha reliability coefficient is a value demonstrating that a sample randomly selected from a group of samples randomly picked from the universe of observations is appropriate for generalization. In cases where the items in the test are not provided as true and false, as is the case with this study which presents them in the form of 1-1, 1-2, 1-3 etc., the Cronbach alpha coefficient method is an appropriate method for estimating internal consistency. The Cronbach alpha coefficient is a weighted average standard change which is obtained by proportioning the total variances of n number of items to the overall variance. The reliability coefficient has a range of values between 0 and 1, and the closer is the value to 1, the more reliable is considered measurement. Using the SPSS-11 software for Windows, the present study calculated the Cronbach alpha reliability coefficient, and α reliability coefficient of the test was found to be 0.69. This test prepared during the application was used both as the pre-test and the post-test.

Application

This study was administered to a total of 90 sophomore students receiving education in two separate sections in the Department of Science Education of Agri Faculty of Education at Ataturk University during a period of four weeks in the spring semester of the 2004-2005 academic year. However, based on the results of a classical examination and the pre-test data, only the consistent data obtained from 70 of

these students were taken into consideration. The study investigates the effectiveness of teaching methods that employ conceptual change texts on the learning of geometric optics concepts. To this end, besides using the traditional teaching method, it also employed teaching methods based on the conceptual change approach about the subjects of geometric optics for the students included in the experiment group. As they achieved similar scores in the Student Selection Examination (OSS), it was understood that there is not any significant difference among the levels of the students constituting the sample group of the study. Following the pre-tests, the application was initiated in both groups included the sample group of the study. Covering two class hours per week, the application was performed by the researcher himself. The subjects pertaining to the geometric optics were discussed in accordance with the physics curriculum. For a period of four weeks, the students constituting the sample group of the study were taught the subjects of geometric optics using methods based on the conceptual change model. Thus, attempts were made to determine the effectiveness of this method on students' comprehension of the related concepts. To put it another way, it was the effectiveness of this approach that was investigated to accomplish conceptual change, which is defined as the process of accommodating the scientifically incorrect knowledge (misconceptions) of the students or replacing them with more correct conceptions. As was stated above, certain conditions must be met for conceptual change to take place. Thus, the first priority is to make students feel that their existing conceptions are deficient. In the subsequent stages, students are supposed to find the new information intelligible, reasonable and productive. Hence, the conceptual change texts were used in order to meet these conditions.

In a conceptual change text, which is defined as a method clearly demonstrating the contradictions between scientifically correct information and misconceptions, students are first addressed a question to activate their misconceptions on a particular subject. Next, placing emphasis on common misconceptions about the issue, they are explained why such knowledge is incorrect. This leads students to question their own misconceptions, feeling the deficiency in their knowledge. Finally, the new information is illustrated through examples. As for the control group, sessions were delivered in the form of simple lecturing, which are applied in traditional teaching methods. Thus, attempts were made to determine in which of the two methods permanent learning takes place; the traditional method based on a strict, lecturer-centered sessions using limited materials, or the method applied to the experiment group, aiming to achieve meaningful learning through the use of conceptual change texts. The program which is based on the conceptual change approach, using the conceptual change texts and accordingly applied in teaching the subject of geometric optics is briefly summarized in Table 2 presented. During the teaching of the subjects in the experiment group, students were invited to be as active as possible in order to ensure their participation. To this end, frequently addressing questions to the students, the researcher aimed to reveal the ideas of the students on the subjects in order to create a discussion environment. The acquisitions expected to be observed in students during the discussion of each subject are provided in. The last fifteen minutes of each session with the experiment group were dedicated to the use of conceptual change texts, which constitute the principal method of the conceptual change approach. Namely, fifteen minutes

before the end of each session, conceptual change texts, which were prepared to place emphasis on and remediate the misconceptions of that particular session, were used. The conceptual change texts were distributed to all the students in the class and after ensuring a careful reading of the texts, the researcher answered their questions – if any – about the concepts explained in the texts, provided explanations on the points left unclear and through discussions on the concepts, aimed to bring about a shift from unscientific knowledge to those considered as scientifically correct, in other words, subjecting them to conceptual change. The post-test, which is generally designed in order to understand whether a permanent learning takes place through conceptual change texts, should be applied one month after the pre-test at the most. Therefore, the post-test of the study was administered one month after the process of applying the conceptual change texts. The summary of the program administered to the experimental group is given in Table 2.

Table 2. The program administered to the experimental group

1 st Week	1	The phenomenon of light; students' ideas about the generation of light, the nature of light, interaction between light and matter, and the dual nature of light.
	2	Solving problems following the explanation of the diffusion, speed and frequency of light, and the characteristics that change these parameters. A discussion on these concepts – the nature of light – by distributing the related conceptual change texts to the students.
2 nd Week	1	Laws of reflection, explanation of the subject of images formed by reflection (formation of image in a plane mirror) by teaching specular and diffuse reflection. Solution of related problems.
	2	The phenomenon of reflection on smooth surfaces. Reflection of light and special rays in concave mirrors. A discussion on the reflection of light, laws of reflection and special rays in concave and convex mirrors by distributing the related conceptual change texts to the students.
3 rd Week	1	Special rays in convex mirrors. Image formation in concave and convex mirrors, solution of example problems, and a discussion on the issue by distributing the related conceptual change texts to the students.
	2	Laws of refraction. The reasons behind the refraction of light when passing through transparent media. Snell's Law. Solution of related problems. A discussion on the laws of refraction by distributing the related conceptual change texts to the students.
4 th Week	1	Lenses. Special rays in convex and concave lenses. Solving example problems about special rays.
	2	Images formed by refraction, image formation in convex and concave lenses. Solution of related example problems. A discussion on images formed by refraction by distributing the related conceptual change texts to the students.

Data analysis

For the present study conducted to determine prospective teachers' comprehension levels of the concepts of geometric optics; to identify their misconceptions; and to remediate them, the obtained data were analyzed using simple statistical methods. The results of the study were subjected to a two-stage analysis, which consisted of the analysis of the interview questions used as the data collection instrument and the analysis of the data from the pre- and post-tests. The analysis of the interview questions was performed by evaluating the student responses to questions. In the face-to-face interviews, the students were addressed with some questions about the

subject; their responses were recorded; and securing consistency was aimed between what the students meant by their statements and what they articulated. Thus, generalizations were made with the response frequencies. The identified misconceptions provided the basis for the pre-test and post-test to be prepared. Thereby, frequency and percentage calculations were performed to identify the student misconceptions about the geometric optics, as well as to reveal to what extent they abandoned these misconceptions after the administration of conceptual change texts. The Experiment and Control groups were separately administered the t-test in order to identify the relationship between the pre- and post-test results of the students in both groups. The t-test is performed to determine whether there is a significant relationship between the pre-test and post-test responses of a group or between the pre-test and post-test results of two groups. SPSS 11 was used for data analysis. Moreover, the results of the t-test obtained using the SPSS 11 program were employed to determine whether there was any difference among the students in terms of their scientific process skills, as well as for the significance check between the test questions. The Assumptions and Limitations of the Study

The assumptions and limitations of the study are as follows:

Assumptions

- 1- The study sample and the study universe are the same.
- 2- It was assumed that the intelligence levels of the individuals in the study sample were similar.
- 3- It was assumed that there was no interaction between the experiment and control groups during the application.
- 4- The researcher was unbiased towards the participant students who were included in the sample group, as well as to those who did not participate in the study.
- 5- The level of preparedness on the part of students was the same in both the experiment and control groups.

Limitations

- 1- The sample group of the study was limited to a total of 90 sophomore students enrolled in the Science Teaching Program at the Faculty of Education at Ataturk University.
- 2- The subjects of the study were limited to certain subjects of geometric optics, which are the nature, diffusion, reflection and refraction of light.
- 3- The application was completed in four weeks.

RESULTS

Comparison of the Results

In this section, comparisons were made between the pre- and post-test results of the control and experiment groups, respectively, and the mean values are presented below in tables.

Comparison of the pre-test results

The comparison of the pre-test results revealed a striking similarity between the frequency and percentage levels of comprehension and misconception of the students for the same

subjects of geometric optics (Table 3). These results could be considered as indicating that both groups (experiment and control groups) were homogenous both at in-group and inter-group levels.

Table 3. Comparison of the pre-test results of the experiment and control groups

Group	Subject	Comprehension		Misconception		Level of Certainty	
		Frequency	Percentage (%)	Frequency	Percentage (%)	Frequency	Percentage (%)
Experimenta 1 group	Reflection of light	20	57.1	15	42.9	29	82.9
	Refraction of light	19	54.3	16	45.7	30	85.7
	Diffusion of light	9	25.7	26	74.3	23	65.8
Control group	Reflection of light	19	54.3	16	45.7	29	82.9
	Refraction of light	18	51.4	17	48.6	30	85.7
	Diffusion of light	10	28.6	25	71.4	23	65.8

The comparison of the pre-test results revealed a striking similarity between the frequency and percentage levels of comprehension and misconception of the students for the same subjects of geometric optics (Table 3). These results could be considered as indicating that both groups (experiment and control groups) were homogenous both at in-group and inter-group levels.

Comparison of the post-test results

Table 4. Comparison of the post-test results of the experiment and control groups

Group	Subject	Comprehension		Misconception		Level of Certainty	
		Frequency	Percentage (%)	Frequency	Percentage (%)	Frequency	Percentage (%)
Experiment Group	Reflection of light	25	71.4	10	28.6	32	91.4
	Refraction of light	24	65.7	12	34.3	32	91.4
	Diffusion of light	19	54.3	16	45.7	29	82.9
Control group	Reflection of light	21	60	14	40	32	91.4
	Refraction of light	22	62.9	13	37.2	32	91.4
	Diffusion of light	16	45.7	19	54.3	33	94.1

An examination of Table 4. reveals that the mean of the post-test results of both the experiment and control groups is higher than the mean of their pre-test results. The higher mean values of the experiment group confirm the superior qualities of the method of using conceptual change texts over traditional methods.

DISCUSSION AND CONCLUSION

This section discusses the study results presented in the preceding section; focuses on the origins of the

misconceptions about light and evaluates the effectiveness of the conceptual change texts designed to remediate them; makes comparisons drawing upon the related literature; and puts forward some suggestions concerning future studies on the subject.

As the findings obtained from the pre-test results show, for the subject of reflection, students' level of comprehension was 57 % in the experiment group and 54 % for the control group (Table 3.). On the other hand, the post-test results for the same subject reveal that the comprehension levels of prospective teachers considerable increased after the CCT (conceptual change text) application. The level of increase was 14 % for the experiment group and 5 % for the control group (Table 4.). The comprehension level of the students is low for reflection of light. At comprehension level, a student must be able to organize and interpret that s/he has learned, which means that s/he can visualize and express in different ways using different words any information presented to her/himself. An examination of the responses of the participant students reveals that in the free response items in the second step of test questions, in particular, they could not express what they learned using different statements and in most questions, the statements failed to convey the expected information. The primary misconceptions of students about the reflection of light were as follows: "To see an object in a plane mirror, the light source should shine on the mirror", "To see an object in a plane mirror in a dark room, both the mirror and the object should be illuminated", "The moving of the light source used to create images affects the size of the plane mirror image of the object", "The plane mirror image of an object will move and change in height when the observer moves", "The rays sent to concave and convex mirrors refract at the mirror surface, then pass to the back of the mirror", "The image of a black object cannot be seen in the mirror". These results confirm those obtained by other researchers (Chen *et al.* 2002). It could be suggested that such misconceptions are created since the students believe that the light must radiate from the mirror so that an object can be seen; teachers do not emphasize the light source while presenting the students with drawings about image formation; and they do not represent the observer in their drawings.

The results of the pre-test results showed that, for the subject of refraction, students' level of comprehension was 54 % in the experiment group (Table 3.), while the results of the post-test following the introduction of CCT reveal that the mean of their comprehension levels on the subject was 65.7 % (Table 4.). On the other hand, the comprehension level of the control group on the refraction of light was found to be 51 % (Table 3.). These results also demonstrate that the application of CCT significantly contributed to the comprehension levels of students (12 %), the reason for which, it is obvious that, is the application of conceptual change texts to achieve meaningful and permanent learning in instruction.

Certain misconceptions were detected in students regarding the refraction of light, which are "The image of an object in a dense medium moves away when it is observed through a less dense medium" and "A light ray moving in any direction towards a convex lens reflects away from the lens and continues its travel". These results are also consistent with those of other researchers (Cansungu and Bal, 2002). Similar

to the misconceptions which Chen *et al.* (2002) obtained in their study, "To see an object in a plane mirror, the light source should shine on the mirror. Changing the position of a light source in a plane mirror will also change the position of the image. While the positions of the observer in a plane mirror changes, the position of the image will change as well". The study by Goldberg and McDermott (1986) obtained almost the same misconceptions about the subject.

The findings obtained from the pre-test results showed that, for the subject of the diffusion of light, students' level of comprehension was 25.7 % in the experiment group (Table 3.), and 28.6 % (Table 4.) for the control group. On the other hand, according to the post-test results, it was observed that these figures were 54.3 % (Table 4.) for the experiment group and 45.7 % (Table 4.) for the control group. These results indicate that the application of CCT brought a positive effect of 28 % in the remediation of misconceptions. In contrast, the positive change in the control group for the same subject could only amount to 17%.

It is obvious that the students' comprehension of the diffusion of light is at a quite low level. The misconceptions detected in students regarding the diffusion of light are "While diffusing in different media, the refractive index of light does not depend on the factor of refractive index of its speed", "Speed, intensity and wavelength of light do not change while it propagates in different media" and "As light passes from one transparent medium to another, its frequency changes".

It could be suggested that such a low level of comprehension about the subjects of optics result from the fact that, during their secondary school years, students did not receive a sufficient and effective education about the issue, that secondary schools fail to attach the due importance to these subjects because of the OSS (Student Selection Examination) system of examination, and that no sufficient laboratory exercises were held. In the study they conducted on the concepts of light and atom, Kaya and Buyukkasap concluded that the misconceptions of students are basically because of the primary and secondary school teachers as well as textbooks and other written teaching materials (Kaya and Buyukkasap, 2004). It could be argued that another reason behind this low figure is that the students of our sample group generally receive their secondary education in rural schools where physics lessons are taught by out-of-field teachers.

Nevertheless, it should be acknowledged that, following the CCT application, an 18 % decrease in the misconceptions about the reflection, refraction and diffusion of light is a considerable achievement. As a matter of fact, such an increase could be considerably attributed to the interest in the subjects of geometric optics and that drawings about the subjects of optics are easier to those in other branches of physics.

As seen in Table 5 and 6, a t-test was performed regarding the pre- and post-tests administered to the sample group and it was concluded that there is a statistically significant relationship between the pre-test and post-test responses of the students in the experiment group.

Table 5. t-test results of pre-test and post-test for the control and the experiment groups.

Sample Group	Tests	N	\bar{X}	S.S	t	p
Experiment Group	Pre-test	35	50.542857	11.23634	-6.937	0.001
	Post-test	35	68.571428	10.49449		
Control Group	Pre-test	35	48.502421	10.41532	-4.581	<0.001
	Post-test	35	62.453916	9.34486		

Table 6. t-test results of post-test for the control and the experiment groups

Sample Group	Tests	N	\bar{X}	S.S	t	p
Experiment Group	Post-test	35	68.571428	10.49449	-4.923	0.001
Control Group	Post-test	35	62.453916	9.34486		

After the scoring, the mean of the post-test results of both the experiment and control groups was higher than the mean of their pre-test results, which demonstrates that the sample group was homogenous and when the mean scores for the pre- and post-tests are considered, the mean scores for the post-test were higher than the mean scores for the pre-test. The higher mean scores of the experiment group show that the method using conceptual change texts produces better results than the traditional method. In other words, a significant increase in the success levels of students was observed following the application of conceptual change texts. Besides, a significance at the level $p = 0,001$ was detected as a result of the t-tests between the post-tests of the experiment and control groups.

It is meaningful that a decrease occurred in the number of student misconceptions observed in both the experiment and control groups after the administration of conceptual change texts and traditional instruction methods, respectively. Such decrease is the expected outcome of any instruction in both groups. However, the level of decrease in the misconceptions of the experiment group is higher than that of the control group. Furthermore, an examination of the results of the t-test with regard to the mean of the correct student responses for each question reveals that the mean scores for each response in the post-test were usually higher when compared to the pre-test responses. In general, the student misconceptions about geometric optics was remediated by 53 % using conceptual change texts, while the level of remediation achieved was only 34 % in the control group to which the traditional instruction method was applied.

All these results show that using conceptual change texts in classes will be effective to get students grasp the related concepts, a result which is confirmed by similar studies investigating the effectiveness of conceptual change texts (Goldberg and McDermott 1986; Chen *et al.* 2002). Suggesting in their study that science educators should seriously deal with the process of conceptual change, Posner *et al.* (1982) maintain that to accomplish conceptual change, the student should realize the deficiencies in his/her own knowledge; find the newly-offered information as intelligible, reasonable and productive, and use it in solving new problems. Similarly, Chambers and Andre (1997) report that, when compared to the traditional method, students are much more

successful in learning new concepts through the teaching process using the conceptual change approach and also claim that applying the conceptual change texts will yield much more positive results in classes with smaller number of students. Carey (2000) also states that the teaching method of conceptual change could be fruitful, while Wang and Andre (1991) propose the method of conceptual comparison for conceptual change to take place. Yet, it is acknowledged that the teaching method applying conceptual change texts is one of the most illuminating and elucidative models for the process of conceptual structuring (Demastes *et al.* 1996; Tyson *et al.* 1997; Beeth 1998; Feldman 2000; Thorley and Stofflett 1996; Guzzetti *et al.* 1992; Dagher 1994; Cobern 1996). Basili and Sanford (1991) report that, even though they do not encompass conceptual maps, collaborative groups in concept-based teaching methods play an evident role in helping students remediate certain misconceptions. Several studies also report that conceptual change texts constitute one of the effective teaching methods for remediating student misconceptions about the subjects of science (Hewson and Hewson 1983; Hynd *et al.* 1997; Pinarbasi 2002; Canpolat 2002; Palmer 2003; Chen and Lin 2002). In the light of the prior studies and the results of the previous study, it has been concluded that instruction using conceptual change texts will be useful to achieve an effective learning.

Suggestions

1. Considerable space in the existing literature has been devoted to conceptual change texts as a crucial method for their effects on student success, remediating their misconceptions. The present study also confirms these suggestions. Therefore, before starting to lecture the subjects in science teaching, teachers should first identify the knowledge or misconceptions of students about a particular subject, and use CCT to remediate such misconceptions.
2. During their preparation, conceptual change texts should include well-defined conceptual information, and, if possible, be enriched through computer-aided animations, simulations, and media files such as slides etc. This will promote student interest in the concepts, ensuring an easier and permanent learning. It should also be noted that, even students receive education on the basis of conceptual change texts, these will not themselves suffice to achieve a thorough change, which also needs active participation of students by creating a discussion environment in the class (Guzzetti *et al.* 1992; Hynd *et al.* 1994; Eryilmaz 2002).
3. In drawing figures about image formation while teaching the subject of reflection, teachers and instructors should lay emphasis on the behavior of the rays outgoing from the light source to the object and indicate the position of the observer; and even include the observer in their drawings.
4. Since textbooks and education process usually focus rather on the principles of image formation and the rays are not illustrated behind the image point, the ray diagrams that students draw do not help them understand the role of the eye. The position of the observer plays a critical role in optics education (Ronen and Eylon 1993). Therefore, while teaching the subject of lenses as well as the image formation, teachers should emphasize the

position of the eye. Using a functional eye model in ray diagrams is essential for comprehending the relationship between image formation and observation (Epik *et al.* 2001). Educators should illustrate ray diagrams through PowerPoint presentations on the computer and use action effects for each ray. Incorporating the observer and the light source into such a presentation could be more fruitful.

5. Most students do not know about the function of lenses, without which they believe that image formation could take place. This is also emphasized in a study by Goldberg and Dermott (1987). For students to observe the contradictions between the experiments they themselves conduct using lens systems and their own knowledge, which would lead them to question and overcome their misconceptions; laboratory and demonstration experiments should be much more valued and classroom environments should be better equipped to earn them concrete experiences.
6. For further similar studies, researchers should make use of the literature at the utmost level, be in continuous dialogue with the specialists in the field and try to have access to detailed information about the educational experiences and studying environments of each individual who will be a part of their sample groups to be subjected to the conceptual change texts. Particularly taking the attendance status of the individuals included in the experiment group, researchers should adjust their timing for further studies. Furthermore, there is the need for investigating the weaknesses of similar studies, which should be overcome through certain activities. While conducting this study in the Department of Science Education at Agri Faculty of Education, the researcher attempted to overcome difficulties by rewarding and encouraging the participants, organizing the lectures as student-centered sessions, and arranging certain hours so as to ensure their optimum level of participation.

REFERENCES

- Akdeniz, A.R. Yıldız, I. Yiğit, N (2000). İlköğretim 6. sınıf öğrencilerinin "Işık" ünitesindeki kavram yanlışları. H.Ü. Eğitim Fakültesi Dergisi, 19, 5-14.
- Basili, P. A. and Sanford, P. J (1991). Conceptual Change strategies and cooperative group work in chemistry. *Journal of Research in Science Teaching*, 28 (4), 293-304.
- Beeth, M. E (1998). Teaching science in fifth grade: Instructional goals that support conceptual change. *Journal of Research in Science Teaching*, 35 (10), 1091-1101.
- Brown, D. E (1992). Using examples and analogies to remediate misconceptions in physics: factor influencing conceptual change. *Journal of Research in Science Teaching*. 29 (1), 17-34.
- Buyukkasap, E. Düzgün, B. Ertuğrul, M (2001). Lise öğrencilerinin "Işık" hakkındaki yanlış kavramları. *Milli Eğitim Dergisi*, 149, 32-35.
- Buyukkasap, E. Samancı, O (1998). İlköğretim öğrencilerinin "Işık" hakkındaki yanlış kavramları. *Kastamonu Eğitim Dergisi*, 4, 109-120.
- Canpolat, N (2002). Kimyasal denge ile ilgili kavramların anlaşılmasında kavramsal değişim yaklaşımının

- etkinliğinin incelenmesi. Yayınlanmamış Doktora Tezi, Atatürk Üniversitesi Fen Bilimleri Enstitüsü, Erzurum.
- Campbel, D. T, Stanley, J. C (1963). Experimental and Quasi-experimental design for research on teaching. In N.L. Gage (Ed), *Handbook of Research on Teaching*, Chicago: Rand, McNally.
- Cansungu K, O Bal, S (2002). İlköğretim 5. ve 6. Sınıf Öğrencilerinin Işık ve Işığın Hızı ile İlgili Yanlış Kavramları ve Bu Kavramları Oluşturma Şekilleri, G.Ü. Gazi Eğitim Fakültesi Dergisi 22 (1), 1-11.
- Carey, S (2000). Science education as conceptual change. *Journal of Applied Developmental Psychology*, 21(1), 13-19.
- Carmichael, P, Watts, M., Driver, R, Holding, B, Philips, I, and Twigger, D (1990). Reserch on students' misconceptions in science. A bibliography. Leeds, Childrens' Learning in Science Group.
- Chambers, S. K. and Andre, T (1997). Gender, prior knowledge, interest and experience in electricity and conceptual change text manipulations in learning about direct current. *Journal of Research in Science Teaching*, 34(2), 107-123.
- Champagne, A. B, Gunstone, R. F, & Klopfer, L. E (1985). "Effecting changes in cognitive structures among physics students", in L. H. T. West & A. L. Pines, eds., *Cognitive structure and conceptual change*, Academic Press, Orlando FL.
- Chen, C. C, Lin, H. S Lin, M. L (2002). Developing a Two-Tier Diagnostic Instrument to Assess High School Students' Understanding of The Formation of Images by a Plane Mirror. *Proc. Natl. Sci. Coun. ROC(D) Vol. 12, No. 3, 106-121.*
- Cobern, W.W (1996). Worldview Theory and Conceptual Change in Science Education. *Science Education*, 80(5), 579-610.
- Dagher, Z.R (1994). Does the Use of Analogies Contribute to Conceptual Change. *Science Education*, 78(6), 601-614.
- Demastes, S.S, Good, R.G, Peebles, P (1996). Patterns of Conceptual Change in Evolution. *Journal of Research in Science Teaching*, 33(4), 407-431.
- Epik, Ö, Kalem, R, Kavcar, N. ve Çallica, H (2001). " Işık ve Görüntü Oluşumu " İle İlgili Kavram Yanlışlarının ve Bilgi Eksikliklerinin Belirlenmesi Üzerine Bir Çalışma. *Buca Eğitim Fakültesi Dergisi*, sayı: 14, s. 64 - 73. İzmir.
- Eryılmaz, A (2002). Effects of conceptual assignments and conceptual change discussion on students' misconceptions and achievement regarding force and motion. *Journal of Research in Science Teaching*, 31(10), 1001-1015.
- Feldman, A (2000). Decision Making in the Practical Domain: A model of Practical Conceptual Change. *Science Education*, 84, 606-623.
- Goldberg, F, McDermott, L. C (1986). Student diffculties in understanding image formation by a plane mirror. *The Physics Teacher*, 24(8), 472-480.
- Goldberg F, McDermott, L.C (1987). An Investigation of Student Understanding Of The Real Image Formed By A Converging Lens Or Concave Mirror, *American Journal of Physics*, 55(2), 108-119.
- Guzzetti, B, Snyder, T.E. and Glass, G.V (1992). Promoting conceptual change in science: Can texts be used effectively? *Journal of reading*, 35(8), 642-649.

- Hynd, C. ve Alvermann, D.E., 1986. The Role of Refutation Text in Overcoming Difficulty With Science Concepts. *Journal of Reading*, 29(5), 440-446.
- Hynd, C, McWhorter, Y, Phares, V.L, Suttles, C.W (1994). The role of instructional variables in conceptual change in high school physics topics. *Journal of Research in Science Teaching*, 31(9), 933-946.
- Kaya A, Buyukkasap E (2004). Fen Bilgisi Öğretmen Adaylarının Işık ve Atom Kavramlarını Anlama Seviyelerinin Tespiti, 6. Ulusal Fen Bilimleri ve Matematik Eğitimi Kongresi, 9-11 Eylül, Marmara Ün., İstanbul.
- Palmer, D. H (2003). Investigating the relationship between refutational text and conceptual change. *Science Education*, 87, 663-684.
- Posner, G. Strike, K. Hewson, D. Gertzog, W (1982) "Accommodation of a scientific conception: Toward a theory of conceptual change. *Science Education*, 66(2), 211-227.
- Prieto, T. Blanco, A. Rodriguez, A (1989). The Ideas of 11 to 14-Year-Old Students About the Nature of Solutions. *International Journal of Science Education*, 11(4), 451-463.
- Ronen, M, Eylon, B.S (1993). To See or Not to See: The Eye in Geometrical Optics -When and How ?. *Physics Education*, vol: 28, s.52 - 59.
- Rota, K.J. (1985, April). Conceptual change learning and students processing of science texts. Paper presented at the annual meeting of the American Research Association, Chicago, IL.
- Strike K, Posner G (1992). A revisionist theory of conceptual change. In: Duschl R, Hamilton R, eds. *Philosophy of Science, Cognitive Psychology, and Educational Theory and Practice*. Albany, NY: State University of New York. Pp. 211-231.
- Thorley, N.R, Stofflett, R.T (1996). Representation of the Conceptual Change Model in Science Teacher Education. *Science Education*, 80(3), 317-339.
- Tyson, L.M, Venville, G.J, Harrison, A.G, Treagust, D.F (1997).. A Multidimensional Framework For Interpreting Conceptual Change Events in the Classroom. *Science Education*, 81, 387-404.
- Wang, T, Andre, T (1991). Conceptual change text versus traditional text and application questions versus no questions in learning about electricity. *Contemporary Educational Psychology*, 16, 103-116.
