Eğitim ve Bilim
2013, Cilt 38, Sayı 167

Education and Science
2013, Vol. 38, No 167

The Effect of Concept Cartoon Worksheets on Students' Conceptual Understandings of Geometrical Optics

Kavram Karikatürleri ile Zenginleştirilmiş Çalışma Yapraklarının Öğrencilerin Geometrik Optik Konusundaki Kavramsal Anlamalarına Etkisi

Erdal TAŞLIDERE*

Mehmet Akif Ersoy University

Abstract

The purpose of this study was to investigate the effect of concept cartoon worksheets, gender and their interaction on pre-service science teachers' conceptual understanding of geometrical optics. Participants were 121 sophomore students from four intact classes. A quasi-experimental design was used as the research method. The experimental group studied geometrical optics with implementation of concept cartoon worksheets prepared in consideration with a constructivist view of learning while the control group studied the lesson unit with traditional instruction. Students' conceptual understandings of geometrical optics were measured by a tree-tier misconception test. The main effects of treatment, gender and their interactions on post-test scores were examined via ANCOVA test. The analysis yielded that the worksheets produced a statistically significant treatment effect; however, gender and gender*treatment interaction effect on students' post-test performances were not significant.

Keywords: Concept cartoon worksheet, geometrical optics, conceptual understanding, misconception

Öz

Bu çalışmanın amacı, yapılandırmacı öğrenme kuramına göre hazırlanmış kavram karikatürleri ile zenginleştirilmiş çalışma yapraklarının, cinsiyetin ve her ikisinin birlikte fen bilgisi öğretmen adaylarının geometrik optik konusundaki kavramsal anlamalarına etkilerini araştırmaktır. Çalışmanın örneklemini ikinci sınıfta öğrenim gören 4 farklı sınıftan 121 öğretmen adayı oluşturmaktadır. Çalışmada yarı deneysel desen kullanılmış olup, geometrik optik konusu deney grubunda çalışma yaprakları uygulanılarak, kontrol grubunda ise geleneksel öğretim yöntemi kullanılarak işlenmiştir. Adayların geometrik optik konusundaki kavramsal anlamaları üç aşamalı kavram yanılgısı testi ile ölçülmüştür. Çalışma yapraklarının, cinsiyetin ve bu iki faktörün birlikte sontest puanları üzerindeki etkisi ANCOVA analizi ile test edilmiştir. Analiz sonuçları, kavram karikatürleri ile zenginleştirilmiş çalışma yapraklarının adayların geometrik optik konusundaki kavramsal anlamaları üzerinde istatistiksel olarak anlamlı etkilerinin olduğunu, cinsiyet ve çalışma yaprakları etkileşiminin ise anlamlı etkilerinin olmadığını göstermiştir.

Anahtar Sözcükler: Çalışma yaprakları, geometrik optik, kavramsal anlama, kavram yanılgısı.

* Assist. Prof. Dr. Erdal TAŞLIDERE, Mehmet Akif Ersoy University, Faculty of Education, Department of Primary Teacher Education, Burdur, Turkey, etaslidere@mehmetakif.edu.tr.

Introduction

Over the last decades, students' understandings of key concepts related to physics education have been an interesting research area for researchers. Studies revealed that students come to classes with conceptions most of which are different from scientific explanations (Driver, Guesne, & Tiberghien, 1985; Hammer, 1996; Hestenes, Wells, & Swackhamer, 1992). Learners' experiences of the world, the influence of their peers, the media and previous instruction would lead them to develop these conceptions (Chu, Treagust, & Chandrasegaran, 2009; Fetherstonhaugh & Treagust, 1992; Hestenes et al., 1992; Redish, Saul, & Steinberg, 1998). Often, students' previous conceptions interfere with the concepts that are being thought in physics courses and prevent them construct scientific knowledge (Hammer, 1996; Redish et al., 1998).

These conceptions that contradict with scientific views are called misconceptions (Odom & Barrow, 1995). Misconceptions are stable cognitive structures that change and affect students' understanding of scientific concepts (Hammer, 1996). They act as filters and prevent permanent and meaningful learning (Shunk, 2009). Hence, it is reported that traditional physics instruction is ineffective in helping students develop a scientific view and their conceptual understandings (Blizak, Chafigi, & Kendil, 2009). In general, the approaches encouraging active participation of learners in learning environment are thought to help students construct knowledge meaningfully (Powell & Kalina, 2009). There exist some alternative teaching strategies such as using worksheets (Hand & Treagust, 1991), concept cartoons (Keogh & Naylor, 1999; Keogh, Naylor, & Wilson, 1998) and concept cartoon worksheets (Atasoy, 2008; Burhan 2008) to eliminate misconceptions and promote conceptual understanding within constructivist approach.

Worksheets

Worksheets are important educational tools that help them construct knowledge in their own minds and encourage students to participate in classroom activities (Atasoy, 2008; Kuo, Chang, Ying & Jia–Sheng, 2011). It was reported that worksheets draw students' attention to lessons and help them gain conceptual understanding (Burhan, 2008; Coştu & Ünal, 2005). There exist studies about worksheets in the literature. Hand and Treagust (1991) developed seven worksheets to encourage conceptual conflict in acids and bases unit. They used worksheets in one of the two groups in 10th grade in 1986 and 1987. They reported that the group instructed with worksheets within constructivist approach outperformed the other group in both years. Redfield (1981) investigated the effects of different types of worksheets on fifth grade students' achievement. The worksheets were administered to the students at three different reading ability levels. The results suggested that type of worksheet does not have immediate differential effect on students' achievement. Rix and McSorley (1999) designed a mini museum and explored how a school-based science center can contribute to a child's whole science education, to their knowledge that, how and why, to their development of scientific skills and processes, and to their development of positive attitudes. They used three groups of students; first group investigated the exhibit freely, the second group completed worksheets during their visits and the third group, whose background knowledge was different from others, experienced the museum as the first group. The authors reported that there is no apparent difference between children who were not given worksheets and those who were, in terms of their learning. Cahyadi (2004) investigated the effect of a teaching method consisting of peer instruction, worksheet utilization, constructivist classroom dialogue and in-class demonstration. She used worksheets that provide step-by-step guidance to solve physics problems. The results of the study indicated that the conceptual understanding of students in the experimental group was better. Atasoy and Akdeniz (2006) evaluated the implementation process of worksheets developed according to constructivist view of learning in energy unit. The analyses of the lesson observations and interviews showed that the worksheets were very useful for observing and obtaining expected results, and made the learning fun. Demircioğlu, Demircioğlu and Ayas (2004) investigated the effect of worksheets on remedying teacher candidates' misconception in granular structure of matter. The results denoted that the worksheets were effective in remedying misconceptions.

Concept Cartoons

Concept cartoons were developed by Keogh and Naylor (1992) to propose an innovative teaching and learning strategy through a constructivist view of learning in science (Keogh & Naylor, 1999). Concept cartoons express scientific problems related to daily life via character cartoons and present different views related to real life (Keogh et al., 1998). They can be prepared as in both posters and worksheets and be used either as instructional material or teaching method in science courses (Kabapınar, 2009). Two or more characters, who suggest different explanations, discuss problems or express diverse opinions about the science (Stephenson & Warwick, 2002). Keogh and others (1998) underlined that by considering these alternatives, the instructor influences learners' ideas. It is thought that the use of concept cartoon encourages students inquire and discuss different opinions over daily life problems. Hence this approach is a crucial leg of constructivist approach (Naylor & Keogh, 1999; Stephenson & Warwick, 2002).

In the literature, there exist studies about concept cartoons. Keogh and others (1998) investigated the effectiveness of concept cartoons via classroom observations. They reported that the use of concept cartoons is an effective approach for finding out pupils' ideas and provided a manageable way to promote pupils' investigation. Keogh and Naylor (1999) studied the effectiveness of concept cartoons according to the ideas of students, teachers and student teachers. They reported that according to teachers and learners, the use of concept cartoons was generally positive and appear to provide a powerful stimulus for learners to focus their attention on constructing meaningful explanations. Stephenson and Warwick (2002) evaluated the effectiveness of concept cartoons by investigating the changes in students' ideas over the instructions. They reported that the use of concept cartoons is seen as one way of supporting the teacher attempting to adopt a constructivist approach. Kabapınar (2009) used concept cartoons as a teaching learning approach and investigated the effectiveness of it on learning according to students' ideas. She proposed several ways of making concept cartoons effective. Findings showed that the concept cartoons in the form of worksheets are effective as posters in remedying students' misconceptions. Birisci, Metin and Karakas (2010) investigated pre-service elementary teachers' views on concept cartoons. They reported that concept cartoons improved instruction and made the lecture interesting and entertaining.

Concept Cartoon Worksheets

More recently, the worksheets were developed with concept cartoons. Concept cartoon worksheets include concept cartoons and some instructional directions. Atasoy (2008) developed nine concept cartoon worksheets to investigate the effect of them on remedying freshmen science teacher students' misconceptions of Newton's Law of motion in General Physics-I lesson. Findings showed that concept cartoon worksheets helped students construct knowledge scientifically in their minds and students gained right interpretation skills. Burhan (2008) developed five concept cartoon worksheets and investigated the effect of them on 8th grade students' understanding in acid and bases. She reported that the worksheets significantly improved students' understanding of the concepts and facilitated their conceptual understanding. Özmen and Yıldırım (2005) developed three worksheets and investigated the effect of them on 10th grade students' achievement in acids and bases. They reported that worksheets increased experimental group students' achievement significantly. Gürses, Akdeniz and Atasoy (2006) searched the effect of the concept cartoon worksheets on 6th grade students' achievement in electrostatics. The findings indicated that use of worksheets resulted in increased students' achievements and scientific skills.

Keogh and others (1998) suggested using concept cartoons in physics education. In this study, I aimed to investigate the effectiveness of concept cartoon worksheets on students' conceptual understanding of geometrical optics. Students' understanding of geometrical optics has been investigated in several studies (Bendall, Goldberg & Galili, 1993; Blizak et al., 2009; Galili, Bendall & Goldberg, 1993; Langley, Ronen & Eylon, 1997). Langley et al. (1997) reported that students' individual notions and the ideas of school optics interfere and this conflict can be expected to emerge as a source of difficulty during and after formal instruction. Even after the instructions, students have difficulties in integrating knowledge in certain optics concepts (Galili et al., 1993). Similar misconceptions related to propagation of light, the vision, the reflection and the refraction, exist among the students as in different countries (Bendall et al., 1993; Langley et al., 1997).

In the literature, it was reported that one of the factors affecting students' conceptual understanding in science education is gender. Although some of the previous studies (Chu, 2009; Wang & Andre, 1991) reported significant interaction between gender and treatment, some of them (Ates, 2005; Chambers & Andre, 1997; Taşlıdere, 2007) reported insignificant interaction. There was no consensus among the researchers about the effectiveness of gender on post-test performances in science education (Ates, 2005). There is a gap about the effects of gender and treatment on students' post-test performances. Besides, while conceptual change approaches have been advocated for helping students deal with misconceptions, hardly any of the research has examined the effectiveness of concept cartoon worksheet and the relationship between concept cartoon worksheet and gender for geometrical optics.

Previous studies also indicated that students' pre-existing conceptions about the scientific phenomena affect their learning of scientific concepts (Chambers & Andre, 1997; Sencar & Eryilmaz, 2004). For this study, students' pre-knowledge in geometrical optics was considered as the potential confounding factor. Further, it was also considered that students' age and the high school type, from which they graduated (Anatolian (AHS), General (GHS), Super (SHS), Vocational (VHS) high schools), may affect students' post-test performances. Hence, this study aimed to investigate the effect of concept carton worksheets, gender, and their interaction on pre-service science teachers' post-test conceptual understanding scores in geometrical optics, when their age, conceptual understanding of pre-test scores and school type are controlled.

Method

Purpose

The following research questions framed this study;

1. What is the effect of concept cartoon worksheets on pre-service science teachers' conceptual understanding of post-test scores (PSTMT) in geometrical optics when their age, conceptual understanding of pre-test scores (PREMT) and school type (STYP) are controlled.
2. What is the effect of gender on the PSTMT when their age, the PREMT and STYP are controlled?
3. Is there an interaction effect between concept cartoon worksheets and pre-service science teachers' gender when their age, the PREMT and STYP are controlled?

The variable age was the participants' age at the beginning of the study in terms of year.

Population and Sample

The population of the study consists of all 397 pre-service science teachers studying at a state university in Turkey, 121 of which participated in the study. These 121 students were sophomores, taking General Physics-III lesson in the fall semester of 2010-2011. The students were studying geometrical optics as a first time with General Physics-III lesson after high school. Two classes (n_1=63, female=39, male=24) were assigned randomly as experimental groups and the remaining two (n_2=58, female=35, male=23) were assigned as control groups, making the sample 30% of the population. Students' ages ranged from 18 to 24 and graduated from the AHS, GHS and SHS. The number and percentage of students within study groups according to their gender, age and the STYP are given in Table 1.

An experienced researcher who holds Ph.D. degree in Physics Education conducted the study. He taught the geometrical optics to both control and experimental groups. The researcher has thirteen years of teaching experience in high school and university level physics courses.

Table 1.

Number and Percentage of Students within Groups According to Their Gender Age and STYP

Experimental Group										
	Gender		Age				STYP			Total
	M	F	Below 20	20	21	Above 21	AHS	GHS	SHS	
N	24	39	37	16	5	5	23	35	5	63
%	38.1	61.9	58.7	25.4	7.9	7.9	36.5	55.6	7.9	100
Control Group										
	Gender		Age				STYP			Total
	M	F	Below 20	20	21	Above 21	AHS	GHS	SHS	
N	23	35	23	20	11	4	17	28	13	58
%	39.7	60.3	39.7	34.5	19.0	6.8	29.3	48.3	22.4	100

Procedure

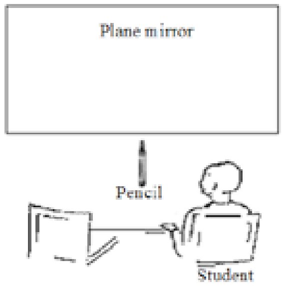
A quasi-experimental design was used in the study. The study began with the administration of the measuring tool to all groups as pre-test. For the three-week treatment period, the experimental group was instructed the application of concept cartoon worksheets and the control group received traditional instruction. After the treatments, the same measuring tool was re-administered as post-test to both groups. The raw data was inserted into the Excel and the SPSS programs and then it was analyzed both descriptively and inferentially.

Measuring Tool

To measure students' conceptual understanding of geometrical optics, a Tree-Tier Geometric Optics Misconception Test (MT) was used. The test was developed by Kutluay (2005) and consists of 16 questions, measuring 20 misconceptions in geometrical optics. The characteristic of the MT is that, each item has tree-tiers; the first tier is a conventional multiple-choice question, the second tier presents some reasons for the given answer to the first tier and the third tier examines if students are confident about their answers for the previous two tiers (Kutluay, 2005). An example question is given in Figure 1.

13.1 A student is sitting in front of the plane mirror and looking at the image of the pencil as shown in the figure.
If the student sits on the left chair, does the position of the image of the pencil change?

a) Does not change.
b) Changes.



13.2 For the previous question, how can you explain your reasoning?

a) Since students' sight of view changed, he sees the image of pencil on the right side of the mirror.
b) Since the student moved towards left, the image at the back of the mirror also moves towards left.
c) Since the position of the pencil did not change, the position of image on the surface of the mirror does not change.
d) Since students' sight of view changed, he sees the image of pencil at the back, right side of the mirror.
e) Since the position of the pencil did not change, the position of the image at the back of the mirror does not change.
f) Since the student moved towards left, the image on the surface of mirror also moves towards left.

13.3 Are you sure about your answers given to the previous two questions?

a) Sure.
b) Not sure

Figure 1. An example three tier item

Kutluay (2005) administered the test to 141 students, and collected the evidences for the validity and reliability of the test. The validity of the test was estimated by three quantitative techniques; checking the correlation between students' scores according to first two tiers and the confidence level, conducting factor analysis, and estimating the probabilities of false positives and false negatives. Kutluay calculated the correlation coefficient significant as 0.33 and found five factors. The proportions of false positives and negatives were estimated as 28.2% and 3.4% respectively. The reliability coefficient of the Croanbach's alpha was reported as 0.55. For the current study, according to the results of post-test, the correlation coefficient was found significant as 0.46 and reliability coefficient was found as 0.81. The factor analysis denoted five factors and the proportions of false positives and negatives were calculated as 21.9% and 2.2% respectively.

Development of Concept Cartoon Worksheets

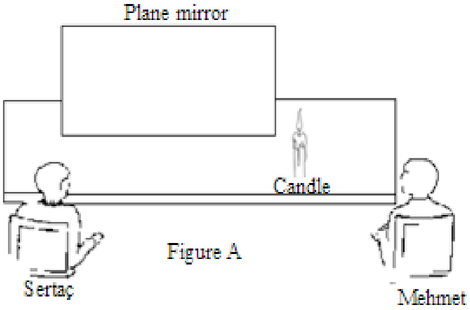
Related literature concerning geometrical optics was searched and students' possible misconceptions were determined. Seven concept cartoon worksheets were developed keeping misconceptions of students in mind. The worksheets were developed by regarding the basics features of concept cartoons suggested by Keogh and Naylor (1999).

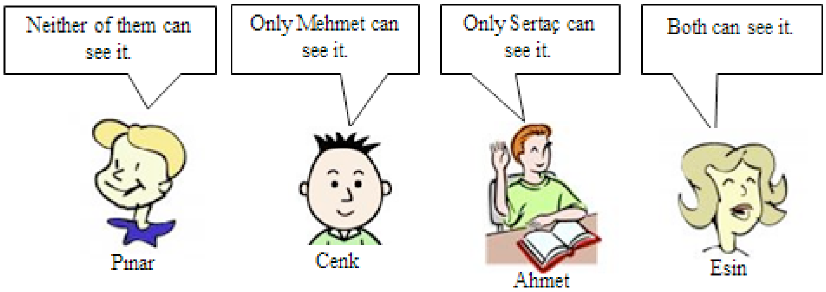
Each worksheet includes title, context, discussion, and activity sections. The context presents scientific problems related to daily life and at least two characters are discussing and offering scientific and alternative answers to the question asked in the context. A blank area was placed under characters for students to write their own ideas about why the character is likely true before the discussion section. The main purpose of discussion section is to determine students' pre-knowledge to a particular concept in depth. Finally there exist activity sections which allow students to construct and test their hypothesis.

The developed worksheets were checked by one physics teacher, two instructors, and one research assistance. Regarding their feedbacks, necessary adjustments were made. Then, the worksheets were applied in three different classes as pilot study. The deficiencies in worksheets and in their application procedures were determined and relevant revisions were made. One of them is given in Figure 2.

PLANE MIRROR & IMAGE FORMATION – 1

In Figure A, Sertaç and Mehmet are sitting on the seats. The plane mirror and the flaming candle are placed on the table as shown. Mehmet and flaming candle are located outside of the front facade boundaries of reflecting surface of the plane mirror. Can Sertaç and Mehmet see the image of the flaming candle formed by plane mirror? Determine which of the following characters is true about this situation?





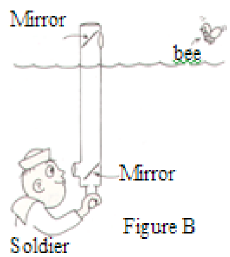
*Explain your reasoning why the character you determined is true? Write your idea into the area given below.

____
____
____
____

Discuss with your friends about your reasoning and try to convince your friends about the correctness of your opinion.

<u>Activity-1</u>

The soldier within the submarine is lurking above the water surface with the help of periscope as in Figure B. Can the soldier see the bee? Explain your reasoning by drawing light rays.



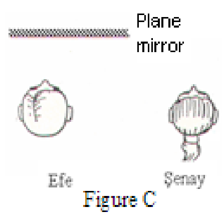
____
____
____
____
____
____

<u>Activity-2</u>

Efe and Şenay are positioned themselves in front of the reflecting surface of the plane mirror as in Figure C.

a- Can these students see their own images through the mirror?

b- Can each student see the other's images through the mirror? Explain and discuss your answers with your friends.



____
____
____
____

Figure 2. Concept cartoon worksheet-1

Treatment

The study was conducted over three-week treatment period within the context of General Physics-III Lesson. It consists of the chapters of thermodynamics, geometrical optics, wave optics, optical instruments, wave motion, alternating current circuits, electromagnetic waves and particle physics. The topics related to geometrical optics were covered as part of regular classroom curriculum. Geometrical optics includes the topics of the structure and velocity of light, reflection and mirrors, refraction and lenses. Students in both groups were exposed to the same content for the same duration. Students in the experimental groups studied their lessons via concept cartoon worksheets in line with the Keogh and Naylor's (1999) suggestions;

- a brief introduction to the activity,
- an invitation to the learners to reflect on the concept cartoons and to discuss in groups what they think and why,
- interaction and intervention by the teacher as appropriate during the teaching session,
- practical investigation or research-based activity to follow up the learners' ideas as appropriate, encouraged and supported by the teacher as necessary,
- whole class plenary to share and challenge ideas.

The worksheets were distributed to the students and then students were told to read the context and the question. Meanwhile the worksheet was projected to the screen via projection equipment. Then, students were encouraged to predict the correct answer by encircling the character. Each character presents possible scientific or alternative answers in shortly rather than expressing the underlying reasons in detail. After then, students were asked to write why the selected character is likely true into the blank area. Upon completing their writings, students were told to express and discuss their ideas within classroom environment and tried to convince their friends. Finally, the instructor provided activities to resolve confusion and remediate misconceptions.

The application of "Image formation by plane mirror-2" worksheet, given in Figure 3, was presented briefly. The worksheets were distributed to the students. Upon reading the statement and the question in the context, each student selected their character. For three minutes, the instructor requested them write why the selected character is likely true and what is the underlying idea? Students wrote their reasoning and then instructor asked them to advocate their ideas. Some of them stated that "both characters see the image at different locations as Cenk expressed. Since line of sights of Ali and Ayşe are different, both observe in different positions". Some presented that "both characters observe the image at the same location as Ahmet expressed, because the image is symmetric with respect to object". Various ideas, like the ones above, were obtained during discussions; meanwhile most of students were confused. Then, the instructor introduced the activity section. A similar set up given in the context was constructed and one student (S1) was sat on the seat as in Ayşe's position. The remaining students were positioned behind the S1 and enabled to observe the pencil and its' image through the mirror. Later, the instructor asked S1 identify the position of the image of the pencil. S1 identified position as behind the mirror, symmetric with respect to pencil. At that moment, instructor positioned himself behind the mirror and held 1 m stick ruler above the mirror horizontally in such a way that the ruler directed from over the head of S1, the pencil and the mirror as in Figure 4.

After that, instructor asked S1: do you see the image of the pencil at any position under the alignment of the ruler?

S1 answered: no

Then, instructor told S1rechange his position by sitting on the next seat as in Ali's position and redefine the position of the image of the pencil. S1 defined it as symmetric with respect to the pencil, behind the mirror. Later, the instructor repositioned himself rightward and held the ruler horizontally as directing from the above of the head of S1, the pencil and mirror in diagonal position compared to previous position.

Instructor asked S1 again: do you see the image of the pencil at any position under the alignment of the ruler?

S1 answered: no

Upon this, instructor asked S1 stand up from the seat, look at the image of the pencil and then move towards the next seat by staring at the image. S1 completed the trip.

After that, instructor asked S1: during your movement, did the location of the image change?

S1 answered: no.

IMAGE FORMATION BY PLANE MIRROR -2

In Figure D, on the table, a pencil is placed in front of a plane mirror vertically. Both Ali and Ayşe sit on the seats side by side and are looking at the reflecting surface of the plane mirror. Where do Ali and Ayşe see the image of pencil formed by the plane mirror? At the same location or different locations? Determine which of the following characters is true about the situation?

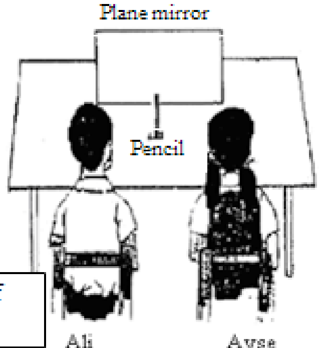
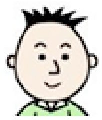


Figure D

Both Ali and Ayşe see the image of pencil at the same location.

Ahmet

Both Ali and Ayşe see the image of pencil at different locations.



Cenk

*Explain your reasoning why the character you determined is true? Write your idea into the area given below.

Discuss with your friends about your reasoning and try to convince your friends about the correctness of your opinion.

Activity -1
Step 1: Prepare a set up similar to the one given in Figure D.
Step 2: Sit on the seat placed on the right side, in Ayşe's position, and try to observe the image of the pencil formed by the plane mirror.
Question 1: Where do you see the image?

Step 3: Then, sit on the seat placed on the left side, and try to observe the image of the pencil formed by plane mirror.
Question 2: Where do you see the image at this time?

Activity - 2
Step 1: First sit on the seat placed on the left side, in Ali's position. By staring at the image of the pencil, stand up, walk towards the seat placed on the right, and then sit on it. During this trip, don't leave your eyes from the image of the pencil formed by the plane mirror.

Question 3: During this trip, did the location of image formed by the plane mirror change? Write your answer and reasoning in the blank given below;

Figure 3. Concept Cartoon Worksheet-2

Most of the students tried this activity which enabled them discover the fact that, "the position of image is independent of the position of the observer". After all, students were asked to explain why the position of image is independent of observer. Some of them presented their ideas. Later, the instructor asked one student draw the formation of image of pencil, given in Figure 3, by drawing light rays on the board. After drawing, a figure similar to Figure 5 was obtained.

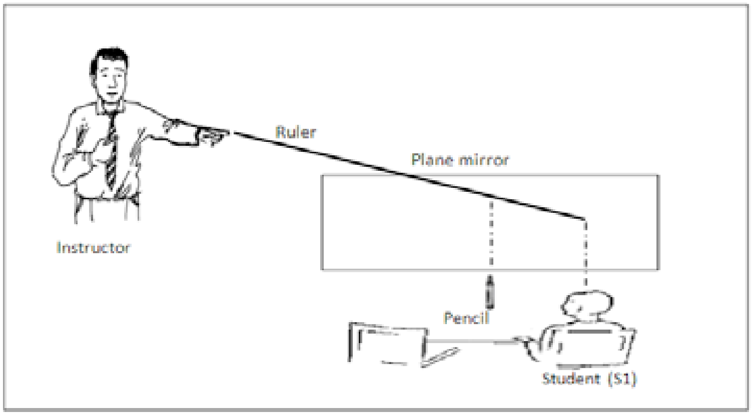


Figure 4. The set up used in the activity section.

Finally, the instructor explained that; billions of the light rays, coming from each point of the pencil, reach the reflecting surface of the mirror and reflected obeying the laws of reflection as in Figure 5. It does not matter where the location of the observer is. Wherever the observer looks at the mirror, he always observes the image of that point at a position where the extensions of the reflected rays intersect behind the mirror. As the reflected rays reach our eyes, we always observe the image of pencil at a location which is symmetric to the pencil. During the study, 5 more worksheets were used like the worksheets given in Figure 3 and Figure 4.

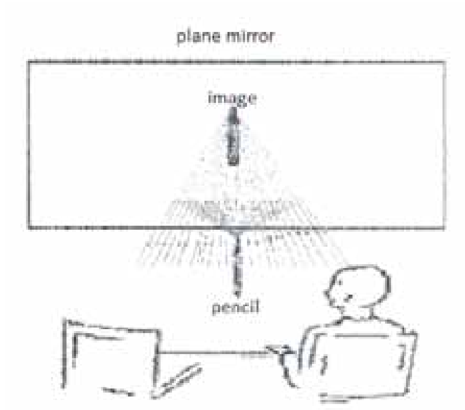


Figure 5. Formation of the image of pencil by plane mirror using light rays.

On the other hand, the control groups received traditional instruction which relied on instructors' explanations with no consideration of the students' misconceptions. The instructor used overhead projector to show the definitions of concepts, explained the facts, solved the questions, meanwhile students took notes through the lessons. Students mainly focused on concepts related to the subject that require less conceptual restructuring. Neither of the activities developed for experimental groups was used in the control groups.

Results

Students' Conceptual Understanding Scores about Geometrical Optics

Students' test scores were calculated according to the correctness of each item regarding all tires. If students' answers for the first two tiers are correct and student is sure about the correctness of the previous two selections at the third tier, then the item was scored as 1 point. Otherwise, if one of the first two tiers was wrong or the student was unconfident about his/her pre-selections at the third tier, then the item was scored as 0 point. Total score was calculated by summing the scores of each item.

Scores could range from 0 to 16 points; in which higher score denotes higher conceptual understanding and lower score denotes less conceptual understanding in geometrical optics. Table 2 shows the descriptive results. As seen, the experimental group gained a mean increase of 5.9 points and the control group gained a mean increase of 0.7 points from the PREMT to PSTMT. In the experimental group, the males and females increased their average means by 5.1 and 6.5 points respectively. In the control group, the males and females increased their average means by 0.6 and 0.9 points respectively.

Table 2.

Descriptive Statistics Results for the PREMT and PSTMT by Treatment and Gender

			PREMT		PSTMT	
Treatments	Gender	N	Mean	SD	Mean*	SD
Experiment	Male	24	2.7	2.1	7.8	2.7
	Female	39	1.9	1.6	8.4	3.2
	Total	63	2.2	1.9	8.1	3.0
Control	Male	23	2.7	2.1	3.3	2.4
	Female	35	1.5	1.4	2.4	1.4
	Total	58	2.0	1.8	2.7	2.0
Total	Male	47	2.7	2.1	5.8	3.4
	Female	74	1.7	1.6	5.4	4.0
	Total	121	2.1	1.8	5.5	3.7

Mean: Adjusted post-test mean scores evaluated at covariate appeared in the model pre-test=2.1*

Kutluay (2005) reported the items collected under factors. Items 13, 15, 3, 2 and 1 are only one members of first, second, third, fourth and fifth factors respectively. The number and percentages of both experimental and control group students who selected the correct answers of above items were also investigated. Table 3 denotes the contents of items, the number and percentages of students having correct answers for both groups before and after instructions. For example, Item 13, given in Figure 1, asks whether the image position of any object in a plane mirror depends on the observers' position or not. The analysis denoted that 4 students in the experimental group (6.3%) and 3 students in the control group (5.2%) selected the correct answer before instructions. But after instructions, 22 students in the experimental (34.9%) and 4 students in the control group (6.9%) selected the correct answer. The similar increases in the number and percentages of students having correct answers can be seen in other items also. As seen from Table 3, experimental group students gained more conceptual understanding than those of control group.

Table 3.

Content of Items, and Number and Percentage of Students Having Correct Answers

Items and their contents	Experimental Group		Control Group	
	PREMT	PSTMT	PREMT	PSTMT
	N (%)	N (%)	N (%)	N (%)
Item 13 asks whether the image position of any object in a plane mirror depends on the observers' position or not	4 6.3	22 34.9	3 5.2	4 6.9
Item 15 asks whether an observer can see image of any object that is not inside the front region straight ahead of the mirror.	8 12.7	41 65.1	8 13.8	9 15.5
Item 3 asks what would happen to the shadow of any object when the illuminant position is changed or different sizes of illuminants are used.	5 7.9	36 57.1	6 10.3	10 17.2
Item 2 asks whether the speed of light changes during day and night.	13 20.6	52 82.5	10 17.2	10 17.2
Item 1 asks whether the objects are seen in the total darkness.	8 12.3	47 74.6	4 6.9	10 17.2

For the current study, the PREMT, age and STYP was pre-determined as potential confounding factors. Hence, these variables were correlated with the dependent variable of the PSTMT. Table 4 denotes the significance test of correlations between the independent variables and the PSTMT. As seen from Table 4, the PREMT significantly correlated with the PSTMT. Hence, the PREMT was determined as covariate of the study.

Table 4.

Correlations between Dependent and Independent Variables

Variables	Correlation coefficients
	PSTMT
PREMT	.246**
Age	.11
STYP	-.11

***Correlation is significant at least 0.01 level (2-tailed)*

The major purpose of this study was to determine the effects of the concept cartoon worksheets, gender and treatment*gender interaction on pre-service science teachers' conceptual understanding of geometrical optics. Hence, the statistical analysis of ANCOVA was conducted by considering the PREMT as covariate. During analyses, the probability of rejecting true null hypothesis (Type 1-error) was set to 0.05 as a priori to hypothesis testing. The effect size was set to large value (0.8 for mean difference and 0.33 for variance). All of the assumptions for the ANCOVA were tested and verified. The results of the ANCOVA denoted that, there was a statistically significant main effect of treatment on the PSTMT ($F(1, 116) = 129.5$, $p = .000$). On the other hand the main effect of gender ($F(1, 116) = 0.100$, $p = .824$) and the interaction effect of treatment *gender ($F(1, 116) = 3.00$, $p = .088$) were insignificant on the PSTMT. Table 5 shows the ANCOVA results.

Table 5.

ANCOVA Table for the PSTMT Means Scores by Treatments and Gender

Source	SS	Df	MS	F	P	ES	OP
Corrected Model	975.0	4	243.7	41.3	.000	.59	1.00
Intercept	995.4	1	995.4	168.5	.000	.59	1.00
PREMT	55.3	1	55.3	9.4	.003	.08	0.86
Treatment	764.9	1	764.9	129.5	.000	.53	1.00
Gender	0.3	1	0.3	0.1	.824	.00	0.06
Treatment*Gender	17.5	1	17.5	3.0	.088	.03	0.40
Error	685.1	116	5.9				
Total	5370.0	121					
Corrected Total	1660.1	120					

R Squared = .587 (Adjusted R Squared = .573)

Discussion

The current study investigated the effects of concept cartoon worksheets, gender and their interaction on pre-service science teachers' conceptual understanding of geometrical optics. The study also presents development of concept cartoon worksheets and practical application of them in constructivist classroom environment. The effect size was preset to a large value (0.33 for variance) and the SPSS calculated it 0.53 (Eta Squared), which corresponds to large value (Cohen & Cohen, 1983). The observed statistical power was calculated as 1.00. These evidences denote that the current study has practical significance as well as statistical significance.

The outcomes of the study indicated that the group instructed through the concept cartoon worksheets significantly outperformed the students instructed with traditional instruction in understanding key concepts involved in geometrical optics. The results are consistent with those of the previous studies (Atasoy, 2008; Birisci et al., 2010; Burhan, 2008; Cahyadi, 2004; Coştu et al., 2003; Demircioğlu et al., 2004; Gürses et al., 2006; Özmen & Yıldırım, 2003). This expected success can be attributed to the active participation of experimental group students into the teaching learning activities. According to the constructivism, students actively engage in the development of their own ideas, be guided and supported by the instructor and their peers (Powell & Kalina, 2009). For the current study, as constructivist approach implied, students were active both socially and cognitively throughout the study. Students had enough time to identify and express their pre-conceptions, examine their usefulness and apply them in context. Students read the context, the focus question and then found themselves in discussions over the characters. With discussions, students' pre-conceptions were activated and shared with others. It was observed that most of the students were influenced from each other and confused about the correctness of their ideas. After discussions, conduction of activities enabled them examine the adequacy of their pre-conceptions and forced them argue about their pre-knowledge. During activities, students were encouraged to generate, test and accept or reject their hypotheses. This led to disequilibrium when predictions based on prior beliefs are contradicted and provided the opportunity to construct scientific concepts. As previous studies (Birisci et al., 2010; Keogh et al., 1998; Keogh & Naylor, 1999) reported, students participated actively in all phases of the study.

The results of the statistical analyses denoted that the use of concept cartoon worksheets increased experimental group students' conceptual understanding in key concepts more than that of control group. For example, students in both groups were confusing whether the image position of any object in a plane mirror depends on the observers' position or not. After instruction, 28.6% in the experimental and 1.7% in the control group did better at the post-test than the pre-test. Students were also having difficulties in determining whether an observer can see the image of any object that is not inside the front region straight ahead of the mirror or not? After instruction, 52.4% in the experimental and again only 1.7% in the control group students did better at the post-test. Another weakness of students was that they were confusing image formation with shadow formation. They were not able to explain what would happen to the shadow of any object when the illuminant position is changed or different sizes of illuminant are used. After treatment, 41.3% in the experimental and 1.8% in the control group did better at the post-test. In high school geometrical optics lessons, the speed of light, its' value and dependency of medium are always studied. But unfortunately most of the students presented that the speed of light differs according to day time and night time at the pre-test. After instruction, 61.9% in the experimental group selected the correct answer compared to the pre-test. On the other hand, no gain was observed in control group students. Another important weakness of students was that most of them were confusing luminous and nonluminous objects. They were considering that all white objects emit their lights and can be seen in a completely dark room. Students were confusing the fact of "white objects can reflect the light well" with "all white objects emit their own light". But after instruction, 62.3% in the experimental group and 10.3% in the control group realized this difference and did better at the post-test.

On the other hand, the students in the control group just followed the lectures and solved the questions. Students were just passive listeners following the instructor. Hence, they did not apply their pre-conceptions to different context offered as in concept cartoon worksheets and did not discuss their ideas to influence each other. They mainly focused on concepts related to the subject that require less conceptual restructuring. Since they have no experienced the activities, they were not able to generate and test their hypotheses and no conceptual restructuring happened in their minds. Although in control group, neither of the activities developed for the experimental group was conducted, their average achievement means slightly increased. This increase in the mean score of achievement has resulted from normal traditional instruction, because traditional instruction also aimed to success the objectives of the course. The content of the unit was explained verbally over power point, blackboard, and the related questions were solved without applying concept cartoon worksheets, conducting classroom discussions and encouraging conceptual restructuring.

Gender is a potential factor which is likely to affect students' post-test performances in science education. However, the current study denoted no significant effect of gender and gender*treatment interaction on students' post-test performances like the previous studies (Ates, 2005; Chambers & Andre, 1997; Taşlıdere, 2007). The results showed that when the PREMT was controlled, the application of the concept cartoon worksheet was found to be equally effective in teaching geometrical optics for both females and males. In the literature, there is a gap about the effects of gender and treatment*gender interaction on students' post-test performances and no theoretical explanation is available for the topic of geometrical optics. Wang and Andre (1991) reported that the instructional manipulations may have different effects for the males and females because of differential motivation. During the conduction of the current study, the instructor observed that males and females' motivation were almost equal and high. Both were actively participated in the study, took part in discussions and activities. This may have led to the insignificant effect of gender and treatment*gender interaction.

Beyond these, the effects of students' age and STYP on the PSTMT were also investigated. But, no statistically significant results were found. Findings indicated that although the ages of the participants were 18 to 24 years, and they were graduated from different types of high schools, all have benefited equally from the application of concept cartoon worksheets.

Conclusion and Suggestion

The results of the current study indicated that the use of concept cartoon worksheet was beneficial for pre-service science teachers' conceptual understanding of geometrical optics regardless of their gender, age and high school type. The applications of concept cartoon worksheet helped them overcome common learning difficulties and construct key concepts in geometrical optics. Hence, the use of concept cartoon worksheet in science education may be of particular value to the pre-service science teachers. It could be used in all grade levels and other subject matters.

Efforts to increase future science teachers' conceptual understanding by concept cartoon worksheets are of particular importance in that they may result in effective science instruction which affects large numbers of future science learners. Taking consideration that the participants will be science teacher in the future, this study enables them define the development and practical application of concept cartoon worksheets and compare it with other alternative teaching methods. Physics teachers or instructors may develop concept cartoon worksheets and use them in their lessons. A similar study can be conducted with other units of physics lessons or other disciplines and the results can be compared with the results of current study.

References

Atasoy, Ş. (2008). Öğretmen adaylarının Newton'un hareket kanunları konusundaki kavram yanılgılarının giderilmesine yönelik geliştirilen çalışma yapraklarının etkililiğinin araştırılması. Yayımlanmamış doktora tezi, Karadeniz Teknik Üniversitesi, Trabzon.

Atasoy, Ş., & Akdeniz, A.R. (2006). Yapılandırmacı öğrenme kuramına uygun geliştirilen

çalışma yapraklarının uygulama sürecinin değerlendirilmesi. *Milli Eğitim Dergisi, 170*, 157–175.

Ates, S. (2005). The effectiveness of the learning-cycle method on teaching DC circuits to prospective female and male science teachers. *Research in Science and Technology Education, 23*(2), 213-227.

Bendall, S., Goldberg, F., & Galili, I. (1993). Prospective elementary teachers' prior knowledge about light. *Journal of Research in Science Teaching, 30*(9), 1169-1187.

Birisci, S., Metin, M., & Karakas, M. (2010). Pre-service elementary teachers' views on concept cartoons: a sample from Turkey. *Middle-East Journal of Scientific Research, 5*(2), 91-97

Blizak, D., Chafiqi, F. & Kendil, D. (2009). Students misconceptions about light in Algeria. *Optical Society of America Technical Digest Series*. [Online]: Retrieved on 18.02.2011, at URL http://www.opticsinfobase.org/abstract.cfm?URI=ETOP-2009-EMA5.

Brown, T. R., Slater, T. F. & Adams, J. P. (1995). Gender difference with batteries and bulbs. *Physics Teacher, 17*(3), 311-323.

Burhan, Y. (2008). "Asit ve Baz Kavramlarına Yönelik Karikatür Destekli Çalışma Yapraklarının Geliştirilmesi ve Uygulanması." Yayınlanmamış yüksek lisans tezi, Karadeniz Teknik Üniversitesi, Trabzon.

Cahyadi, V. (2004). The effect of interactive engagement teaching on student understanding of introductory physics at the faculty of engineering. *University of Surabaya, Indonesia, Higher Education Research and Development*, *23*(4), 455-464.

Chambers, S. K., & 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.

Chu, H.-E, Treagust, D. F., & Chandrasegaran, A. L. (2009). A stratified study of students' understanding of basic optics concepts in different contexts using two-tier multiple-choice items. *Research is Science & Technological Education*, *27*(3), 253-265.

Cohen, J. & Cohen, P. (1983). *Applied multiple regression / correlation analysis to the analysis of behavioral Science.* New Jersey: Lawrence Erlbaum Associates.

Coştu, B., & Ünal, S.(2005). Le-Chatelier prensibinin çalışma yaprakları ile öğretimi.*Yüzüncü Yıl Üniversitesi, Elektronik Eğitim Fakültesi Dergisi*, 1-10. [Online]: Retrieved on 20.08.2011, at URL http://efdergi.yyu.edu.tr/makaleler/cilt_I/ozetler/bay_su_ozet.htm.

Demircioğlu, H., Demircioğlu, G., & Ayas, A. (2004). Kavram Yanılgılarının Çalışma Yapraklarıyla Giderilmesine Yönelik Bir Çalışma, Milli Eğitim Dergisi, *163*. [Online]: Retrieved on 20.08.2011, at URL http://dhgm.meb.gov.tr/yayimlar/dergiler/Milli_Egitim_Dergisi/163/demircioglu.htm

Driver, R., Guesne, E., & Tiberghien, A.(1985). *Children's ideas in science.* Milton Keynes, UK: Open University Press.

Fetherstonhaugh, T. & Treagust, F. D. (1992). Students' understanding of light and its properties: teaching to engender conceptual change. *Science Education, 76,* 653-672.

Galili, I., Bendal, S., & Goldberg, F. (1993). The effects of prior knowledge and interaction on understanding image formation. *Journal of Research in Science Teaching, 30*(3), 271-301.

Gürses, E., Akdeniz, A. R., & Atasoy, Ş. (2006). Durgun elektrik konusunda 5E modeline göre geliştirilen materyallerin öğrenci başarısına etkisi, VII. Ulusal Fen Bilimleri ve Matematik Eğitimi Kongresi, Gazi Üniversitesi Eğitim Fakültesi, Ankara.

Hand, B. & Treagus, D. F. (1991). Student achievement and curriculum development using a constructive framework. *Science & Education Center*, 172-176.

Hammer, D. (1996). More than misconceptions: multiple perspectives on student knowledge and reasoning, and an appropriate role for education research. *American Journal of Physics, 64*, 1316–1325.

Hestenes, D., Wells, M., & Swackhamer, G. (1992). Force concept inventory. *The Physics Teacher*, *30*, 141-158.

Kabapınar, F. (2009). What makes concept cartoons more effective? Using research to inform practice. *Education and Science, 34*(154), 104-118.

Keogh, B., Naylor, S. & Wilson, C. (1998). Concept cartoons: a new perspective on physics education. *Physics Education, 33*(4), 219-224.

Keogh, B. & Naylor, S. (1999). Concept cartoons, teaching and learning in science: an evaluation. *International Journal of Science Education, 21*(4), 431-446.

Kuo, R., Chang, M., Ying, K. & Heh, S-J. (2011). Design electronic botany worksheet generation based on bloom's taxonomy for mobile learning. 11th IEEE International Conference on Advanced Learning Technologies, 192-194.

Naylor, S., & Keogh, B. (1999). Constructivism in classroom: theory into practice. *Journal of Science Teacher Education, 10*(2), 93-106.

Kutluay, Y. (2005). "Diagnosis of Eleventh Grade Students' Misconceptions About Geometric Optics By a Three-Tier Test." Unpublished master thesis, Middle East Technical University, Ankara.

Langley, D., Ronen, M., & Eylon, B. (1997). Light propagation and visual patterns: preinstruction learners' conceptions. *Journal of Research in Science Teaching*, *34*(4), 399-424.

Odom, A. L., & Barrow, L. H. (1995). Development and application of a two-tier diagnostic test measuring college biology students' understanding of diffusion and osmosis after a course of instruction. *Journal of Research in Science Teaching*, *32*(1), 45-61.

Özmen, H., & Yıldırım, N. (2005). Çalışma Yapraklarının Öğrenci Yapısına Etkisi: Asitler ve Bazlar Örneği. *Türk Fen Eğitimi Dergisi*, *2*(2), 124-143.

Powell, C. K., & Kalina, J. C. (2009). Cognitive and social constructivism: developing tools for an effective classroom. *Education*, *130*(2), 241-250.

Rix, C. & McSorley, J. (1999). An investigation into the role that school-based interactive science centers may play in the education of primary-aged children. *International Journal of Science Education*, *21*(6), 577-593.

Redish E. F., Saul J. M., & Steinberg R. N. (1998). Student expectations in introductory physics. *American Journal of Physics, 66*(3), 212-224.

Redfield, D. I. (1981). A comparison of the effects of using various types of worksheets pupil achievement. *Reports-Research*, ERIC: ED203300.

Sencar, S., & Eryilmaz, A. (2004). Factors mediating the effect of gender on ninth-grade Turkish students’ misconceptions concerning electric circuit. *Journal of Research in Science Teaching, 41*(6), 603–616.

Shunk, D. H. (2009). *Eğitimsel Bir Bakışla Öğrenme Teorileri.* (Çev.Ed.: M. şahin) Ankara: Nobel Yayın Dağıtım.

Stephenson, P., & Warwick, P. (2002). Using concept cartoons to support progression in students’ understanding of light. *Physics Education, 37*(2), 135-141.

Taşlıdere, E. (2007). The effects of conceptual approach and combined reading study strategy on students’ achievement and attitudes towards physics. Unpublished Ph.d Dissertation, METU Graduate School of Natural and Applied Sciences, Ankara.

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*(2), 102-116.