T.C.
KIRIKKALE UNIVERSITY
GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

DEPARTMENT OF PHYSICS
MASTER’S DEGREE THESIS

THE EFFECTS OF SIMULATIONS SUPPORTED 5E TEACHING MODEL ON ACADEMIC ACHIEVEMENTS AND ATTITUDES IN PHYSICS EDUCATION

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JULY 2015

T. C.
KIRIKKALE ÜNİVERSİTESİ
FEN BİLİMLERİ ENSTİTÜSÜ

FİZİK ANA BİLİM DALI
YÜKSEK LİSANS TEZİ

SİMÜLASYON DESTEKLİ 5E ÖĞRETİM MODELİNE DAYALI FİZİK ÖĞRETİMİNİN AKADEMİK BAŞARI VE TUTUMA ETKİSİ

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TEMMUZ 2015

I confirm that this Master's Thesis entitled THE EFFECTS OF SIMULATIONS SUPPORTED 5E TEACHING MODEL ON ACADEMIC ACHIEVEMENTS AND ATTITUDES IN PHYSICS EDUCATION submitted by Abdillahi Hajiomer HASSAN in accordance with the standards of the **Department of Physics**

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ABSTRACT

THE EFFECTS OF SIMULATIONS SUPPORTED 5E TEACHING MODEL ON ACADEMIC ACHIEVEMENTS AND ATTITUDES IN PHYSICS EDUCATION

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July 2015, 117 pages

The purpose of this study was to investigate the effects of interactive simulations supported 5E teaching model on students’ academic achievements and attitudes in physics education. Evaluating students’ views, thoughts and their comments towards using simulations in teaching physics was another aim of this study. The study was conducted in the fall semester of 2014/2015 academic year at Sh. Ali Jowhar Secondary School in Borama, Somalia. 80 students (male: 57; female: 23) from two 11^{th} grade science stream classes participated in the study which included pre-test / post-test control group quasi experimental design. One of the two classes was randomly assigned to be the experimental group and the other class to be the control group. Subtopics in the chapter Light (Introduction to light, reflection of light and mirrors, refraction of light and lenses, and colors of light) were taught to the experimental group using materials prepared on the basis of interactive simulations supported 5E teaching model whereas the same topic designed traditionally was taught to the control group by the same teacher. The implementation lasted for 24 periods in 6weeks.

Tools used for data collection were Light Concepts Achievement Test, Attitude Scale Towards Physics and Semi-structured Evaluation Survey Form. The achievement test was developed on the basis of Somaliland physics program. Internal consistency coefficient of achievement test items was found to be 0.8521. Attitude scale towards physics developed by Barmby et al. (2005) which was then reviewed and used by Kaya and Böyük (2011) with reliability coefficient of 0.73 was adopted. The achievement test and the attitude scale were applied to both groups at the beginning and at the end of the study. Computer simulations evaluation survey form aimed to investigate students' views towards using simulations in teaching physics was also applied to experimental group at the end of the study. Data obtained through the achievement test and the attitude scale were analyzed with spss17.

Findings from the achievement and attitude posttest scores revealed that there was statistically significant difference between the two groups. Computer based simulation supported 5E teaching model caused significantly better acquisition of scientific concepts related to light and relatively higher positive attitudes towards physics than traditionally designed instruction. The results have also been supported by the views and thoughts collected from students in the experimental group at the end of the study.

Key Words: Physics Teaching, Computer Simulations, Virtual Experiments, Constructivist Approach, 5E Teaching Model, Attitude.

ÖZET

SİMÜLASYON DESTEKLİ 5E ÖĞRETİM MODELİNE DAYALI FİZİK ÖĞRETİMİNİN AKADEMİK BAŞARI VE TUTUMA ETKİSİ

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Temmuz 2015, 117 sayfa

Bu çalışmanın amacı interaktif simülasyonlarla desteklenmiş 5E öğretim modeline dayalı fizik öğretiminin öğrencilerin akademik başarı ve tutumlarına etkisini araştırmaktır. Ayrıca bir başka boyutta öğrencilerin interaktif simülasyon destekli fizik öğretimine yönelik görüşlerini incelemektir. Çalışma, Somali-Borama ili Sh. Ali Jowhar Lisesinde 2014–2015 eğitim-öğretim yılının güz döneminde yapılmıştır. Çalışma grubu fen bilimleri alanında iki ayrı 11. sınıfta öğrenim gören toplam 80 öğrenciden (erkek: 57, kız : 23) oluşmaktadır. Öntest-sontest kontrol gruplu yarı deneysel model biçiminde desenlenmiş araştırmada iki sınıftan biri deney grubu diğer ise kontrol grubu olarak rastgele seçilmiştir. Araştırmanın uygulama aşaması ışık ünitesi içinde yer alan ışığa giriş, ışığın yansıması ve aynalar, ışığın kırılması ve mercekler, ışığın renkleri konularda 6 hafta 24 ders saati süresince gerçekleştirildi. Her iki grubun dersileri araştırmacı tarafından yürütülmekle birlikte kontrol grubunda geleneksel yöntem kullanılırken deney grubunda araştırmacı tarafından geliştirilen interaktif simülasyonlarla desteklenmiş 5E öğretim modeline uygun materyaller kullanıldı. Çalışmada akademik başarı testi, fizik dersine yönelik tutum olçeği ve yarı yapılandırılmış görüşme formları aracılığıyla veriler toplanmıştır. Somaliland fizik programı içerisinde ışık konusunda başarı testi geliştirilmiştir. Başarı testi maddelerinin iç tutarlık katsayası 0,8521 olarak bulunmuştur. Barmby ve diğ. (2005) tarafından geliştirilen ve daha sonra Kaya ve Böyük (2011) tarafından revize edilip kullanılan 0,73 güvenilirlik katsayısına sahip fizik dersine yönelik tutum ölçeği kullanılmıştır. Başarı testi ve tutum ölçeği deney ve kontrol grubuna çalışmanın öncesi ve sonrası uygulanmıştır. Fizik öğretiminde simülasyonların kullanımına yönelik öğrenci görüşlerinin değerlendirilmesi amacıyla bilgisayar destekli simülasyonun değerlendirme formu deney grubuna uygulanmıştır. Başarı testi ve tutum ölçeği ile elde edilen veriler spss17 ile analiz edilmiştir.

Sontest akademik başarı ve tutum puanlarından elde edilen bulgulara göre iki grup arasında istatistiksel olarak anlamlı farklılık bulunmuştur. Simulasyon destekeli 5E öğretim modelinin ışık ile ilgili kavramların anlaşılmasında geleneksel yönteme göre daha etkili olduğunu ve fizik dersine yönelik daha olumlu tutuma yol açtığı belirlenmiştir. Bu bulgular çalışmanın sonunda deney grubu öğrencilerinden toplanan görüşler ve düşünceler ile de desteklenmiştir.

Anahtar kelimeler: Fizik Öğretimi, Bilgisayar Simülasyonları, Sanal Deneyler, Yapılandırmacı Yaklaşım, 5E Öğretimi Modeli, Tutum.

AKNOWLEDGEMENTS

Iwould like to express my deepest gratitude to Assoc. Prof. Dr. Kutalmış GÜVEN and Prof. Dr. Uğur SARI, the supervisor and co-supervisor of my thesis, for their encouraging efforts, guidance and valuable suggestions throughout the study. I would also like to express my gratitude to Assis. Prof. Dr. Harun ÇELİK for his contributions and assistance.

I wish to thank to Mohamed Ali Hussein, Sh. Ali Jowhar Physics teacher and his students for their participation of this study. Finally, I would like to thank to my uncle Mohamed Sh. Hassan for his encouragements, to my sister Fathia Hussein Egeh for her financial assistance, and to my wife and my children for their patience and moral support throughout this project.

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SYMBOLS AND ABBREVIATIONS

SYMBOLS

N	Sample Number
$\bar{X}$	Mean of the Sample
p	Significance Level
t	t-value
η^2	Effect size

ABBREVIATIONS

LCAT	Light Concepts Achievement Test
ASTP	Attitude Scale towards Physics
ECSEF	Effectiveness of Computer Simulations Evaluation Form
CSSCA	Computer Simulation Supported by Constructivist Approach
TDPI	Traditionally Designed Physics Instruction
SBVL	Simulation Based Virtual Lap
TEAL	Technology-Enabled Active Learning
CLA	Constructivist Learning Approach
KR-20	Kuder and Richardson Formula – 20
SD	Standard Deviation
df	Degree of Freedom

1. INTRODUCTION

1.1. General Overview of the Research Problem

Science may be defined as systematic structure and behavior of physical and natural world through observation and experiment. It is basically practical subject by nature. The rationale in teaching science and in particular physics is to make learners interested and understand the world around them. In science, learners must be provided with an opportunity and carefully guidance way to acquire basic scientific knowledge, skills and attitudes. Teaching a science should enhance the learners self development and provide ways of finding out information, testing ideas and hypotheses, develop creative minds and make them capable to use what they learnt in the school for solving problems in real life. The above mentioned knowledge, skills and attitudes can only be developed through learner - centered and practical approach in the teaching learning process. However, teaching physics requires teaching resources. These resources include well equipped laboratory, real objects, models, audio visuals, well trained teachers etc.

In developing countries, in which Somalia is a part, the above mentioned resources are either very limited or not available. For example schools in big cities may have very small laboratories with insufficient equipment but most of schools in the small towns and villages do not have laboratories at all. Because of the lack of resources and the traditional of way of teaching in which the teacher is information giver to passive students make students unable to successfully integrate and apply what they learnt in the classroom to the real life. Many students think that what they are learning in the class and what is going on in their surroundings are either mutually exclusive or there is very little connections between them. The traditional methods of teaching does not encourage students to work together, share ideas, use their pre-existing knowledge to explore new knowledge through their creative thinking and extent their findings to connect to the real world. Studies conducted in the past decays also showed that students' motivation and their attitude towards science in general and physics in particular declines (kaya & Böyük, 2011; Ibeh, et al., 2013;

Trivedi & Sharma, 2013). The need for attitudinal research has been well documented, especially in science education, where it has been shown that becoming a scientific literate person is not a high priority of many students (Atwater, Wiggins, & Gardner, 1995). Because of lack of motivation and interest, the number of secondary school graduates joining science classes at colleges and universities becomes much less than those joining social classes in many parts of the world and in particular in Somalia. To overcome the problem, it is necessary to change the focus of the classroom from teacher-centered to Learner-centered using appropriate methods and to change theoretical concepts of physics into practical activities and experiments. This can be done using interactive simulations supported 5E teaching model. Computer simulation could play the role of real laboratory where there is no lap and can be used as a pre- lap where there is a real laboratory (Rutten, et al., 2012; Jimoyiannis & Komis 2001; Liao & Chen, 2007; Bayrak, 2008; yesilyurt, 2011; Gok, 2011; Güven, 2012; Chen & Howard, 2010). 5E teaching model may prepare students to actively participate the learning, use their pre-existing knowledge and become deep thinkers.

Halloun and Hestenes (1985) have indicated that student's pre-instructional concepts are surprisingly consistent among diverse populations of students and that traditional methods do little to influence their way of thinking. According to Richards, et al.(1992), the process of teaching by simply telling students about scientific theory is viewed as inadequate, for it fails to engage students in reflecting upon and modifying their own view of the way they think the world works.

We believe that learning physics will be easier when students use simulations through 5E teaching model. That is, they will be able to develop their own knowledge when they are given the opportunity to become actively involved in altering simulation process. In the case of attitude, according to Haladyna and Shaughnessy (1982a), students' attitudes toward science are determined by three independent constructs: teacher, student, and learning environment. Computer simulations supported 5E teaching model can alter all these three factors. It changes the role of the teacher from information giver to facilitator, the role of the student from passive to active and the learning environment from individual learning centre to group discussion and co-learning environment and so computer simulations may have a great impact on students' attitude towards learning.

1.2. Objectives and Significance of the Study

1.2.1. Objectives of the Study

The main purpose of this study is to find out through research, an alternative way of teaching science classes in particular physics in Somali secondary schools, where there is a lack of real science laboratories by investigating whether computer simulations supported 5E teaching model is more effective than traditionally based instructions in terms of academic achievements as well as attitudes towards physics as a school subject by evaluating students' performances, perceptions and opinions. The study is to investigate the state of the art in simulations for physics education; focusing on the ways simulations can be used to enhance traditional instruction and on the ways they can be embedded in instructional support to promote learning processes. Highlighting the advantages of using computer simulations and integrating the technology to the teaching learning environment is another purpose of this study.

1.2.2. Significance of the Study

In this study the topic, light, from grade 11syllubus was used to investigate the effectiveness of computer simulation on learning outcomes by comparing it with traditionally designed instruction of the same topic through pretest posttest experimental design that involves 80 students from two science classes at Sh. Ali Jowhar Secondary School.

Light is one of the main topics in the Somali secondary school physics program. It contains a lot of concepts that students can't understand unless otherwise they learn it by doing. Students have many misconceptions related to light concepts such as image formations (Kocakülah & Demirci, 2010). Light has many practical applications in real life and there for students must be taught well. Computer simulation supported 5E learning cycle model may provide students a chance to do the activities by themselves develop creativity and critical thinking and may make them capable of using of what they learnt in the classroom to solve real life problems.

1.3. Main Problem and Sub- problems

1.3.1. The main Problem

The main purpose of this study was to investigate the effects of interactive simulations supported 5E teaching model on students' academic achievements and attitudes towards physics compared to traditionally designed physics instruction.

1.3.2. Sub-problems

1. Is there a significant mean difference between the effects of computer simulations supported 5E teaching model and traditionally designed physics instruction on students' academic achievements towards light concepts?
2. Is there a significant posttest score mean difference between students taught through computer simulations supported 5E teaching model and those taught through traditionally designed physics instruction with respect to their attitudes towards physics as a school subject?
3. How do students in the experimental group see using computer simulation in teaching physics? What are their opinions, views and comments?

1.4. Limitations

1. This study was limited to the data collected from grade 11 students of Sh. Ali Jowhar Secondary School in the academic year of 2014/2015.

2. This study was limited to 80 students from two classes of Sh. Ali Jowhar Secondary School.
3. The study was limited to the topic light “Introduction to light, reflection of light and mirrors, refraction of light and lenses, and colors of light’’ on the basis of Somaliland secondary school physics program.
4. Duration of the study was limited to the time allocated for master’s degree thesis.

1.5. Definition of the Important Terms

Science: from latin s*cientia*, meaning "knowledge" is a systematic enterprise that builds and organizes knowledge in the form of testable explanations and predictions about nature and the universe.

Science education: Is the field concerned with sharing science content and process with individuals not traditionally considered part of the scientific community. The learners may be children, college students or adults within the general public.

Constructivism: Is an epistemology, a learning or meaning – making theory that offers an explanation of the nature of knowledge and how human beings learn. It maintains that individuals create or construct their own understanding or knowledge through the interaction of what they already know or believe and the ideas, events, and activities with which they come in contact (Richardson, 1997).

5E Learning cycle model: A five-phase model in which learners begin to investigate phenomenon and eventually complete the learning cycle by creating conceptions, theories and generalizations based on their work. It is based on constructivist approach (Bybee, et al. 2006).

Computer based science education: Is defined as students’ interaction with computers during the lecture under the guidance of teachers. During the process teacher assumes the role of the guider and the computer assumes the role of the platform.

Simulation: A computer simulation is “a program that contains a model of a system (natural or artificial; e.g., equipment) or a process”. It is the imitation of the operation of a real-world process or system over time, (de Jong and van Joolingen, 1998).

Meta-analysis: Is defined as the analysis of analysis method that analysis combines and compares the results of multiple independent studies in specific area. It provides a common judgment by combining the conclusions, suggestions and recommendations of the studies.

1.6. Assumptions

1. There was no interaction between students in the experimental group and those in the control group.
2. The tests were administered under standard conditions
3. Participants’ responses to the items in the instruments used in the study were sincere.

2. LITERATURE REVIEW

2.1. Science & Science Education

Improvement of science education is a significant need that has received considerable attention throughout the world. The challenges, while great in the developed world, are even greater in the developing world where well-trained teachers, effective materials and even the most basic scientific equipment and supplies are often in short supply (UNISCO, 2006). In recent years, the focus in workshops for teacher trainers has been on the active learning approach. This has included the development of teaching and learning materials that incorporate this approach. The introduction of active learning in physics in developing countries is especially encouraged by UNESCO because it fosters hands-on laboratory work, promotes conceptual learning and encourages instructors to do research in physics education that may lead to a significant improvement in their students' learning. The goal of these active learning projects is to foster the implementation of student-centered, minds-on, hands-on learning as much as possible in introductory physics courses (UNISCO, 2006). An evolving product of many years of physics education research, the active learning method has been demonstrated to measurably improve conceptual understanding. It reproduces the scientific process in the classroom and aids in the development of good physical reasoning skills.

Learning science should start with hands on experience that the child is familiar instead of abstract definitions. The school science should have more to do with getting the pupils to behave like a scientist, i.e., getting the pupils involved in the scientific processes in order to appreciate and understand the products of science (Tindi et al., 2001). According to Hofsten and Lunetta (2003) laboratory activities offer important experiences in learning science that are unavailable in other school disciplines. Laboratory activities promote key science education goals including the enhancement of students' understanding of scientific concepts.

According to Fensham (2000) there are two basic aspects of school science needs to be considered if it is to respond to society demand for science. These are i) the science to be taught (the content) and ii) its manner of teaching (the pedagogy). The concepts of Constructivist Approach and 5E Learning Cycle Models which are the study of philosophy as well as the pedagogy of teaching will be discussed in preceding sections.

2.2. Constructivist Approach

2.2.1. Constructivism

Constructivism is an epistemology, a learning or meaning-making theory that offers an explanation of the nature of knowledge and how human beings learn. It maintains that individuals create or construct their own new understandings or knowledge through the interaction of what they already know and believe and the ideas, events, and activities with which they come in contact (Richardson, 1997). According to Jonassen (1990) there are three fundamental differences between constructivist teaching and other teaching methods. Firstly, learning is an active constructive process rather than the process of knowledge acquisition. Secondly, teaching is supporting the learner's constructive processing of understanding rather than delivering the information to the learner. Thirdly, teaching is a learning-teaching concept rather than a teaching-learning concept. It means putting the learner first and teaching is second so that the learner is the center of learning. Constructivism sets the foundation for many instructional methods in mathematics and science.

Von Glasersfeld (1993) defined constructivism as a way of knowing that recognizes the real world as a source of knowledge. Brooks and Brooks (1999) suggested that constructivism is a philosophy of learning founded on the premise that, by reflecting on our experiences, we construct our own understanding of the world we live in. Each of us generates his own "mental models," which we use to make sense of our experiences. From this we can say learning is the process of adjusting our mental models to accommodate new experiences. The realization of the learner as a “constructer” of knowledge and not an empty container to be filled with facts is what differentiates constructivism from other educational theories (Campbell, 2006). According to Driver et al. (1994) children's prior knowledge of phenomena is an important part of how they come to understand school science. Often the interpretation of phenomena from a scientific point of view differs from the interpretation children construct; children construct meanings that fit their experiences and expectations. This can lead children to construct meanings different from what was intended by a teacher. By using a constructivist epistemology as a referent teachers can become more sensitive to children's prior knowledge and the processes by which they make sense of phenomena.

Researchers and educationalists conducted many studies that investigating the effectiveness of constructivist approach in teaching- learning environments. Results of such studies revealed that constructivist teaching strategies are effective in enhancing students understanding scientific concepts, they promote students’ active participation of the teaching-learning activities and as a result students’ achievements are increased (Driver et al., 1994; Lord, 1999; Kim, 2005; Mahmood, 2007; Khalid & Azeem, 2012). The summaries of such studies are presented below:

Mahmood (2007) conducted a study that focuses on determining the relationship between students’ proximity with constructivist principles of learning and their engagement in science lessons. Constructivist Learning Scale (CLS) developed by the researcher was used to distribute students in two groups on the basis of their proximity to using constructivist learning approach for their science learning. The results from the comparison between these two groups showed that students exposed with the greater proximity to the constructivist approach towards learning developed higher motivation and interest, collaborated well among their peers, actively involved in the discussions and learned interactively from each other and from the teachers. The students of high CLS achieved an average score of 76.5 (range from 71 to 86) where as the average for students in low CLS score group was 38.1 (range from 37 to 65). The researcher concluded that students with constructivist approach toward their learning showed greater engagement in the lessons as compared to students with less constructivist approach in quantitative terms.

Khalid and Azeem (2012) conducted a study aimed to compare constructivist approach based instructional modules with the traditional Method in teacher Education at Science college township campus, University of Education, Lahore, Pakistan. 64 students, experimental group (32) and control group (32), selected randomly from teacher education department of the university were enrolled for the study. Students in the experimental group were administered with constructivist approach by using developed modules where as the control group was exposed to instructions based on traditional approach. A pretest – posttest experimental design was applied to investigate whether there is significant difference between students' academic achievements in the two groups as a result of the different teaching approaches used. The findings of the study proved that the students of the experimental group scored better than and developed higher rate of proficiency than that of control group. This significant performance showed by the experimental group, researchers interpreted that, it might be due to the active participation of student teachers in this group as a result of the constructivist approach used.

Kim (2005) carried out a study that investigated the effects of a constructivist approach on academic achievement, learning strategies and self-concept, and student preference. 76 grade six students were enrolled for the study and divided into two groups. The experimental group was taught using the constructivist approach while the control group was taught using the traditional approach. Research instruments used for the study were as follows: mathematics tests administered by the teacher, learning strategies inventory, self-concept inventory and a classroom environment survey. After analyzing post test results, the study revealed that constructivist teaching is more effective in terms of academic achievements of students and has some effects upon their motivation to learn.

Lord (1999) conducted a study in which he compared the effects of two instructional methods (teacher centered and student centered) in non-laboratory-based environmental science course for college undergraduates. Students in 2 teacher-centered (traditional) classes (n = 46 and n = 45) were instructed with material in standard lecture fashion for 90 min twice a week. Students in 2 student-centered (constructivist approach) classes (n = 48 and n = 42) worked in small groups in question-discussion fashion. The same teaching materials, learning resources, questionnaires and examinations were used for both Groups. Post-test results showed that students taught with the 5E Learning Cycle method understood the course material in a much deeper than students in the traditional classes.

2.2.2. Characteristics of Constructivist Teaching and Learning

During the last decades, considerable interest has been paid to the design of constructivist learning environments. Constructivist instructional design aims to provide generative mental construction embedded in relevant learning environments that facilitate knowledge construction by learners (Jonassen, 1991). The implications of constructivism for instructional design are revolutionary as they replace rather than add to our current understanding of learning. Instructional designers are thus challenged to translate the philosophy of constructivism into actual practice (Karagiorgi & Symeou, 2005). According to constructivism, the centre of instruction is the learner. Meaningful understanding occurs when students develop effective ways to resolve problematic situations. Such situations foster motivation, because students have an opportunity to experience the pleasure and satisfaction inherent in problem solving. Constructivists recommend that designers provide problems which may be solved in different ways and leave students struggle with problems of their own choice (von Glasersfeld, 1993). In constructivist class room, activities are student centered and students are encouraged to ask their own questions, carry out their own experiments, make their own analogies and come to their own conclusions (Akar, 2005). However, the translation of constructivism into practice constitutes is an important challenge for instructional designers (Karagiorgi & Symeou 2005). Jonassen (1991) proposed some principles to design learning environments which are based on constructivism:

1. “Real world environments which are relevant to learning context should be created.
2. In order to solve real-world problems, realistic approaches should be focused.
3. The instructor should act as a coach and analyzer of the strategies when solving the problems.

4. Multiple representations and perspectives on the content should be presented.
5. Instructional goals and objectives should be negotiated.
6. Learning should be internally controlled and mediated by the learner".

According to the constructivist approach a teacher may structure the lesson first by engaging student interest on a topic that has a broad concept by doing demonstration or showing a short film and then asks an open- ended questions that test students prior knowledge on the topic. Next the teacher presents some information that does not fit with their existing understanding and lets students time to think and set their hypothesis and experiments in small groups, try to reconcile their previous understanding with the new knowledge. The role of the teacher during the group interaction time is to circulate around the class, ask questions that guide the students to understand the concepts being studied. After sufficient time for experimentation the small groups share and exchange their ideas and conclusions with the rest of the class. The table below shows the roles of teachers and students in constructivist approach learning class.

Table 2.1. The roles of the instructor and the learner in constructivist approach learning environment (Giesen, 2004).

Student-centered learning environment	
Instructor	**Student**
Facilitator of knowledge	Adaptive learner
Co-learner/collaborator	Collaborator/co-learner
Developer of instruction	Co-developer of goals and objectives
Reflective instructor	Knowledge seeker
Discovery facilitator	Knowledge creator
Negotiator of knowledge	Reflective learner
Team member	Learning through discovery
Information receiver	Negotiator of knowledge
Coach / facilitator	Team member
Evaluator	Active learner
	Responsible learner
	Mediate own learning

Evaluation is an important component in constructivist learning environment. Not all interpretations or opinions are good that learners are free to construct any knowledge. The concepts, ideas, theories and models constructed are both built and tested. Even though the learner is free to build a personal interpretation of the world, this interpretation has to be coherent with the general 'Zeitgeist' (Karagiorgi & Symeou, 2005). One way to address constructivism and inquiry learning in a classroom setting is through the 5E learning cycle model. 5E learning cycle model is rooted in constructivism and is supported by researches that address methods for conceptual change (Bybee & Landes, 1990). 5E learning cycle model will be discussed in detail in the following section.

2.2.3. 5E Learning Cycle Model

Today it is widely agreed that the fundamental aim of science teaching in school is to develop competence that will permit students to modify their pre-existing knowledge and to acquire new knowledge throughout their lives. This means that students must learn how to obtain information by themselves. To do so students must learn how to reason and argue (Castells, Enciso, Cervero & Lepoz, 2007). This issue can be addressed by using 5E learning cycle model because this model considers student's pre-existing knowledge to build up the new knowledge through students actively participating group discussions. It is understood from studies made that 5E model contributes positively to students' success, their developing concepts and development of their cognitive structures. 5E learning cycle is inquiry-based method that encourages students' active participation of teaching-learning process and as a results it increases students' academic achievements (Bevenino et al., 1999; Akar, 2005; Campbell, 2006; Cardak et al., 2008; yalçın & Bayrakçeken, 2010; Sadi & Çakıroğlu, 2010). The philosophy about learning that proposes learners need to build their own understanding of new ideas has been labeled constructivism. Much has been researched and written by many eminent leaders in the fields of learning theory and cognition (Akar, 2005). The Biological Science Curriculum Study (BSCS), a team whose Principal Investigator was Roger Bybee developed an instructional model for constructivism, called the "Five Es". Briefly, this learning approach as it relates to science can be summarized as follows: Learning something new, or attempting to understand something familiar in greater depth, is not a linear process. In trying to make sense of things we use both our prior experience and the first-hand knowledge gained from new explorations (Bybee et al., 2006). Using the learning cycle approach, the teacher invents the science concepts at the 2nd stage rather than defining it at the start of the lesson as in the case of traditional approach. The introduced concepts subsequently enable students to incorporate their exploration in the third stage and apply it to new examples. The five phases whose titles capture the essence of students' actions are listed below:

Engagement, Exploration, Explanation, Elaboration, Evaluation

Engagement: the activities in this section capture students' attention, stimulates their thinking, and helps them access prior knowledge. The activities of this phase make connections to past experiences and expose students' misconceptions; they should serve to mitigate cognitive disequilibrium. The role of the teacher is to present the situation and identify the instructional task. Successful engagement results in students being puzzled by, and actively motivated in, the learning activity. The word "activity" refers to both mental and physical activity. Sample Strategies:

- Observe surroundings for points of curiosity
- Ask questions about the real world
- Consider possible responses to questions
- Note unexpected phenomena
- Identify situations where student perceptions vary.

Exploration: Students are given time to think, plan, investigate, and organize collected information. This phase should be concrete and hands on. The teacher's role in the exploration phase is that of facilitator or coach. The teacher initiates the activity and allows the students time and opportunity to investigate knowledge. Sample Strategies:

- Brainstorm possible alternatives
- Observe specific phenomena
- Collect and organize data
- Employ problem-solving strategies
- Select appropriate resources

Explanation: students are now involved in an analysis of their explorations. Their understanding is clarified and modified because of reflective activities. In this phase, the teacher directs students' attention to specific aspects of the engagement and exploration and experience. The key to this phase is to present concepts, processes, or skills briefly, simply, clearly, and directly and to move on to the next phase. Teachers have a variety of techniques and strategies at their disposal to elicit and develop student explanations.

Sample Strategies:

- Communicate information and ideas

- Construct and explain a model or new explanation
- Review and critique solutions
- Utilize peer evaluation
- Assemble multiple answers/solution
- Integrate a solution with existing knowledge/experiences

Elaborate: this section gives students the opportunity to expand and solidify their understanding of the concept and apply it to a real world situation. This phase facilitates the transfer of concepts to closely related but new situations. In some cases, students may still have misconceptions, or they may only understand a concept in terms of the exploratory experience. Elaboration activities provide further time and experiences that contribute to learning. Sample Strategies:

- Make decisions
- Transfer knowledge and skills
- Share information and ideas orally
- Ask new questions
- Develop products and promote ideas
- Conduct activities in other disciplines

Evaluation: evaluation occurs throughout the lesson as shown in figure 2.1. The teacher should observe students' knowledge and skills along with their application of new concepts and a change in thinking. The teacher can complete a formal evaluation after the elaboration phase. This is the phase in which teachers administer assessments to determine each student's level of understanding. Sample Strategies:

- Constructs mental and physical models
- Performance assessments
- Rubrics and Scoring Tools
- Tests

Each of these phases of 5E model has a specific function and contributes to the teacher's coherent instruction and to the learners' formulation of a better understanding of scientific and technological knowledge, attitudes, and skills (Bybee et al., 2006).

The diagram below illustrates the sequences of the steps in 5E model as an input and output factors.

Figure2.1. Phases of 5E learning model

5E learning cycle is sequence of instruction that exposes students to problem situations in which they engage their thinking and then provides opportunities to explore, explain, extend, and evaluate their learning (Bybee et al., 2006).

Many studies conducted by scientists and researchers show that 5E learning cycle model is an effective teaching strategy in enhancing students understanding and achievements. In this section we will discuss the findings and results of some of the researches conducted in the past years across the different levels of students (from primary to undergraduate and in-service and pre-service teacher trainees), that investigated the effectiveness of 5E learning cycle in teaching science classes and the conclusions and suggestions given by the researchers. Some of the studies were masters' and doctoral thesis; some of them were international journal publications while others were studies conducted by universities.

We start with, Akar (2005) for his masters' degree thesis, conducted a study aimed to compare the effectiveness of instruction based on 5E learning cycle model over traditionally designed chemistry instruction on students' understanding of acid-base concepts and to investigate the effect of the method to students' motivation. Fifty-six tenth grade students from two classes of a chemistry course taught by the same teacher in Atatürk Anatolian High School 2003-2004 spring semester were enrolled for the study. The classes were randomly assigned as control and experimental groups. Students in the control group were instructed by traditionally designed chemistry instruction whereas students in the experimental group were taught using an instruction based on 5E learning cycle model. According to the findings from the study the researcher concluded that 5E learning cycle model caused significantly better acquisition of scientific concepts related to acid-base concepts than traditionally designed chemistry instruction.

Sadi and Çakıroğlu (2010) conducted a study aimed to investigate the effectiveness of 5E learning cycle instruction on 11th grade students' human circulatory system achievement. In this study, Human Circulatory System Achievement Test was used as research instrument to assess students' achievement on human circulatory system. Total of 60 students in four classes and two teachers, in a private high school in Ankara, were enrolled to participate in this study. The results of this study showed that 5E learning cycle instruction increased students' achievement in biology more than the traditional instruction did. Similarly, Bevenino, Dengel and Adams (1999) have investigated the advantages of 5E learning Cycle approach in their study. After analyzing the results of their study, researchers concluded that 5E Learning Cycle approach encourages students to develop their own frames of thought and it is an effective way of learning.

5E Learning Cycle is also effective for primary school students' understanding. Cardak, Dıkmenlı and Sarıtaş (2008) conducted a study aimed to investigate the effect of 5E instructional model on sixth grade students' success during the circulatory system unit. 38 students in two different classes instructed by the same researcher, in 2006-2007, participated in the study. One of the classes was assigned as the control group and the other as the experimental group. Appropriate activities of 5E instructional model were used in the experimental group while traditional teaching, using question and answer method, was applied with the control group. Pretest means of groups with respect to the Circulatory System Achievement Test were quite close (31.68 and 30.21) to each other, indicating there was no significant difference between the groups in terms of their prior knowledge. After the treatment the average post-test application scores from the experimental group (72.57) were higher than average scores obtained from the traditional science teaching method post-test application (53.42). Based on the evidence obtained through the activities carried out in the scope of the study, positive changes from the experimental group of students receiving the 5E instructional model activities have an effect of increasing success when learning about the circulatory system.

Similarly, Campbell (2006) published a study that investigated the fifth grade students' understanding of force and motion concepts as they engaged in inquiry-based science investigations through the use of the 5E Learning Cycle. Initial data were provided by a pretest indicating students' understanding of force and motion concepts. Findings from posttest results revealed that student knowledge of force and motion concepts increased and the survey results showed that after the study, students believed that they learned science better than via textbook-based instruction.

5E learning cycle model is not only effective for enhancing students' understanding and achievement but also effective for pre-service teacher training programs. Yalçın and Bayrakçeken (2010) carried out a study to determine the effect of the activities developed as compatible with 5E learning model based on constructivist approach to instruction on pre-service science teachers' achievement of acids-bases subject. 43 science pre-service teachers were enrolled for the study. Students were divided randomly into two groups, experimental (20) and control (23). Acids-Bases instruction based on 5e learning cycle was given to the experimental group where as the content designed traditionally was given to the control group that lasts for four weeks by the same teacher. Data was gathered using an achievement test of acids-bases with 20 items developed by the researchers and a semi-structured interview performed by the lecturer. Pretest means of groups with respect to acid-base achievement were quite close (6.10 and 6.83) to each other. After treatment posttest mean scores for the experimental and control groups were 12.20 and 9.35 respectively, which shows an average gain of 3 points. According to the findings researchers recommended that 5E learning is more effective than traditional approach by engaging students in the course content, developing students' critical thinking, contributing to students' learning and interest to the course, and helping them develop their scientific process skills.

Combining theses literatures we conclude that 5E learning cycle model eliminates students' misconceptions of scientific concepts and is more effective than traditional instructions in terms of academic achievements as well as motivations and attitudes towards science.

2.3. Computer Based Science Education

2.3.1. General over view of computer based science education

With increasing technological developments in the late 20th century, there have been fundamental changes in educational system with respect to factors like teachers, students and learning environment. Parallel to these, there have been important changes in contents and presentations of curriculum, process of teaching and learning and the roles of teachers and students in the teaching learning process (Akpınar & Aydın, 2007).

New technologies provide opportunities for creating learning environments that extend the possibilities of old technologies such as books, blackboard, etc. They offer a brand of new possibilities not accessible before. New technologies can be used to:

- "bring exciting curricula based on real world problems into the classroom,
- provide scaffolds and tools to enhance learning,
- give students and teachers more opportunities for feedback, reflection and revision,
- build local and global communities that include teachers, administrators, students, practicing scientists, . .

- expand opportunities for teacher learning" (Bransford et al., 2000).

Computers and modern technologies offer new opportunities to support Inquiry - based learning. Blumenfeld et al. (1991) in their analysis of technology as a support for project - based science learning identified six contributions that technology can make to the learning process:

1. "Enhancing interest and motivation,
2. Providing access to information,
3. Allowing active representations,
4. Structuring the process with tactical and strategic support,
5. Diagnosing and correcting errors,
6. Managing complexity and aiding production".

All of the fundamental properties of computing technologies offer benefits for inquiry-based learning the ability to store and manipulate large quantities of information, the ability to present and permit interaction with information in a variety of visual and audio formats, the ability to perform complex computations, the support for communication and expression, and the ability to respond rapidly and individually to users (Blumenfeld et al., 1991).

This study focuses the integration of computer simulations and constructivist approach in the teaching – learning environment so that effective learning outcomes are expected.

2.3.2. Computer Based Simulations

In order to achieve the targeted objectives and desired level of achievements of teaching learning process a suitable teaching method must be carefully chosen. Computer based simulation in physics education can play a positive role for increasing students understanding scientific concepts (Rutten, et al., 2012; Yesilyurt, 2011; Tekbiyik & Akdeniz, 2010; Bayrak, 2008; Jimoyiannis & Komis, 2001) and may promote their interest and motivation towards learning physics (Chen &

Howard, 2010; Bozkurta & Ilik, 2010; Gok, 2011; Güven, 2012). This is because computer simulation provides an easier way of visualizing abstract concepts of physics through virtual experiments. In constructivist approach learning is active construction of knowledge rather than passive reception of information. In comparison with traditional methods of learning which mainly based on lectures and text books, a learning environment with computer simulation has the advantage that students can systematically explore hypothetical situations, interact with simplified version of a process or system, manipulate the time scale of events, carry out hands on activities, and solve real life problems without facing difficulties (van Berkum & de Jong, 1991).

Today numerous Information and Communication Technology (ICT) applications are available, aiming to stimulate students' active engagements. The use of such ICT applications has developed a new research field in physics education, since it radically changed the framework under which physics teaching is being understood and implemented (Jimoyiannis & Komis, 2001). Among the various ICT applications, computer simulations are of special importance in Physics teaching and learning. Simulations offer new educational environments, which aim to enhance teachers' instructional potentialities and to facilitate students' active engagement. Computer simulations offer a great variety of opportunities for modeling concepts and processes. Simulations provide a bridge between students' prior knowledge and the learning of new physical concepts, helping students develop scientific understanding through an active reformulation of their misconceptions. Specifically, they are open learning environments that provide students with the opportunity to:

1. "Develop their understanding about phenomena and physical laws through a process of hypothesis-making, and ideas testing;
2. isolate and manipulate parameters and therefore helping them to develop an understanding of the relationships between physical concepts, variables and phenomena;
3. employ a variety of representations (pictures, animation, graphs, vectors and numerical data displays) which are helpful in understanding the underlying concepts, relations and processes;

4. express their representations and mental models about the physical world; and
5. Investigate phenomena which are difficult to experience in a classroom or lab setting because it is extremely complex, technically difficult or dangerous, money-consuming or time-consuming, or happen too fast", (Jimoyiannis & Komis, 2001).

The increasing availability of computers and related equipment such as projectors, smart boards, and mobile devices, as well as the fact that computer simulations have become available for a wide range of physics software programs (e.g., interactive physics, crocodile physics, Algodoo, Phet simulations **etc**), have led to simulations becoming an integral part of many science curricula (Rutten et al., 2012). A computer simulation is "a program that contains a model of a system (natural or artificial; e.g., equipment) or a process". It is the imitation of the operation of a real-world process or system over time (de Jong & van Joolingen, 1998).

Using computer based simulations in science classroom raises the question of how simulations are best used to contribute and improve the learning of science (de Jong & van Joolingen, 1998) and as result many researchers and teachers turned their eyes to computers and conducted studies focusing the impacts of computer-based simulations on students' understanding of scientific concepts by comparing with traditional methods. Early studies soon realized that computers showed a great potential to enhance students' achievements, but only if they are used appropriately, as a part of coherent educational approach (Bransford et al., 2000).

Jimoyiannis and Komis (2001) conducted a study on two groups, control and experimental, of 15-16 years old students to determine the role of computer simulations in the development of functional understanding of the concepts of velocity and acceleration of projectile motion. A total of 90 students attending the first year of Lyceum1 participated in the research. These students were attending courses in three typical public high schools in the city of Ioannina, Greece and represented a wide range of achievement levels. After the data was analyzed the results of the study provided supportive evidence regarding the effectiveness of using computer simulations in physics teaching. The students who used computer simulation in addition to the traditional instruction achieved significantly higher results on the research tasks. The researchers recommend that computer simulations can be used as a complement to or alternative for other forms of instructions in order to facilitate student's understanding of scientific concepts.

Duran et al. (2007) conducted a study that focuses on the affective and cognitive domains in order to investigate the effects of computer simulation on students' motivation and interaction. Researchers replaced part of the traditional method in a subject titled "Electrical Machines and Installations" with a software based method that makes use a computer simulation. This method appeared to stimulate discussions among the students themselves as well as the teachers during the brainstorm session. Although the results of cognitive domain could not be easily interpreted, the results of the affective domain indicated that this new method has a great influence on students' satisfaction. The researchers interpret this improvement as consequent of the use of real world examples and showing real time simulations during the lecture. The method also increases participation and involvement of students in the learning environment compared to traditional instruction.

Bayrak (2008), carried out a study which investigated whether computer assisted instruction was more effective than face-to-face instruction in increasing students' success in physics. The study was conducted in the spring semester of 2006 at the Department of Science and Mathematics for Secondary Education at Hacettepe University. There were 78 freshman students from the Divisions of Biology Education (N=39) and Chemistry Education (N=39) participants in the quantitative study which included a pre-test/post-test control group design. The subject of geometric optics covered in Physics II Course was provided through a simulation program to the experiment group whereas the control group had the same instruction through face-to-face teaching methods. After analyzing posttest results from the study, the researcher concluded that through computer simulations, students had the chance to conduct real-like experiments and see physical facts, which can only be investigated in laboratory settings.

Güven (2012) for her masters' degree thesis conducted a study that investigated the effectiveness of interactive white board application enriched by simulations, animations, and videos with the frame work of inquiry-based learning approach in accordance with 7E learning cycle model on students' academic achievements and motivations in Modern Physics Lessons in undergraduate program in Faculty of Education of kırıkkale University, Department of Science Education. In this study 106 students from two 2^{nd} year undergraduate classes participated. Students were divided randomly into two, experimental (53) and control (53) groups. Technology-supported (simulations, animations, videos and interactive white board) modern physics course with 7E learning cycle model was given to the experimental group where as traditional designed (Lecture, text books, ordinary board,…) instruction was given to the control group. The application continued for 8 weeks in the spring semester of 2011/2012 academic year. The research instruments used in the study were Modern Physics Academic Achievement Test, Teaching Materials Motivation Scale Test and Interactive Whiteboard Case Assessment Form. According to results and findings obtained from the post-test scores the researcher found that experimental group students who took technology based physics instruction scored significantly higher than those took traditionally based physics instruction in terms of academic achievements as well as motivation. The data obtained from experimental student's thoughts and opinions also supported the success and most of the students appreciated the use of technology in the field of science education.

Pektaş, Çelik, Katrancı and Köse (2009) in their study investigated the effect of computer simulations on 5^{th} grade students' achievements of the concepts in the unit light and sound. The results revealed that simulations are more effective than traditional methods with respect to light and sound.

Some researchers studied the role that simulations can play in the real laboratory. Martinez- Jimenez et al. (2003) focused in their study on using simulations as a means of preparing for laboratory activities. Students in both groups, the control and experimental, performed an experiment on the extraction caffeine from tea. A pre-laboratory simulation program introduced the experiment for the experimental group. Student performance was evaluated by: carried out experiment, laboratory report quality, experiment problem-solving and the results of written test. The researchers found that using preparatory simulation to better comprehension of the techniques and basic concepts used in their laboratory work. Similarly, Zacharia (2007) focused in his study the impact of simulations on student' understanding when used as a complementary tool with real laboratory. The control group was exposed to only real experiment where as the experimental group took a combination of real experiments and virtual experiments. The results indicated that replacing real experiment with virtual experiment during specific parts of the experiment has a positive influence on students' conceptual understanding of electrical circuits as measured by conceptual tests. Winberg and Berg (2007) also performed a study which focuses using simulations as pre-laboratory exercise. The researchers considered the questions that students ask their teachers during the laboratory exercise as an indicator of cognitive focus, and took spontaneous use of chemistry knowledge during interviews as an indicator of the usability of knowledge. The results of their experiments suggest that introducing laboratory work with a preparatory computer simulation leads to students asking more theoretical questions during laboratory work and showing more chemistry knowledge during interviewing. The researchers there for concluded that using computer simulations as a preparatory exercises enables students to integrate their theoretical conceptual knowledge with the practical and also contributes to students having a better sense of direction during their laboratory work.

Similarly, Finkelstein, Perkins, Adams, Kohl, and Podolefsky (2004) conducted a study that examines the effects of substituting computer simulations in place of real laboratory equipment in the second semester of a large-scale introductory physics course. The direct current (DC) circuit laboratory was modified to compare the effects of using computer simulations with the effects of using real light bulbs, meters and wires. Three groups of students, those who used real equipment, those who used computer simulations, and those who had no lab experience were compared in terms of their mastery of physics concepts and skills with real equipment. After the data was analyzed, obtained results showed that students who used the simulated equipment performed well both on conceptual survey of the domain and in the coordinated tasks of assembling a real circuit and describing how it worked. Finally, the researcher suggested that simulations necessarily promote conceptual learning and facility with equipment.

Ünlü and Dökme (2011) conducted a study aimed to investigate whether the combination of analogy-based simulation and laboratory activity as a teaching tool was more effective than using separately in teaching the concepts of simple electric circuits. A sample of 66 seventh grade students from urban elementary schools in Turkey was participated in the study. The participants were randomly divided into three groups, two control groups and one experimental group. Control group I students were exposed to laboratory activities; control group II students were taught using analogy-based simulations; whereas the experimental group students were taught using the combination of analogy-based simulations and laboratory activities. Electricity Performance Test (EPT) was administered to students' understanding of simple electricity concepts before and after teaching intervention. Posttest results indicated that the combination of analogy-based simulations and laboratory activities caused greater learning acquisition than the two methods did when used separately.

Rutten, et al. (2012) Carried out a meta-analysis in which the results of 510 research papers, published in the period 2001 – 2010, about the learning effects of computer-based simulations in science education are summarized. The review was based on two questions: the first regards the extent to which traditional science education can be enhanced by using computer simulations, and the second regards how simulations and instructional supports are best shaped and implemented in the most effective ways. Some studies compared computer simulations and traditional instruction while others compared computer simulations and laboratory activities. All reviewed studies that compare conditions with or without simulations report positive results for studies where simulations are used to enhance or replace traditional lectures, in the case of students' performance as well as motivation and attitude. Another effective way of using simulations is as a preparatory activity for real laboratory activities. Positive effects were found for the comprehension of the lab task as well as for practical laboratory skills during the real lab activities. The researchers recommended that simulations can play an important role in making lab activities more effective by offering the simulations as a pre-lab training. Computer simulations are also useful for the study of dynamic behavior of objects or systems in response to conditions that cannot be easily or safely applied in real life as in the case of nuclear physics. For the second question, the reviewed studies show the effects of well designed simulation-based instructions are potentially high. The main factors that need to be considered are the way the learner is addressed and involved and the way information from the simulation is presented

Similarly, Yesilyurt (2011) conducted meta-analysis of computer assisted studies in physics aimed to reach a common judgment about effectiveness of physics lessons carried out by using computer assisted instruction methods. The researcher combined the results and conclusions of 54 findings from 25 studies, investigating the effectiveness of computer assisted physics instruction, carried out from 2002 to 2011 in turkey. These studies examined whether computer assisted physics instruction contributes significantly to students' academic achievements or not compared with traditionally designed instructions. The studies comprised articles published in scientific journals, Master's degree thesis and phD thesis. All of the reviewed studies there were only four of them whose p values were greater than 0.05. From this it is seen that there is significant difference in favor of experimental group at significant level of 0.05 between experimental and control groups in all the data sets of the other studies. According to the statistical analysis performed in the meta- analysis the researcher concluded that computer assisted instruction has an important level of superiority. The researcher argued that post test scores are not the only indicator of the success but considering the qualitative parts of studies are also useful. Similarly, Liao & Chen (2007) and Tekbiyik & Akdeniz (2010) also carried out meta-analytical studies to synthesize existing researches comparing the effects of computer simulation instruction versus traditional instruction on students' achievements in Taiwan and Turkey respectively. Fast majority of the studies reviewed showed positive effects of computer assisted instructions on learning.

The main purpose of computer assisted instruction is to deliver the contents of the course through computers and realize instructional endeavors through the help of computer applications (Bayrak, 2008). In this respect, several software programs with different specifications might be used to deliver the subject matters.

Simulations, which allow representing real-life events in a controlled environment, are effective software programs ameliorating learning endeavors. Students can make their own decisions for each problem they are exposed to and see the results of their decisions in a safe environment (Bayrak, 2008). The current study uses a simulation programs called crocodile physics and PhET simulations to teach students the concepts of light.

2.4. Traditional Instruction

In traditional instruction the classes are usually driven by the teacher and depend heavily on textbooks. A traditional instruction is composed of an inward-oriented environment with a teacher and group of students, text books, blackboard and desks, which do not match the views of constructivists (Cardak et al., 2008). In traditional class there is fixed world of knowledge that the student must come to learn. Information is divided into parts and built into a whole concept and teachers transfer their thoughts and meanings to directly to passive students. There is little involvement for students in the teaching-learning process. The target of the learner is to regurgitate the accepted explanation or methodology transferred by the teacher (Caprio, 1994). In traditional class Students are expected to blindly accept the information they are given without questioning the instructor (kim, 2005). According to Cahyadi (2007) the traditional teaching approach is characterized by lectures requiring little or no active student involvement, laboratories with prescribed practical procedures, and tests or examinations emphasizing quantitative algorithmic problem solving procedures. Current studies that compared student-centered classes via traditional classes provide evidences that traditional approaches are not beneficial for ensuring permanent learning (Cardak et al. 2008).

Results of the studies discussed in the literature of this research that compare traditional instruction with constructivist based learning cycles also show that traditional method is ineffective in qualitative learning. The table below summarizes the major difference between traditional and constructivist approaches in terms of student activities, teachers' roles, teaching materials and the teaching environment.

Table 2.2. Comparison of traditional and constructivist classrooms (Brooks & Brooks, 1993, p.17, cited in Kim, 2005).

Traditional Classroom	Constructivist Classroom
Curriculum is presented part to whole, with emphasis on basic skills	Curriculum is presented whole to part with emphasis on big concepts
Strict adherence to fixed curriculum is highly valued	Pursuit of student questioning is highly valued
Curricular activities rely heavily on textbooks and workbooks	Curricular activities rely heavily on primary sources of data and manipulative materials
Students are viewed as "blank slates" onto which information is etched by the teacher	Students are viewed as thinkers with emerging theories about the world
Teachers generally behave in a didactic manner, disseminating information to students	Teachers generally behave in an interactive manner, mediating the environment for students
Teacher seeks the correct answer to validate student learning	Teachers seek the student's point of view in order to understand student's present conceptions for use in subsequent lessons
Students primarily work individually	Students primarily work in groups

2.5. Students' Attitude towards Physics

Physics education is in a continual evolving together with the changing world conditions. Therefore, creation of new learning media in the continuously improving educational programs and determining attitudes of the students towards physics lessons in a selection of learning materials and methods are essential for effective learning of the lectures (kaya & Böyük, 2011). Attitudes are related to coping with and management of the emotions occurring during learning process, and they play an important role in directing human behavior. Whether attitudes occurring as part of a system of values and beliefs are positive or negative they have an effect on learning process in a direct ma and influences future lives of individuals (Kaya & Böyük, 2011).

According to Hendrickson (1997), attitude is the best predictor for estimation of students' success. Researchers mostly examined attitudes of primary and high school students or candidate teachers, or investigated to the relationship between students' attitudes and their success. Results of the studies show that there is a positive correlation between students' attitude towards learning and academic achievements.
Many factors could contribute to student's attitude towards studying science and in particular physics. According to Ibeh et al. (2013), teachers, government policy, methods of teaching, teaching materials and students themselves, each has a role for improving students' attitudes towards physics and in order to create students' positive attitudes towards physics each of these factors must play a positive role in the teaching-learning environment. Laboratory methods ensure that students learn ways to use the knowledge with this method rather than memorizing it. Students improve their skills to better understand of concepts, and adapt them to daily life and it provides a positive attitude towards physics lessons (Kaya & Böyük, 2011). Thus, adequate methods of teaching could improve students' attitude towards physics.

To create positive attitudes of students towards physics and hence to improve the quality of physics education many researchers conducted studies to find out strategies of improving students' attitude towards physics. Some of such studies are discussed below:

Ibeh et al. (2013) conducted a study aimed at the strategies to improve attitude of secondary school students towards physics for sustainable technological development in Abakaliki Local Government, Area of Ebonyi state, Nigeria. Five research questions were raised to guide the study. A sample of 180 students and 18 teachers participated in the study. The instrument used for data collection was structured questionnaire. The data collected were analyzed and findings revealed the need of qualified/professional physics teachers, adequate instructional materials, equipment, teaching aids and tools, government incentive funding, motivation of both teachers and students, comfortable classroom, recommendation of textbook and comfortable library and laboratory. The researchers concluded that effective use of teaching aids; giving teachers opportunities to attend conferences, workshops and seminars; increasing number of professional physics teachers; use of varieties of teaching methods; encouraging teachers to teach in an interactive manner; adequate funding of schools by donating teaching resources; relating the content to be taught to the real life and arranging classrooms and laboratories properly will improve students' attitude towards physics.

Kaya and Böyük (2011) conducted a study that investigated the attitude of high school students towards Physics Lessons and Physical Experiments and whether factors such as gender, age, grade etc have an effect on students' attitude towards physics. The research has been designed as a scanning study, with population of high school students from the schools in the Kayseri Province Centre in the academic year of 2009/2010. Sample of the study was 295 students selected among the population by random sampling. A questionnaire including 20 items regarding students' attitude towards physics lessons and physical experiments were used in the study. After analyzing the results of the study researchers suggested that students' attitude towards physics lessons can be improved by considering the following comments:

- "Physical topics that consist of abstract concepts should be lectured in the students' daily life, together with simulations, animations and other videos to keep the attention of the students alive.
- Learning by discovery is better than passive listening, so it should be shown how to associate physical concepts with students' daily life experiences.
- Studio physics which is a method of teaching that provides an integrated learning environment with hands-on lab measurements coupled with active student problem-solving should be applied in the physics lessons.
- In order to make physics lessons more interesting, physics instructors should convince students that physics serves them by spending more efforts to associate physics–technology– daily life. Physics instructors should like their profession and reflect this to others".

Similarly, Trivedi and Sharma (2013) published a paper that studies students' attitude towards physics practical at senior secondary level in government schools of Udaipur city, India, which had science stream. 80 senior secondary students (40 girls and 40 boys) were taken as sample of study. Data collection tool was an opinion questioner. The research was based on three questions. One of these research questions was: What is the attitude of students towards practical work? The data gathered through questionnaire have been analyzed and interpreted from various angles including students' attitude towards physics practical work. Findings revealed that most students showed positive attitudes towards practical physics. From this study we can deduce that increasing practical sessions in physics class could develop students' attitudes towards physics.

As shown by the literatures reviewed in this study integration of technology with science education and using constructivist based learning cycles would have great contribution on developing students' positive attitudes towards science in general and physics in particular.

2.6. Light

2.6.1. Importance of light to our daily life

Light plays a vital role to our daily lives. Without sunlight green plants would not grow and animals relay on plants for food would not survive. Animals including humans also relay on light to see. We get information about our surroundings by the light emitted or reflected from the objects around us. With the help of technology scientists have been able to extend and improve the human vision by designing optical instruments such as microscopes and telescopes. Microscopes have enabled scientists to study much about diseases and micro organisms. Telescopes also enabled scientists to study much about the universe. The study of light and optical devices enabled doctors to help people with difficulties in focusing close and distant objects by giving them eye glasses and contact lenses. Optic fibers are used to carry telecommunication messages and pictures over long distances and can be used by doctors as an endoscope to obtain an image of an internal organ of a body. Cameras, projectors, magnifying glasses, etc are also scientific products which have great importance to our lives that depend on light (Taylor, 1999). Study of light may be divided into two branches:

1. **Geometric optics** which deals with the study of light in terms of light rays and beams. It mainly focuses on reflection and refraction of light, mirrors, lenses and devises that make use of lenses and mirrors.
2. **Physical optics** which is the study of nature and behavior of light. It mainly focuses on diffraction, interference and polarization of light, which is beyond the scope of the course of this study.

In this study the content to be taught was mainly geometric optics including rays and beams of light, rectilinear propagation of light, reflection and refraction of light, and Image formation by lenses and mirrors. Optics has become one of the subjects that cause common student misconceptions in physics education. In studies designed to remediate these misconceptions, it was found that simulations supported instructions and analogies are more effective for the correction of such student misconceptions (Aydin, 2012).

2.6.2. Geometric optics

Geometric optics, in which light is treated as traveling straight lines called rays, is a standard unit in the introductory physical science (Reiner et al., 1995). Formal knowledge in geometrical optics can be said to consist of four interrelated components: optical systems (light sources, mirrors, prisms, and lenses); light propagation (rectilinear propagation, absorption, reflection, and refraction); illumination patterns (shadows and images); and, finally, a systematic manner for linking the former components using verbal, graphical, and algebraic representations (Langley et al., 1996). The materials developed for this study was based on these four components of geometric optics.

3. M ETHOD

3.1. Type of the Study

The type of study is pretest-posttest quasi experimental design that involves 80 secondary school students. In order to determine whether the different teaching methods used in the study have different impacts on students' understanding of scientific concepts and attitudes, the performance of two groups of students, the experimental and control groups, were compared before and after the application of different teaching approaches. Since the administration of the school already planed the distribution of the classes at the beginning of the academic year and the study was supposed to run during the normal classes, random sampling could not be possible. However, two grade 11 classes from the science stream in Sh. Ali Jowhar Secondary School were randomly assigned as experimental group and control group for this study. The study consists of both quantitative and qualitative

3.2. Subject and Design of the Study

80 students (male: 57 and female: 23) from two 11^{th} grade science stream classes of Sh. Ali Jowhar Secondary School in the fall semester of 2014/2015 academic year were enrolled to participate in the study. Two different instructional methods used in the study were randomly assigned to the classes as experimental and control groups. An instruction based on computer simulations supported 5E teaching model was administered to the experimental group (N = 40) where as traditionally designed physics instruction was administered to the control group (N=40). The concepts of the light (introduction to light, reflection of light & mirrors, refraction of light & lenses, and colors of light) were taught in different methods to both groups by the same teacher. Light Concepts Achievement Test and Attitude Scale towards Physics as a school subject were applied to all students as a research instruments at the beginning and at the end of the study and Effectiveness of Computer Simulations Evaluation Form was applied to the experimental group at the end of the study. The

design of the experiment, variables involved and the sequences of the steps taken throughout the study are summarized in the tables 3.1, 3.2 and 3.3, respectively.

Table 3.1. Design of the study

Group	Pre-test	Teaching Method	Post-test
Experimental group	LCAT ASTP	CSSCA	LCAT ASTP ECSEF
Control group	LCAT ASTP	TDPI	LCAT ASTP

Where,

LCAT	Represents	Light Concepts Achievement Test
ASTP	,,	Attitude Scale Towards Physics
ECSEF	,,	Effectiveness of Computer Simulations Evaluation Form
CSSCA	,,	Computer Simulation Supported by Constructivist Approach
TDPI	,,	Traditionally Designed Physics Instruction

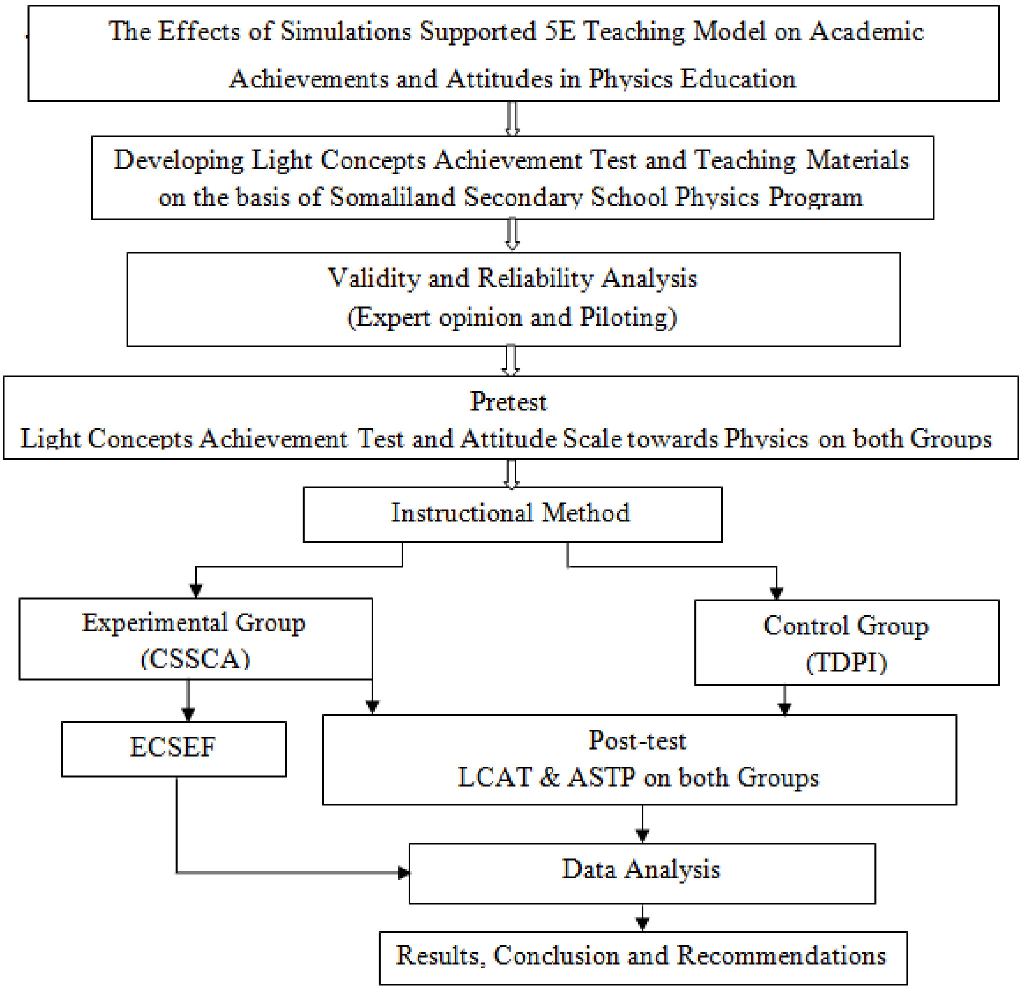
3.3. Variables Involved in the Study

The variables involved in this study were the different instructional methods used in the application of the study and the resulted outcomes due to these methods as shown in table 3.2 below.

Table 3.2. Independent and dependent variables

Independent Variable	1. Computer based simulations supported by constructivist approach (5E teaching model). 2. Traditionally designed physics instruction
Dependent Variable	1. Student' light concepts academic achievements 2. Students' attitude towards physics 3. Students' perceptions and opinions of using computer simulations in learning physics.

Table 3.3. Sequences of the steps taken in the study



3.4. Data Collection Instruments

In order to investigate whether the different teaching methods used in the study have significantly different impacts on students' understanding of scientific concepts and attitudes towards learning physics, research instruments were developed and applied to the students before and after the study. For this study the following three instruments were developed and used:

1. Light Concepts Achievement Test (LCAT) which evaluates students' prior knowledge of the subject matter and the gain in academic achievements due to the instructional methods used,
2. Attitude Scale Towards Physics (ASTP) which measures students' motivation and willingness to learn physics and whether the instructional methods used in the study have different effects on these factors, and
3. Effectiveness of Computer Simulations Evaluation Form (ECSEF) which surveys students' views, opinions and their comments towards using computer simulations in teaching physics.

LCAT and ASTP were applied to all students in both groups at the beginning and at the end of the study where as ECSES was applied to the experimental group at the end of the study.

3.4.1. Light Concepts Achievement Test (LCAT)

In order to evaluate the effectiveness of the different instructional methods used in the application of this study on students' academic achievements of the subject of study, Light Concepts Achievement Test was developed by the researcher. The test developed for the study contained 30 multiple choice questions which cover all subtopics of light across wide range of difficult levels. Each question had one correct answer and three distracters. Some of the items were selected from the past physics exam papers of GCSE developed by Somaliland National Examination Board and the rest were developed by the researcher in accordance to the Somaliland secondary School Physics Program and the literature of the text books used as a references in

Somali Secondary Schools (Bethel & Coppok, 1999; Pople, 1999; Duncan & Kennett, 2001; and Taylor, 1999). The items were developed so that each item evaluates an academic achievement of a particular learning outcome. During the development of test items care was taken to eliminate any irrelevant factor or any ambiguity that might prevent students from understanding what the question was supposed to ask. The language used in writing questions was so simple that students may not face difficulty in understanding the concept. The development stage of the test items was also based on Bloom's taxonomy of cognitive learning. Bloom's taxonomy contains six levels of cognitive learning which are: Knowledge or recall; Comprehension or understanding; application; Analysis or breaking things down through intellectual critical thinking; Synthesis or putting things together through critical thinking; and Evaluation or making judgments. The test items were prepared and developed under the framework of these cognitive levels.

To ensure whether the test items are appropriate to investigate light concepts achievements a group of experts in physics and physics education assessed the test and their recommendations were taken into account. Before using the test in its intended aim, a pilot test with 92 students which are not directly involved to this study was carried to evaluate reliability of the test items. In order to ensure the quality of test items two important characteristics of each item, item difficult and discrimination indices, are given a consideration. The item difficulty index is a measure of how difficult a test item is relative to the level of examinees. It is the ratio of number of examinees who answered the item correctly to the total number of examinees and it sometimes referred as p-value. It can range between 0.00 and 1.00. The higher the value of a difficult index the greater the proportion of examinees that responded to the item correctly, and hence the item is said to be an easier item. In other words, the closer the value of DI to zero the more difficult the item is and vice versa. For example, If 6 out of 50 examinees give correct responses to particular item of a test then the difficult index of the item is 0.12 and the item is said to be difficult. Item difficult of '0.00' means that no examination participant gave correct respond to that item where as item difficult of '1.00' indicates that all participants answer the item correctly. An item which is neither too difficult nor too easy is said to be good question. According to Kutlu (2004); Demir (2006) as cited in Güven (2012) difficult indices of test items can be categorized as follows:

- Items having difficulty indices between“0.00–0.19”are referred as“very difficult”
- Items having difficulty indices between “0.20–0.39” are referred as “ difficult”
- Items having difficulty indices between“0.40–0.59” are referred as “ moderate”
- Items having difficulty indices between “0.60 – 0.79” are referred as “ easy”
- Items having difficulty indices between “0.80 – 0.10” are referred as “very easy”.

Test items having difficulty indices between “0.20 – 0.80” are recommended to be used as a research tool in achievement tests (Singh, Y.K. 2012, as cited in Boopathiraj & Chellaman, 2013).

The item discrimination index is a measure of how well an item is able to discriminate knowledgeable students in the content area from those who are not. In other words Item discrimination corresponds to the ability of an item to distinguish among students on the basis of how well they know the content being tested. Item discrimination is determined by the relationship between an examinee’s performance on the given item (correct or incorrect) and his/her score on the overall test. For an item that is highly discriminating, in general the examinees who responded to the item correctly also did well on the test, while in general the examinees who responded to the item incorrectly also tended to do poorly on the overall test. The possible range of the discrimination index is -1.0 to 1.0; however, negative discrimination indicates that most of knowledgeable examinees are getting the item wrong and the least knowledgeable examinees are getting the item right. This is because either the item has been given incorrect key or its construction contains misleading content. Test items which are very difficult or very easy have low discrimination abilities. That is, the item will have low discrimination if it is so difficult that almost everyone gets it wrong or guesses, or so easy that almost everyone gets it right. Items having negative discrimination are removed from the test or should be reviewed. Test items having discrimination indices above 0.20 are normally considered to be appropriate for the application of academic achievement tests (Aggarwal, 1986 as cited in Boopathiraj & Chellaman, 2013).

Another important factor in test item analysis is reliability coefficient. Reliability is expressed as the consistency of particular research tool in producing the same result in repeated measurements (Sabri, 2013). An instrument is considered to be reliable if it produces the same result every time the instrument is used for the evaluation of an identical measurement. Boyle and Radocy (1987) as cited in Sabri (2013) proposed using Kuder and Richardson formula-20 for determining internal consistency of achievement test with dichotomous items. The values of KR-20 can range between 0 to 1.The closer the value to 1 the better the internal consistency. According to Fraenkel and Wallen (2008) as cited in Sabri (2013) a reliability coefficient of 0.70 or above of test items indicate that the test is reliable enough that can be used as a research tool.

$\text{KR } 20 = \frac{K}{K-1}\left(1 - \frac{\sum PQ}{SD^2}\right)$ (Source:Wiseman, 1999, p.102; as cited in Sabri, 2013)

Where,

K = number of items in the test

P = proportion of the examinees that responded the item correctly

Q = proportion of the examinees that responded the item incorrectly (Q = 1 – P)

SD^2 = variance of scores on the test (or square of the standard deviation)

Table 3.4. Results of LCAT item analysis

Item number	**Difficult index** (Güçlük indeksi)	**Discrimination Index** (Ayırcılık indeksi)
1	0.6957	0.3566
2	0.4565	0.3736
3	0.4565	0.4746
4	0.7174	0.2705
5	0.3370	0.3912
6	0.4348	0.4400
7	0.3913	0.3622
8	0.6848	0.2149
9	0.6739	0.4458
10	0.6304	0.4401
11	0.5326	0.5644
12	0.5652	0.3720
13*	**0.3804**	**0.1699**
14	0.4783	0.4615

Table 3.4.(Continue)

15	0.6630	0.3354
16	0.5543	0.3930
17	0.3696	0.3911
18	0.6522	0.3356
19	0.4457	0.4384
20	0.6196	0.4060
21	0.3696	0.2696
22	0.2826	0.3410
23	0.6739	0.2309
24	0.5870	0.3982
25	0.5000	0.3566
26	0.4783	0.4652
27*	**0.7283**	**0.0829**
28	0.4348	0.62572
29*	**0.8152**	**0.2149**
30	0.4022	0.4164

The highlighted questions, Q13, Q27 and Q29 were removed from the test. Q13 has a discrimination index of 0.1669 which is less than 0.2. This means that it has very low ability to discriminate students who know the content to be tested well from those do not know. Similarly, Q27 has even smaller discrimination index, 0.0829 and so it has no discrimination effect. On the other hand, when we look at the inter-item correlation matrix, it has a negative correlation with the other questions. Q29 has a difficult index of 0.8152 which means that about 82% of the examinees gave correct responses to this question. That is, it is the easiest question of the test and has a low discrimination index as well. After removing these three questions from the test, the difficulty indices of the remaining items lie between ‘’ 0.20 – 0.8’’ with an average of 0.52 and their discrimination indices lie above 0.20. By using Kuder and Richardson formula-20, shown above, the reliability coefficient of test items was found to be 0.8521. The resulted test items used in the study are shown in (see Appendix 2). The developed test items which contain 27 questions were applied to students in both groups at the beginning and at the end of the study and the examinees who gives correct responses to all questions will score 27 marks, i.e each question carries 1mark. The distribution of questions developed from the different sub-topics and their range of cognitive levels are shown in tables 3.5 and 3.6, respectively.

Table 3.5. The distribution of questions across the sub-topics

Sub-topic	Question numbers
4.1 Intro. to Light	1, 2, 3
4.2 Reflection of Light and Mirrors	4, 5, 6, 7, 8, 13, 22
4.3 Refraction of Light and Lenses	9, 10, 11, 12, 14, 15, 16, 17, 23, 24, 25, 26, 27
4.4 Colors of light	18, 19, 20, 21

The number of questions developed from each topic depends on the variety of subtopics included in that particular topic and the number of learning outcomes in the instructional objectives (see Appendix 1) to be measured. There were 13 questions developed from "4.3" sub-unit. This is because about 10 learning outcomes were supposed to evaluate and the largest number of subtopics in the content (Refraction of light in different transparent media; Real and apparent depth; Total internal reflection; image formation by lenses) were covered in this sub-unit. In other words, the number of questions developed from each sub-unit is proportional to its respective instructional learning outcomes.

Table 3.6. Distribution of test items across the different levels of Bloom's Taxonomy

No	Cognitive Level	Number of Questions	Percentage of total (%)
1.	Knowledge/Recall	5	19
2.	Understanding	8	30
3.	Application	6	22
4.	Analysis	4	15
5.	Synthesis	2	7
6.	Evaluation	2	7

3.4.2. Attitude Scale Towards Physics (ASTP)

One of the objectives of this study was to investigate students' attitudes towards learning physics and whether the different instructional methods involved in the study have different effects on these attitudes, and hence attitude scale towards physics is adopted to measure these effects. The attitude scale used in this study (see Appendix 3) was first developed by Barmby et al. (2005) and it is then reviewed and used by Kaya and Böyük (2011) to measure the attitude towards physics and physical experiments of secondary school (9^{th}, 10^{th} and 11^{th} grade) students in Kayseri province centre, Turkey. After the necessary revisions and changes were made in the questioner a pilot study was carried out and reliability factor of the applied scale was found to be as *Cranach's Alpha = 0.73*.

There were 20 items in the scale, 12 items are about the students' attitude towards physics lessons and 8 items are about students' attitude towards physical experiments. The students participating in the study were asked to mark their level of agreement for any given statement which has five degrees of options. Some of the items were aimed to measure students' positive attitudes towards physics or physical experiments (e.g. we learn interesting things in physics lessons; I like physics more than other subjects; I get good marks from physics examinations; etc). For each such questions, students' level of participations were taken as [(1) strongly disagree, (2) disagree, (3) neither agree nor disagree, (4) agree, (5) strongly agree], where as negative statements such as physics lessons are boring; physics lessons are difficult; I only fail physics lesson; etc students' level of participations were taken as [(5) strongly disagree, (4) disagree, (3) neither agree nor disagree, (2) agree, (1) strongly agree]. There for, the maximum students' attitude score is 100 points where as minimum score is 20 points. The attitude scale was applied to students in experimental and control groups at the beginning of the study and immediately after the completion of the study.

3.4.3. Effectiveness of Computer Simulations Evaluation Form (ECSEF)

One of the objectives of this study was to search students' perceptions, opinions and comments of using computer simulations in learning physics. For this reason an interview form that contains 6 items was developed by the researcher (see Appendix 4). The first question asks about the advantages of using computer simulations from the students' point of view; the second question asks whether CBS has an effect on students motivation; the third asks students to compare with reason the CBS method and their traditional way of learning; the fourth asks whether students recommend physics teachers to use CBS or not; the fifth asks which sub-topic in the study they think that CBS was the most effective; and sixth question asks which topics other than light concepts would they recommend to use CBS. This interview form contributes qualitative data to the study. ECSEF was applied to the experimental group only at the end of the study.

3.5. Material Development

The research problems discussed in chapter one, addressed students' lack of engagements due to traditional teaching approach, where students are not active participants in teaching-learning environment. According to the literatures reviewed in chapter 2 traditional ways of teaching encourage students to become more passive and are not beneficial for ensuring permanent learning. Most of the studies discussed in the review also revealed that traditional instructions failed to motivate students in learning science in general and physics in particular and that there is more widespread agreement on the ineffectiveness of traditional instruction.

To overcome these problems, improve the quality of physics education and to reach the educational objectives prescribed in science curricula, students must be intellectually engaged and actively involved in their learning environment. As the most of studies reviewed in chapter 2 agreed, students' active participation can be promoted by using instructional methods based on constructivist approach. They also agreed that activity-based instructions supported by computer simulations result in substantial conceptual learning gains in many different contexts. Since successful computer-supported learning environments follow the practices of good pedagogy, it should not be a surprise that most successful environments involve interactive engagement, peer interactions, or both. The primary use of computer based simulation that we examined here in this study is technology as a tool that the learner manipulates to learn about the physical world.

In order to convert the plan of the study into action in which an integration of 5E learning cycle model with computer simulations is used to enhance interactively students' understanding of light concepts, teaching materials were developed and applied. The materials developed in this stage were based on Somaliland Secondary School Physics Program and instructional objectives (see Appendix 1) prepared from that program.

3.6. Application

After the experimental and control groups were observed that they were academically at the same level and that there was no significant difference between their prior knowledge of the content to be taught, through analyzing their pretest scores, the material developed were taught to both groups in different approaches. The implementation of the study lasted for 24 periods in 6 weeks. The main target was to reach the learning outcomes prescribed in the instructional objectives (see Appendix 1) for both groups.

In the control group the focus of teaching was lecture method where the teacher drives much of the teaching learning process by transferring the scientific concepts of the content to the students through explanations without considering their prior knowledge. During the lecture, the teacher asks questions to the students and students in turn may ask questions to the teacher. The teacher answers students' questions and gives suggestions when needed. At the end of each period, written exercises were given to the learners and then learners do the exercises individually. The teacher uses the worked exercises as a feedback for evaluating whether students understood the content or not. For the questions or problems that students did incorrectly, either they take as home work or they work together with the teacher in the class. Text books, notes prepared by the teacher and diagrams drawn on flip charts were the main teaching resources for this traditionally designed instruction. In contrast, the experimental group was instructed using activity-based computer simulations supported 5E teaching model. The 5E were arranged such that students were actively participated the teaching learning process through activity based simulations. The five phases are summarized as follows: capturing students' attention and curiosity; allowing them to construct the knowledge in the topic; letting them to explain what they have discovered; applying what they have learned in different but similar situations; and observing students conceptual understanding of the content.

The current study uses a simulation programs called **crocodile physics** and **PhET** simulations to teach students the concepts of light. We choose **crocodile physics** because:

1. It is a simulator that lets you model a range of models in electricity, Forces, motion, optics, and waves;
2. You can build simulations by dragging parts from the tool bars at the side of the screen and arrange as you wish;
3. The program includes some ready-made models that students can use for practice and edit by themselves as needed;
4. Work space is enough, appropriate and can be extended as many more pages as you wish;
5. Text part provides whatever necessary for writing such as bold, italics, underline, powers and subscripts, font size, symbols etc;
6. We have the options that we can use experimental tools as pictures as well as symbols;
7. The use of the program is so simple that students can manipulate the activities by themselves.

Similarly, **PhET** simulations program is chosen because they: 1) Define specific learning goals; 2) Encourage students to use sense-making and reasoning; 3) Connect with and build on students' prior knowledge & understanding (including addressing possible misconceptions); 4) Connect to and make sense of real-world experiences; 5) Encourage productive collaborative activities; 6) Require reasoning/sense-making in words and diagrams; 7) help students monitor their understanding.(https://phet.colorado.edu/publications/Teaching).

3.6.1. Engagement

In engagement phase, the teacher captures the attention and curiosity of the learner by showing simple demonstrations and asks open-ended questions through which he evaluates students' prior knowledge. Considering the answers given by students, whether they are right or wrong the teacher estimates the extent to which the students have a background about the topic and their misconceptions. This stage provides a bridge that connects the past and current activities. Engagement prepares students for the next stage and makes them involved to the activities they are doing. Some examples of simulations and pictures used for engagement are shown below.

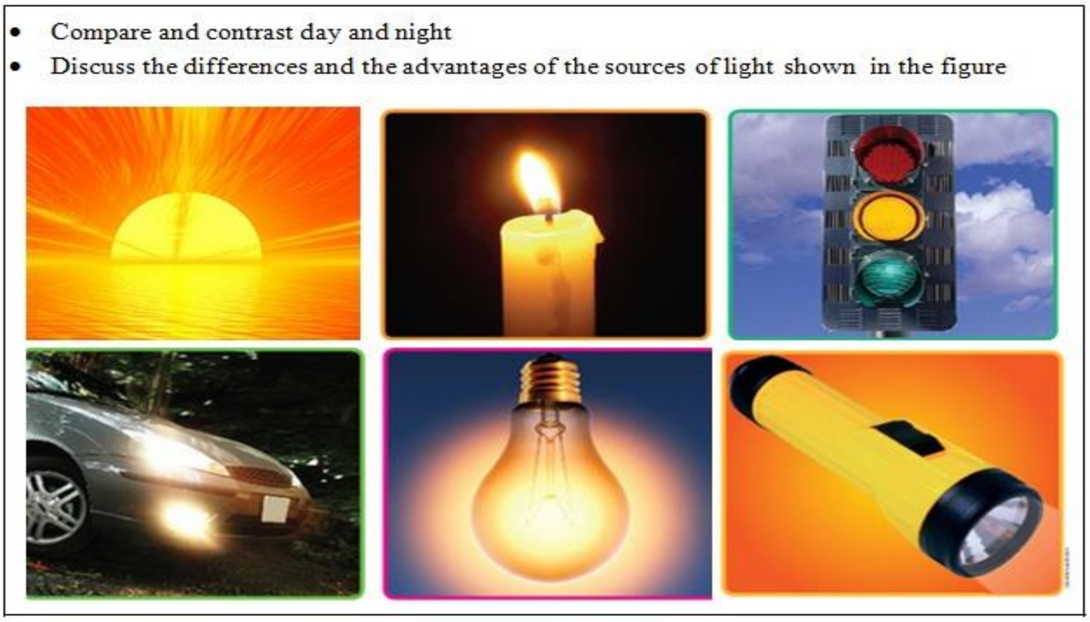


Figure 3.1 Pictures used for engagement in introduction to light.

Reflection of Light

- Have you ever seen light of the sun coming from a pool of water in front of you? If yes how this could happen?
- Do you believe that moon is non luminous object? If yes how can we see it at night?

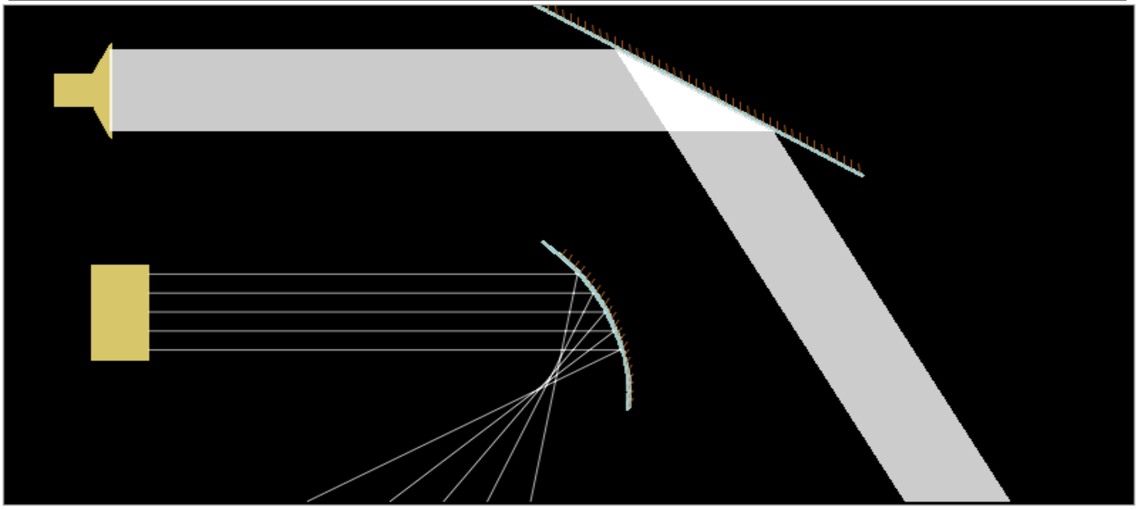


Figure 3.2. An example of a simulation used for engagement in reflection of light

- The pencil in the beaker seems to be bent at the surface of water. In your opinion what causes this phenomena?
- Discuss what happens to the ray of light from the torch as it enters the water in the beaker

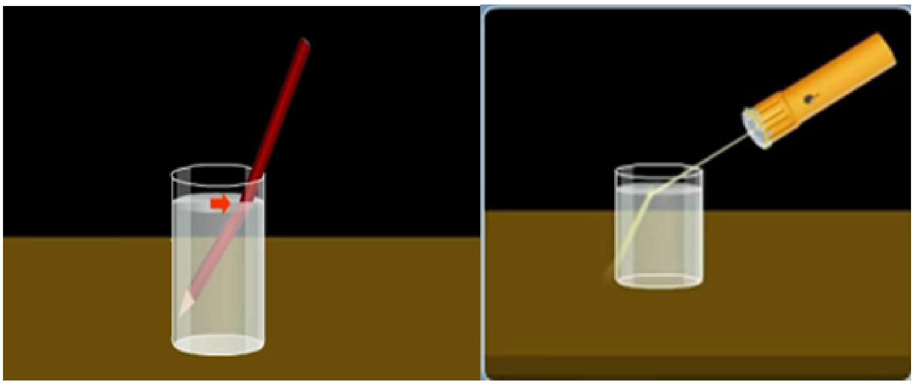


Figure3.3. pictures used for engagement phase in refraction of light

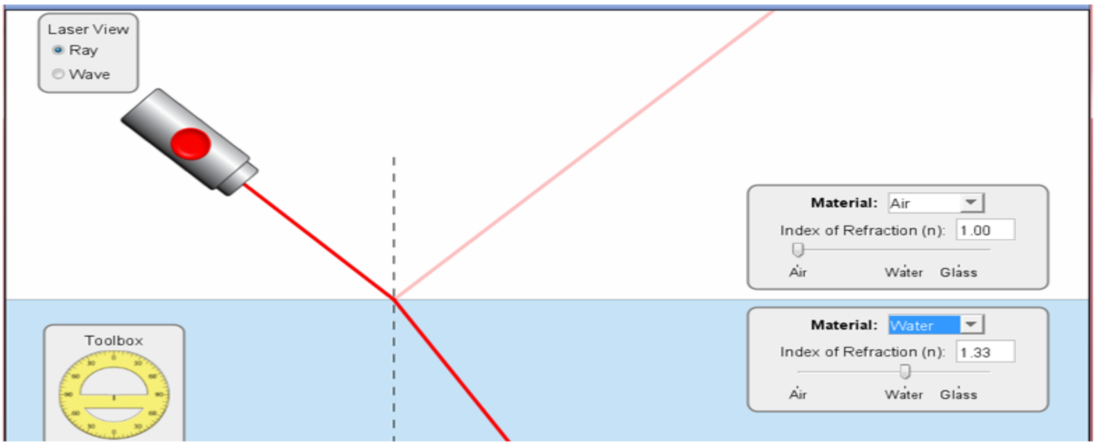


Figure 3.4. An example of a simulation used for engagement in refraction of light.

Students used the simulation shown in figure 3.4 for searching the answers of questions such as: In your opinion what causes the ray of light to be bent? What would happen to the ray of light if the two media were the same? What would happen to the ray if the two media were interchanged? What would happen if the ray was normal to the surface where the two media meet?

Students answered these questions through activity based simulations

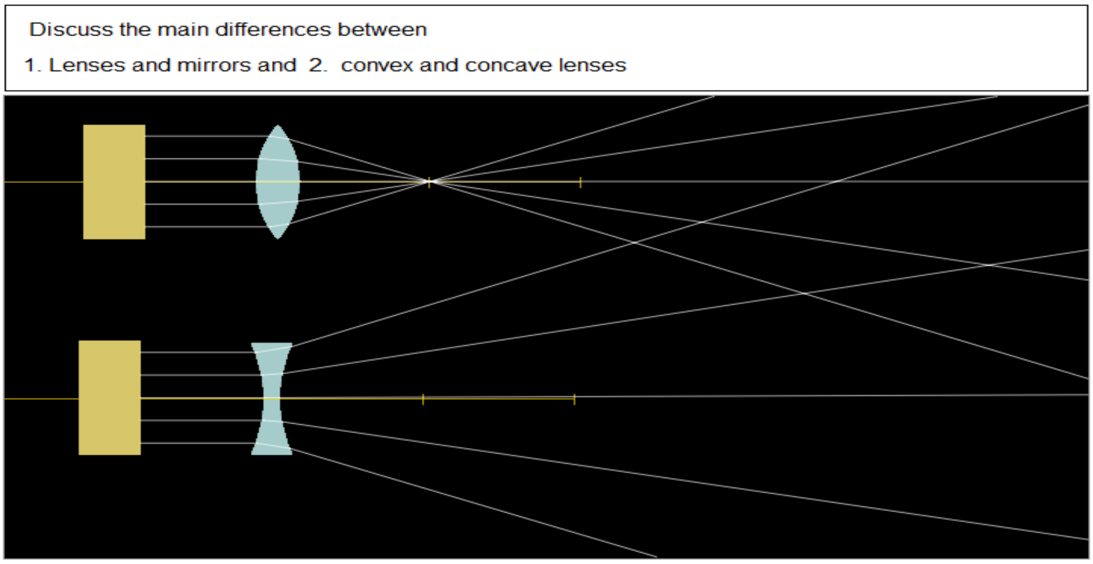


Figure 3.5. a simulation used for engagement in teaching about lenses

- Have you ever seen a rainbow in the sky? If yes what causes a rainbow to appear? In your opinion what are the conditions for a rainbow to appear in the sky?
- Is there any relation between colors of paint and the light that shines on it? What happens when two different colors of paint are mixed together?

Figure 3.6. A picture used for engagement when teaching colors of light

3.6.2. Exploration

In exploration, learners were assigned to carry out activities in groups and discuss their findings among their peers. They were given the chance to write down their own hypothesis, identify the variables involved in the activity and test their hypothesis through virtual experiments. Experiments could be the proofs of familiar laws e.g. the law reflection, Snell's law etc or finding the effects that changing one physical quantity has on another e.g. to answer questions such as " how changing the position of an object from a lens affects the position and size of the resulted image?. In this stage the role of the teacher was a guider or facilitator and had the opportunity to view students' pre-existing ideas. By discussing their findings students tried to reach common judgments within their groups. Some examples of the simulations used in the exploration phase are given below.

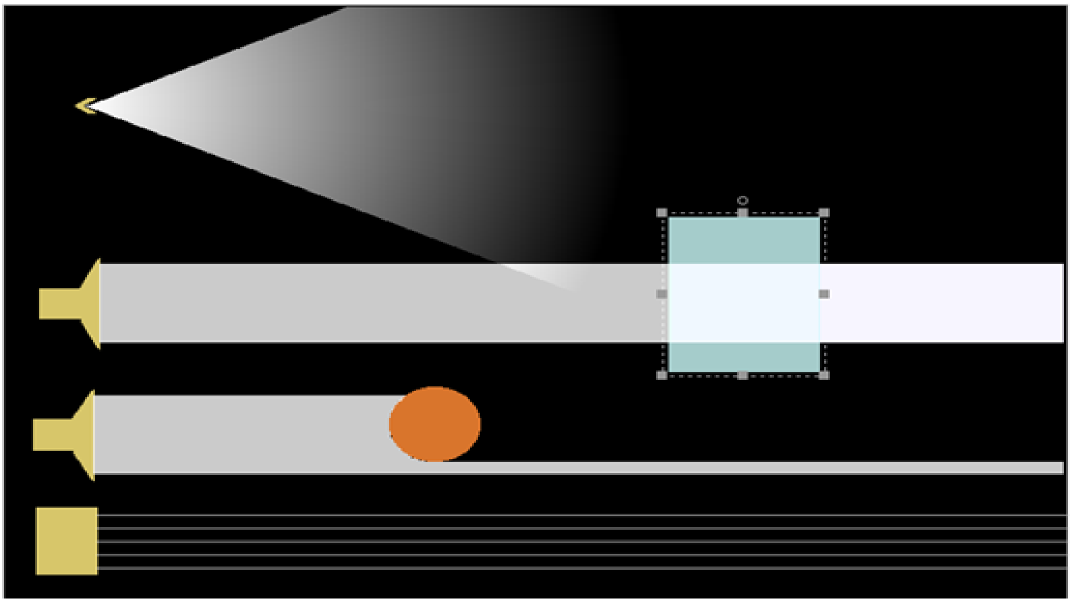


Figure 3.7. A simulation used for exploration in introduction to light

In the simulations shown in figure 3.7 students were searching to identify the different sources of light, light rays and beams, effects of light when it falls on transparent or opaque objects. They were asked to compare these virtual sources of light and the real sources such as the sun, lamps, torches, etc.

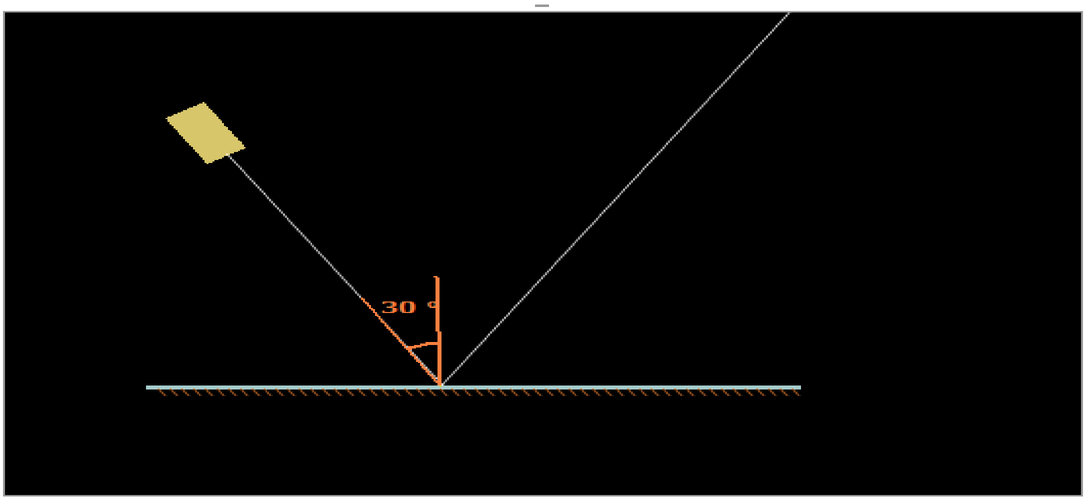


Figure 3.8. A simulation used for exploration in reflection of light

In the simulation shown in figure 3.8 students carried out an activity to verify the law of reflection through virtual experiment by taking different angles of incidence and observing the sequences in each case. They also compared the different types of reflections using different types of mirrors (plane, concave, convex, etc).

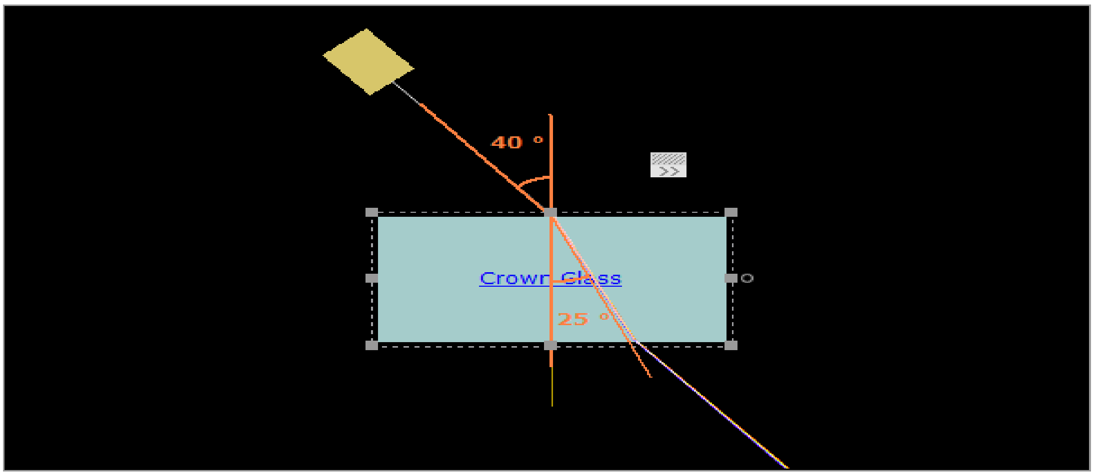


Figure 3.9. An example of simulations used for exploration in refraction of light

In the simulation shown in figure 3.9 students carried out an activity to prove the law of refraction (Snell's law) through virtual experiment by changing the values of the angles of incidence and in turn by changing the medium (e.g. glass, water, ice, diamond etc.) and observing the results.

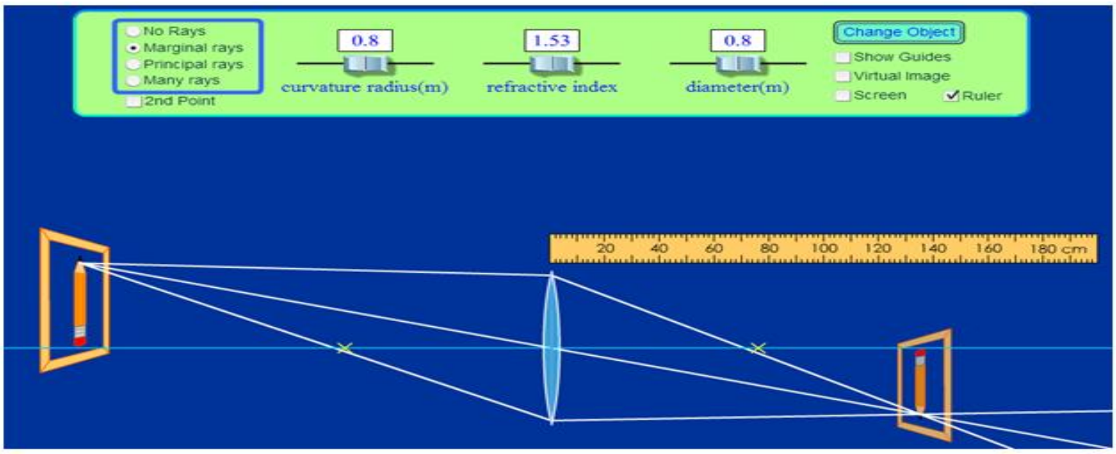


Figure 3.10. Asimulation used for exploration phase in lenses

In the simulation shown in figure 3.10 students carried out an activity to search the effects of changing the focal length of the lens and in turn the position of the object has on the size, nature and position of the resulted image.

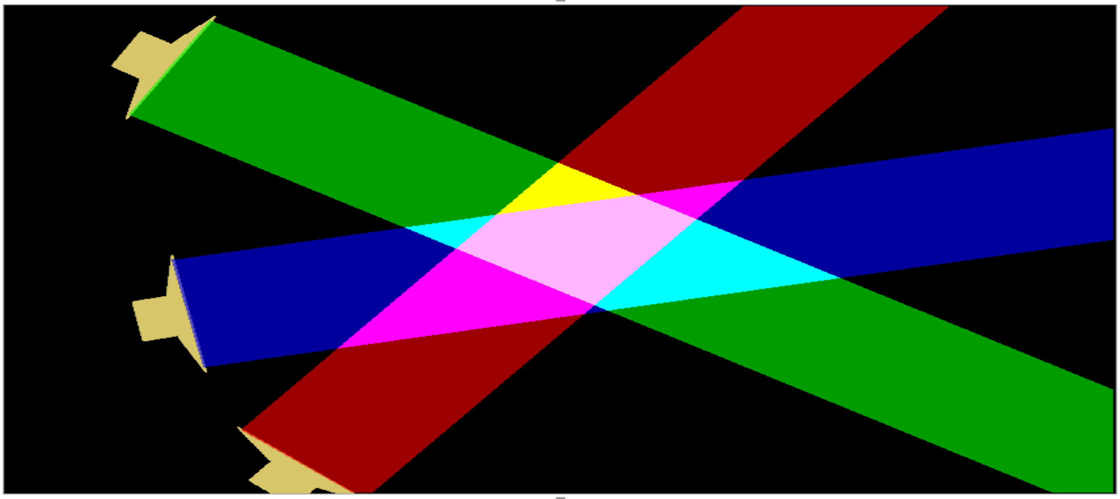


Figure 3.11. An example of simulations used for exploration in colors

3.6.3. Explanation

In this third phase, students were given the chance to demonstrate by expressing their conceptual understandings and explaining their findings, usually one student from each group presented what they found. In this stage students had the opportunity to learn from each other and exchange ideas under the guidance of the teacher. It was also in this stage that the teacher explains the concepts by considering student's misconceptions. In his explanation the teacher focuses the areas where students did not explain in detail and where there is a variation of conceptual understandings among the groups. Some of the simulations used in explanation phase are given below.

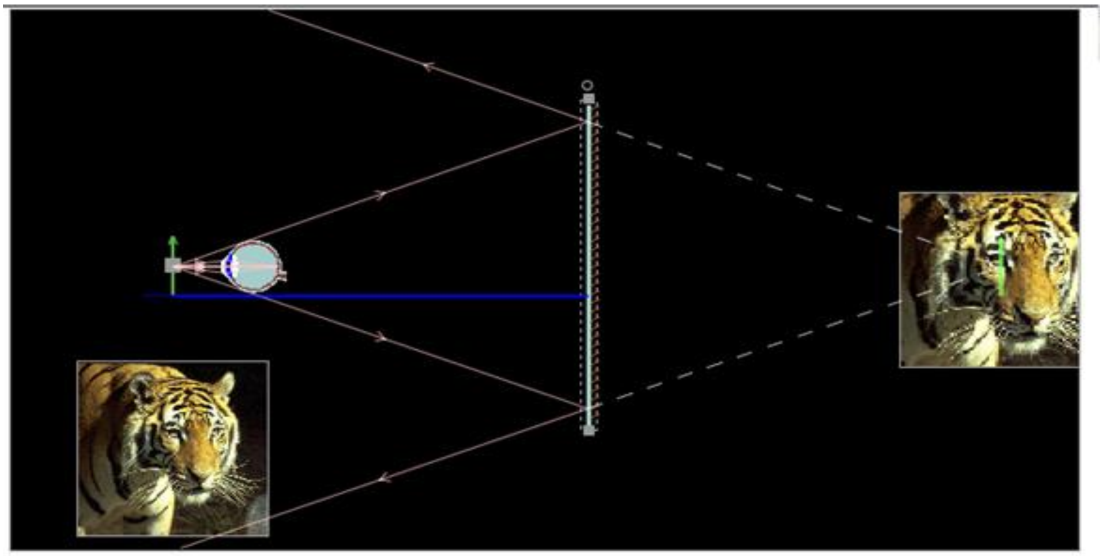


Figure 3.12. An example of simulations used for explanation of image formation due to reflection of light

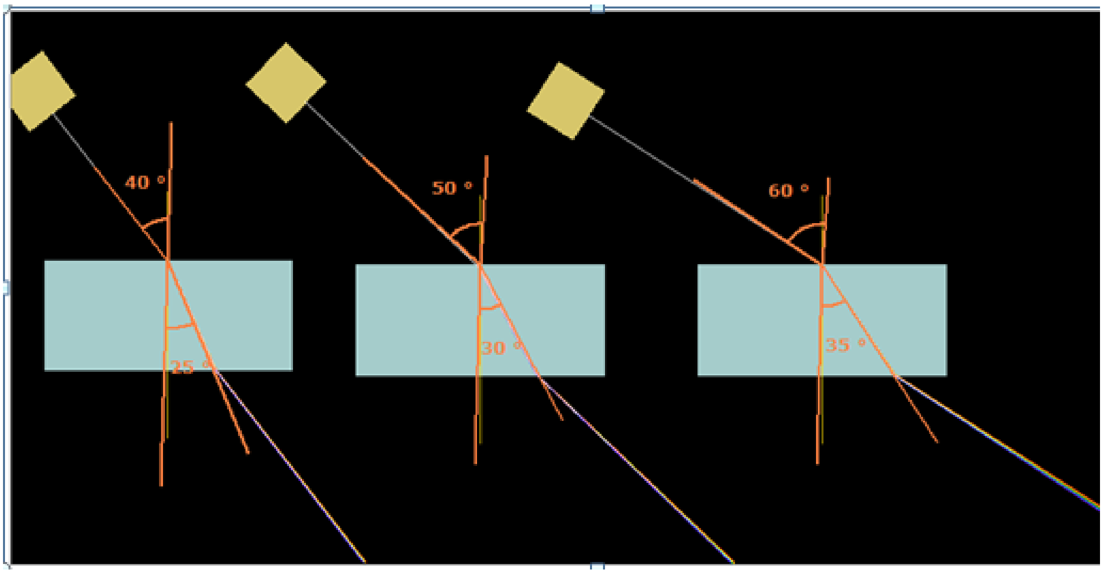


Figure 3.13. An example of simulations used for explanation in refraction of light

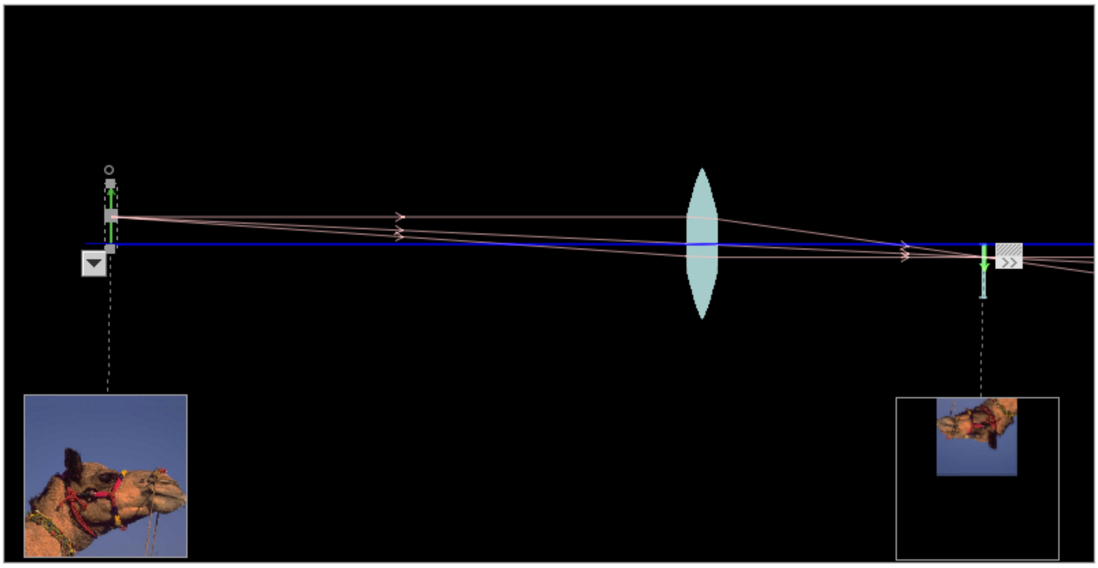


Figure 3.14. A simulation used for explanation phase in image formation by lenses

Figure 3.15. An example of simulations used for explanation in colors

In the simulation shown in figure 3.15 the effects of combining different colors of light, color subtraction by using colored filters and how the brain senses the colors were explained. Addition of colored pigments was also discussed in this phase.

3.6.4. Elaboration

In this phase students worked in groups again and were given the chance to understand the concept in depth and the teacher challenges students' conceptual understandings. In this stage students develop deeper and broader understanding of the topic and use these concepts to conduct additional different but related activities. It is in this stage where the developed concepts were extended to the real world. Some of the examples of simulations and pictures used for elaboration are given below.

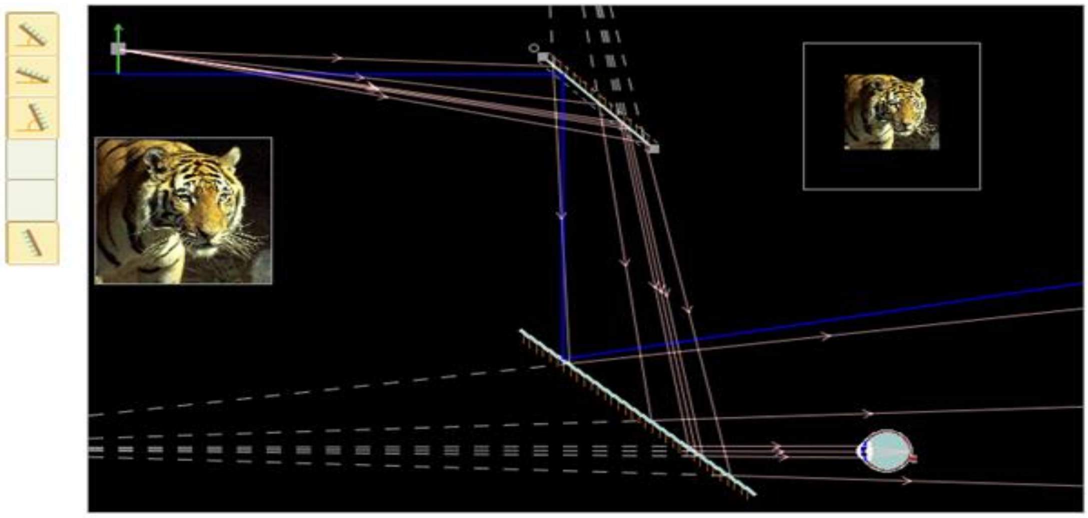


Figure 3.16. A simulation used for elaboration in reflection of light

In the simulation shown in figure 3.16 students carried out an activity which demonstrates virtually how periscopes work. Students did the activity by trial and error and presented their understanding by giving examples of where periscopes are used in real world. A very interesting thing was that one group brought two real plane mirrors in the class and conduct very simple activity which supports their virtual experiment done on the computer.

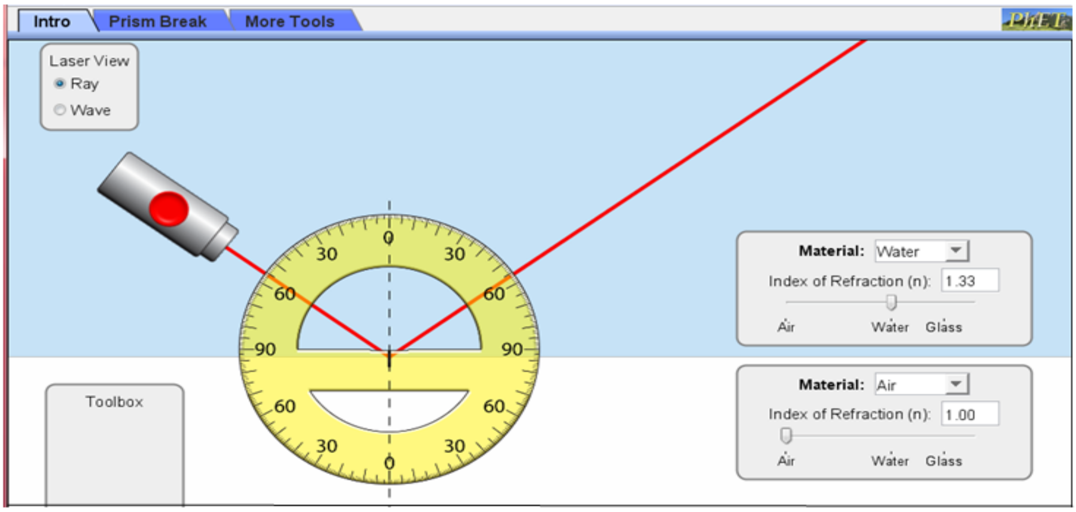


Figure 3.17. A simulation used for extending the concept of refraction into total internal reflection (elaboration).

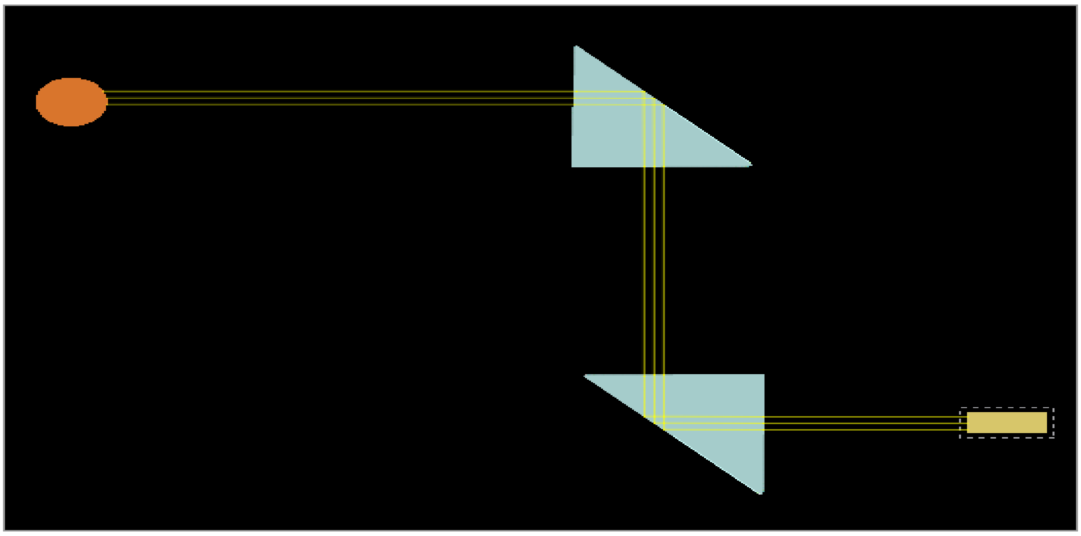


Figure 3.18. A simulation used for elaboration in total internal reflection

In the simulations shown by figure 3.17 and figure 3.18 students carried out activities for using total internal reflection to turn light rays through 90^0 and through 180^0. It was also discussed that this method could be an alternative way of developing a periscope.

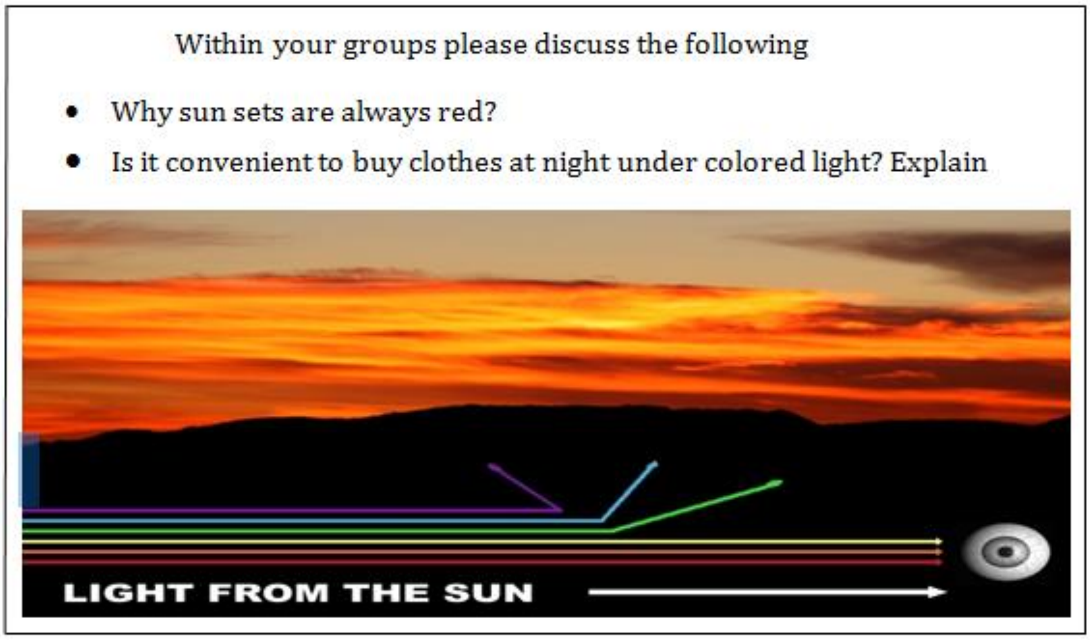


Figure 3.19. A picture used for elaboration phase in colors

3.6.5. Evaluation

Evaluation occurs throughout the lesson in parallel to the phases. For example the teacher evaluates students’ prior knowledge at engagement phase, evaluates how students explore knowledge and how they conduct activities in the next two stages, evaluates how can they apply what they learnt real life in the elaboration phase and finally evaluates the overall progress of the lesson at this fifth phase. In this stage students were encouraged to assess their understanding and the teacher evaluated students’ progress towards the achievements of the instructional objectives through questioning and exercises. Examples of the exercises used for evaluation are given in (see Appendix 5).

Figure 3.20. Experimental group class environment-1

Figure 3.21. Experimental group class environment-2

3.7. Analysis of the Data

Data was collected from various sources based on the research questions stated in chapter one. These sources include Light Concepts Achievement Test, Attitude Scale towards Physics and Effectiveness of Computer Simulations Evaluation Form. With the intention of answering research questions, the collected data was analyzed by using SPSS 17 (Statistical Package for Social Sciences). At the beginning of the study, test item analysis was carried out to find the difficult and discrimination indices of items and reliability factor of the achievement test.

During the data analysis, number of participants was taken as (N), mean samples was taken as ($\bar{X}$), degree of freedom (df), standard deviation (SD), t-value (t), significance level (p) and effect size (η^2). The differences of pre-test and post-test scores between the groups or within the groups were compared at significant level of 0.05. That is, if $p > 0.05$ There is no significant difference between the values to be compared, if $p < 0.05$ there is significant difference between the values. Effect size was also used to confirm the strength of the significance level.

3.7.1. Light Concepts Achievement Test

- To analyze the pretest achievement test scores aimed to assess students' pre-existing knowledge and whether there was significant mean difference between the two groups before the study, "independent samples t-test (bağımsız örnekler t-testi)" was used.
- To analyze the posttest achievement test aimed to assess whether the different instructional methods used in the study have different impacts on students' understanding of scientific concepts "independent samples t-test" was used.
- To analyze whether there is a significant mean difference between pre-test and post-test scores within each group "Paired Samples t-test (Bağımlı Gruplar t-testi)" was used.

- To analyze the differences between the groups across the test items, percentages of students who did respective questions correctly were compared.

3.7.2. Attitude Scale towards Physics

- To analyze whether there was a significant difference between students' pre-test attitude scores before the study and whether there is significant difference between their posttest scores due to the different instructional methods used in the study "Independent Samples t-test" was used.
- To analyze whether there is a significant mean difference between pre-test and post-test attitude scores within each group "Paired Samples t-test" was used.

3.7.3. Effectiveness of Computer Simulations Evaluation Form

In order to investigate the perceptions and opinions of students in the experimental group about simulation assisted physics instructions their answers for each of the questions in ECSEF survey form were analyzed by using content analysis techniques. After reading through the answers on the form and gathering together the responses that occurring most frequently codes were created. By combining the codes which could be under the same umbrella, sub-themes and themes were also determined. The opinions on these codes were interpreted in a way that readers can easily understand. During the interpretation, few examples of comments were given for codes with higher frequencies by directly reporting students' opinions (Sarı & Güven, 2013).

4. RESULTS

In this chapter, the results and findings from the analysis of the data collected during the implementation of the study are presented. The research tools used for the data collection include: Light Concepts Achievement Test, Attitude Scale towards Physics, and Effectiveness of Computer Simulations Evaluation Form. In the first part of this chapter, the findings from the analysis of students' pretest and posttest scores with respect to LCAT for comparison between the groups (experimental and control) and within groups (either experimental or control) are given. Secondly, the findings from the analysis of students' pretest and posttest scores with respect to ASTP for comparison between groups and within groups are given. Finally, the findings from the analysis of the data given by students in the experimental group through ECSEF survey in which they expressed their opinions, perceptions, comments, and recommendations towards using computer simulations in learning physics are presented.

The differences between students' pretest and posttest scores were measured at a significant level or p – value of 0.05. To know how strong the effect of the independent variable had on the dependent variable, effect size was also used. Effect size (Etki büyüklüğü), denoted by the symbol η^2 (eta squared) is a simple way of quantifying the size of the difference between two groups. It is the proportion of variance in the dependent variable that is attributable to the effect of the independent variable. It is given by the formula, (Büyüköztürk, 2010; as cited in Güven, 2012).

$$\eta^2 = \frac{t^2}{t^2 + (n_1 + n_2 - 2)}$$

Possible values for η2 lie between 0 to 1 and 0.01, 0.06 and 0.14 are considered as low, medium and high, respectively. For paired samples t-test, the above formula can be rearranged as follows:

$$\eta^2 = \frac{t^2}{t^2 + (n - 1)}$$

4.1. Findings Related to Light Concepts Achievement Test

4.1.1. Results of independent samples t-test Analysis for Group Comparison with respect to pretest scores on Light Concepts Achievement Test

Before the implementation of the study, independent samples t-test were performed to investigate whether there was a significant mean difference between the experimental and control groups with respect to students' pretest scores on Light Concepts Achievement Test due to their prior knowledge. To make sure whether the small difference between the mean scores of the groups can be negligible or not, effect size was also calculated.

Table 4.1. The results of independent samples t-test analysis for group comparison with respect to pretest scores on LCAT.

	No of students	**Mean**	**Standard Deviation**	**Deg. of freedom**	**t-value**	**Sig. level**	**Effect size**
Group	**N**	$\bar{X}$	**SD**	**Df**	**t**	**P**	η^2
Experimental	40	8.700	3.451	78	–0.289	0.773	0.0011
Control	40	8.925	3.511				

In table 4.1, t-test results revealed that there was no significant mean difference between students in the experimental and control groups before the instructions were given ($t = 0.289$ & $p = 0.773 > 0.05$). As shown in the table, the average pretest score of students in the experimental group was 8.700 where as the average pretest score of students in the control group was 8.925. The two values are quite close to each other and hence there was no significant difference between students' prior knowledge of the subject matter before the application. The value of eta squared (η2) given in the table4.1, which is calculated as 0.0011, also shows that there was no significant difference between the groups at the beginning of the study.

4.1.2. Results of independent samples t-test Analysis for Group Comparison with respect to posttest Scores on LCAT.

After implementation of the study, independent samples t-test were performed again to investigate whether there is a significant mean difference between the groups with respect to students' posttest scores on LCAT due to the different instructional methods used. Effect size was also calculated to show how big the difference between mean scores of the groups is.

Table 4.2. The results of independent samples t-test analysis for group comparison with respect to posttest scores on LCAT.

	Number of students	**Mean**	**Standard Deviation**	**Deg. of freedom**	**t-value**	**Sig. level**	**Effect size**
Group	**N**	$\bar{X}$	**SD**	**Df**	**t**	**P**	η^2
Experimental	40	15.975	4.747	78	3.22	0.002	0.11
Control	40	12.725	4.261				

In table 4.2, t-test results revealed that there is significant posttest mean difference with respect to LCAT between students in the experimental and control groups after the implementation of the study ($t = 3.22$ & $p = 0.002 < 0.05$). As shown in the table, the average posttest score of students in the experimental group was 15.975 whereas the average pretest score of students in the control group was 12.725. This shows that the average gain in academic achievement of students in the experimental group is much greater than the average gain in academic achievement of the students in the control group. The value of eta squared (η2) given in the table4.2, calculated as

0.11, which is little bit higher than the medium value (0.06), also shows that there is significant difference between the groups after the application.

This significantly higher achievement gain in the experimental group when compared to the control group is thought to be students' active involvement in the teaching learning process, constructing their knowledge through observations and critical thinking under the guidance of the teacher.

4.1.3. Results of paired samples t-test Analysis for comparing pretest and posttest scores with respect to LCAT in the experimental group.

Besides independent samples t-test, paired samples t-test were also performed to investigate whether there is significant mean difference between pretest and posttest scores of the achievement test in the experimental group due to the instructional method used. To judge how big the effect of the instructional method on students understanding of the content taught is, effect size was also calculated and interpreted.

Table 4.3. The results of paired samples t-test analysis in comparison with respect to pretest and posttest LCAT scores for the experimental group

	Num. of students	**Mean**	**Standard Deviation**	**Deg. of freedom**	**t-value**	**Sig. level**	**Effec t size**
Group	**N**	$\bar{X}$	**SD**	**Df**	**t**	**p**	**η2**
Pretest	40	8.700	3.451	39	– 14.157	0.00	0.72
Posttest	40	15.975	4.747				

In table 4.3, paired samples t-test results revealed that there is significant mean difference between pretest and posttest scores of students in the experimental group before and after the implementation of the study ($t = -14.157$ & $p = 0.00 < 0.05$). As shown in the table, the average pretest score of students in the experimental group was 8.70 whereas their average posttest score is 15.975. There is great progress in academic achievement of students in the experimental group due to instructional method and teaching resources used during the implementation. The value of eta squared (η2) given in the table 4.3, calculated as 0.72, which is very high value, also confirms that there is significant difference between pretest and posttest scores of students in the experimental group in terms of academic achievements.

4.1.4. Results of paired samples t-test Analysis for comparing pretest and posttest scores with respect to LCAT in the control group.

Similarly, paired samples t-test were performed to investigate whether there is significant mean difference between students' pretest and posttest scores of the achievement test in the control group due to the instructional method used. As in the case of the experimental group, effect size was also calculated to measure how big is the effect of the instructional method on students understanding of the content taught.

Table 4.4. The results of paired samples t-test analysis in comparison with respect to pretest and posttest LCAT scores for the control group

	No of students	**Mean**	**Standard Deviation**	**Deg. of Freedom**	**t-value**	**Sig. level**	**Effect size**
Group	**N**	$\bar{X}$	**SD**	**df**	**t**	**P**	η^2
Pretest	40	8.925	3.511	39	– 8.931	0.00	0.67
Posttest	40	12.725	4.261				

In table 4.4, paired samples t-test results revealed that there is significant mean difference between pretest and posttest scores of students in the control group with respect to the LCAT before and after the implementation of the study ($t = -8.931$ & $p = 0.00 < 0.05$). As shown in the table, the average pretest score of students in the control group was 8.925 whereas their average posttest score is 12.725. There is also an observable progress in academic achievement of students in the control group due to instructional method used in the application even though it is not as big as in the experimental group. The value of eta squared (η^2) given in the table4.4, calculated as 0.67, which is very high value, also shows that there is significant difference between pretest and posttest scores of control group students' academic achievements too. The small gain in academic achievement of students in the control group when compared to that in the experimental group is thought to be: students' less engagement in the lessons where the teacher used to transmit concepts directly to the students. That is, the more students think, search and construct knowledge the more they learn, and this is absent in traditional teaching approach; students in a traditional classes think that it is the responsibility of the teacher when it comes to teaching; their lack of involvement in the classes causes a negative impact to their motivation and attitudes towards physics; there are some abstract concepts and physical laws in physics which students can develop better understanding only if they learn practically with hands on activities.

4.1.5. The results of independent samples t-test analysis for group comparison with respect to their differences in academic achievement gains after application

After implementation of the study, independent samples t-test were performed again to investigate whether there is a significant mean difference between the groups with respect to students' academic achievement gains due to the different instructional methods used. To compare how strong the instructional methods used affect on academic achievements eta squared was also calculated and interpreted.

Table 4.5. The results of independent samples t-test analysis for experimental and control group comparison with respect to their differences in pretest and posttest mean scores in LCAT

	No of students	**Mean**	**Standard Deviation**	**Deg. of freedom**	**t-value**	**Sig. level**	**Effect size**
Group	**N**	$\bar{X}$	**SD**	**Df**	**t**	**P**	η^2
Control	40	3.800	2.691	78	5.209	0.000	0.258
Exper.	40	7.275	3.250				

In table 4.5, independent samples t-test results revealed that there is significant mean difference between academic achievement gains of students in the experimental and control groups after the implementation of the study ($t = 5.209$ & $p = 0.00 < 0.05$). As shown in the table, the average academic achievement gain of students in the control group was 3.80 where as the average gain of students in the experimental group is 7.275 which is higher than that of the control group. The value of eta squared (η2) given in the table4.5, calculated as 0.258, which is very high value, also shows that there is significant mean difference between academic achievement gains of students in the two groups due to different instructional methods used. This difference is thought to be the sequences of the factors highlighted in 4.1.2 above.

4.1.6. Comparing percentages of students' correct responses in posttest

To analyze the differences between group responses across the test items, percentages of students who did respective questions correctly were compared. In this section we will focus the test items where there is an observable difference between the groups and the nature of these items. Table 4.6 gives the percentage of students' posttest correct responses with respect to LCAT.

Table 4.6. Percentages of students' correct responses in the post-test

Item	Experimental Group Post-test (%)	Control Group Post-test (%)
1.	60	62.5
2.	40	30
3.	77.5	55
4.	77.5	67.5
5.	62.5	52.5
6.	57.5	20
7.	57.5	27.5
8.	82.5	60
9.	50	77.5
10.	82.5	67.5
11.	75	55
12.	35	32.5
13.	67.5	52.5
14.	80	77.5
15.	30	52,5
16.	32.5	20
17.	62.5	67.5
18.	47.5	42.5
19.	80	52.5
20.	72.5	35
21.	47.5	10
22.	77.5	62.5
23.	55	57.5
24.	52.5	37.5
25.	45	27.5
26.	60	45
27.	30	25

If we look at table 4.6, it can be seen that there is big difference between the groups in questions with higher levels of cognitive skills which shows that 5E learning cycle model develops. For example, the difference in students' responses of questions, 3, 6, 7, 8, 11, 19, 20, and 21 were greater among other questions after application. Most of these questions come from higher three levels (analysis, synthesis and evaluation) of Blooms' Taxonomy.

4.2. Findings Related to Attitude Scale towards Physics

The scale consisted of 20 items in five-likert scale so that the maximum and minimum scores one can obtain are 100 and 20, respectively. From this we see that the indecisive average score is around 60. The results of independent and paired samples t-test for comparison between groups and within groups with respect ASTP are presented and interpreted in the subsequent sections.

4.2.1. Results of independent samples t-test Analysis for Group Comparison with respect to pretest Scores on ASTP.

Before the application of the study was started, independent samples t-test were performed to investigate whether there was a significant mean difference between the students in the experimental and control groups with respect to their pretest scores on Attitude Scale towards Physics due to their prior perceptions. To judge whether the small difference between pretest mean scores of the groups is small enough to be neglected or not, effect-size was also calculated and interpreted

Table 4.7. The results of independent samples t-test analysis for group comparison with respect to pretest scores on Attitude Scale towards Physics.

Group	No of Students	Mean	Standard Deviation	Deg. of Freedom	t-value	Sign. Level	Effect Size
	N	$\bar{X}$	SD	Df	t	p	η^2
Experimental	40	64.075	11.834	78	0.525	0.601	0.0035
Control	40	65.450	11.586				

In table 4.7, independent samples t-test results revealed that there was no significant mean difference between students' attitude scores before the implementation of the study ($t = 0.525$ & $p = 0.601 > 0.05$). As shown in the table, the average pretest score of students in the experimental group was 64.075, where as the average pretest score of students in the control group was 65.450. The two values are very close to each other and hence students' attitude towards physics was more or less the same before the application. This conclusion is also supported by the value of eta squared (η2) given in table 4.7, calculated as 0.0035, which is very low value effect size.

4.2.2. Results of independent samples t-test Analysis for Group Comparison with respect to posttest Scores on ASTP.

At the end of the study, independent samples t-test were also performed to investigate whether there is a significant mean difference between the groups with respect to students' posttest scores on ASTP due to the different instructional methods used. Effect size was also calculated to show whether the difference between mean scores of the groups is big enough to be considered.

Table 4.8. The results of independent samples t-test analysis for group comparison with respect to posttest scores on Attitude Scale towards Physics.

Group	**No of Students**	**Mean**	**Standard Deviation**	**Deg. of freedom**	**t-value**	**Sign. Level**	**Effect Size**
	N	$\bar{X}$	**SD**	**Df**	**t**	**P**	η^2
Experimental	40	72.975	11.247	78	2.536	0.013	0.076
Control	40	66.175	12.693				

In table 4.8, t-test results revealed that there is significant mean difference between posttest scores of the students in two groups with respect to ASTP after the implementation of the study ($t = 2.536$ & $p = 0.013 < 0.05$). The value of eta squared ($\eta 2$) given in the table, calculated as 0.076, which is little bit above the medium value also shows that there is significant difference between the groups after the application. This observable difference in attitude between students in experimental and control groups is thought to be: experimental students' greater engagement in the lessons as compared with the traditional classes; learning by doing through practical activities increased students understanding and the more students understand the topic the more they develop positive attitude; and children like using computers. Furthermore, the significantly higher academic achievements of the experimental group with respect LCAT is thought to be the consequence of motivational increase due to the computer based simulation supported by 5E learning cycle model used.

4.2.3. Results of paired samples t-test Analysis for comparing pretest and posttest scores with respect to ASTP in the experimental group.

In addition to the independent samples t-test, paired samples t-test was also performed to observe the significant difference between pretest and posttest ASTP scores in the experimental group at the end of the study. Eta squared, was also calculated to interpret the size of the effect of the computer based simulation supported by 5E learning cycle model on students' attitude towards physics.

Table 4.9. The results of paired samples t-test analysis in comparison with respect to pretest and posttest ASTP scores for the experimental group

Group	No of Students	Mean	Standard deviation	Deg. of Freedom	t-value	Sign. Level	Effect Size
	N	$\bar{X}$	SD	Df	t	P	η^2
Pretest	40	64.075	11.834	39	-5.443	0.00	0.431
Posttest	40	72.975	11.247				

As shown in table 4.9, paired samples t-test results show that there was a significant mean difference between scores by the experimental group in pre-test and post-test of attitude scale towards physics after the implementation of the study (t = - 5.443, p=0.00). The value of eta squared, calculated as 0.431, which is high value, also confirms that there is a significant increase in attitude of students in the experimental group at the end of the study. Thus, computer based simulations supported by 5E learning cycle model has positive influence on students' attitude towards physics. The possible factors thought to be the causes of this change were discussed in 4.2.2.

4.2.4. Results of paired samples t-test Analysis for comparing pretest and posttest scores with respect to ASTP in the control group.

Similarly, paired samples t-test was also performed to investigate whether there is significant mean difference between pretest and posttest ASTP scores in the control group at the end of the study. Eta squared, was also calculated to decide whether the small difference between pretest posttest scores is significant enough to be considered or not.

Table 4.10. The results of paired samples t-test analysis in comparison with respect to pretest and posttest ASTP scores for the control group

Group	No of Students	Mean	Standard Deviation	Deg. of Freedom	t-value	Sign. Level	Effect Size
	N	$\bar{X}$	SD	Df	t	P	η^2
Pretest	40	65.450	11.568	39	-0.683	0.498	0.011
Posttest	40	66.175	12.693				

In table 4.10, paired samples t-test results revealed that there was no significant mean difference between pretest and posttest ASTP scores of students in the control group after instructions were given ($t = -0.683$ & $p = 0.498 > 0.05$). As shown in the table, the average pretest score of students in the experimental group was 65.45 where as their average posttest score is 66.175. The two scores are quite close to each other which indicate that there was no significant change in students' prior perceptions before and after the application. The value of eta squared (η2) given in the table, calculated as 0.011, which very low value effect size, also confirms that there was no significant motivational increase in the control group due to the traditional teaching learning approach used.

4.3. Findings Related to the Effectiveness of Computer Simulations Evaluation Survey

To investigate students' opinions and perceptions about using computer simulations in teaching physics, semi-structured interview that contains 6 questions was administered to the experimental group at the end of the study. The findings of the content analysis related to the students' views and opinions towards computer simulations are presented in this section. This section contributes qualitative part of the study and supports the quantitative part discussed in the preceding sections. During the analysis of the data in the evaluation survey form, by combining the related information, themes, sub-themes and codes are determined.

4.3.1. Findings and Interpretations from the analysis of the information related to the theme 'BENEFITS'

Sub-themes and codes under the theme 'BENEFITS' and frequencies of these codes are given in table 4.11

Table 4.11. Sub-themes, codes and frequencies under the theme 'BENEFITS'

THEMES	SUB-THEMES	CODES	FREQUENCY
BENEFITS	Advantages	Makes time sufficient	11
		Harmless and no risk	9
		Can be used at home	5
		Provides the necessary tools	3
		Easy to operate	3
		Accurate measurements	1
	Supporting Effective Learning	Increases understanding	24
		Hands on activities	17
		Encourages active participation	12
		Simplifies learning	11
		Provides permanent learning	10
		Cooperative learning	7
		Associating to real life	2
	Motivation	Interesting	21
		Focusing attention on learning	14
		Modern and technology based	7
		Contains beautiful diagrams	6
		Acts like a game	1

Under the umbrella entitled 'BENEFITS' the sub-themes of 'Advantages', 'Supporting effective learning', and 'Motivation' lie and from each of these sub-themes, related codes are determined. Frequencies, number of times chosen for each code, were given in table 4.11. Answers and comments of the participants for the questions 1, 2, 3, and 4 (see Appendix 4) were interpreted, in this section, under the frame work of these codes.

4.3.1.1. Advantages of Computer Simulations

Under the sub-theme 'Advantages', the answers of participants of the question *"What can you say about the advantages of computer based simulation instruction*" were analyzed. In this category the most frequently view (f=11) was that computer simulations save time. Simulations reduce the time that experiments can be done with the help of simulation and hence students get the chance to do a lot of activities in a short time. Some of the students' opinions were as follows: "*Computer simulation based instruction has many advantages and some of them are: it takes less time to cover huge concepts'* among others S5, "*Yes I recommend simulations because it is easy for the teacher. Experiments can be done in less time"* S20, *Computer simulation saves time"*S34. The next frequently view (f=9) in this category was that computer simulation has no risk so that students do not afraid when doing experiments. Some of their views were: "*Simulation does not have any harmful things so that students did not afraid computer simulation experiments" S3, "If I talk the usefulness of this program based simulation, there is no risk like a real lab"*S13, "*can be alternative if we do not have real lab, more safer than real lab, no more health problem in computer based simulation"* S40. According to these comments it seems that students thought that computer simulations does not cause problems such as electric shock, explosion, fire etc which could be the sequences of misuses of equipments in real laboratories and also there is no harmful and poisonous chemicals. Since simulation is free from these risks it encourages students to do activities by trial and error without afraid.

Other views in this category also include that simulation programs provide students an opportunity to use the program not only in the class but also when they are at home; provides equipment needed for experiments; can be used easily; and that the program gives accurate measurements. Some of students views were: "*We can do experiments when we stay our homes"* S20, "I*n simulation, tools used are all available. There is no damage of tools and equipment"* S5, *"There are so many different advantages: very understanding, group working, easily to use more different models*" S32, "*Tools and measurement are effective*" S18. All these opinions show that simulations have many advantages which can contribute positive effects to the learning environment.

4.3.1.2. Supporting Effective Learning

In this sub-theme, the students' views towards the effectiveness of computer simulations on learning are discussed. In this category, mainly the answers of the question "*Is there a difference between computer simulation based instruction and traditional instructions? If your answer is yes, explain",* are analyzed. The most frequently (f=24) view was that simulations increase the understanding of concepts (see table 4.12). Students claimed that, since computer simulations provide hands on activities and students can do these activities by themselves repeatedly, this will increase the level of understanding. Some of students' views were: "*Computer simulations are good because students can do the work, when the teacher gives one example, repeatedly and understand"* S29*, "Yes there is a difference because computer simulation is more effective than traditional. This way facilitates the understanding of students and gives students mental image of the lesson"*S8*, "Yes of course, computer simulation is like an experiment and experiments have more understanding than traditional instruction"* S14. The second most frequently (f=17) view was that simulations are like practical experiments and that when students do these hands on activities they understand the lesson well. They told that simulation is practical activity and that what they do with their hands is more effective than what they are told orally. Some of their opinions include: "*yes, because computer simulation is practical while traditional instruction is lecture only and as we are* *aware practical method is more effective than lecture*" S3, "*Yes, because traditional instruction is like history and there is no practical but computer simulation is real like practice*" S23, "*Yes, computer simulation is like a practical. It has virtual experiments and students do the practical together*"S16.

Other opinions of students towards the sub-theme 'Supporting Effective Learning' include that that computer simulations, increase the active participation of students and makes them involved to the learning environment, simplifies learning, provides permanent learning, provides cooperative learning by letting students do activities in groups and that it provides real like activities. Some opinions of students towards these codes were as follows: *"Yes, because traditional method was bored but in this system students are active and their attention is present*" S24, "*Yes, I recommend because this method is modern and we like to do the lesson all the time, it makes the lesson easy*"S4, "*I say it has more advantages because it helps students understand easily. It also maintains the remembering of students what they saw*"S33, "*In simulation, all students participate and they are working together" S7*, "*Advantages of computer simulation technology are practical, it is visual, it looks like real objects*"S20. All these opinions support that computer simulation is an effective method of learning.

The analysis of the question "*Would you recommend your physics teacher use computer based simulations while teaching physics lessons? If your answer is yes explain"* is distributed among all the three sub-themes because some students recommend the use of simulations from the point of view of advantages; others from their supporting effective learning; while others look from their motivational increases. Fast majority of students, about 92% recommend the use of simulations without hesitation but view students, about 8%, claim that simulations cannot replace the role of real laboratory and that simulation are needed only when there are no real equipment. Some of their opinions were: "*Yes there is great difference between them. The differences are: you do not see real things in simulation based on computer; the effectiveness of simulation is less than real lab"* S40, "*if students can get 'lab', the lab is better than computer simulation"*S25.

4.3.1.3. Motivation

In this sub-theme, the views of participants about the effects of computer simulation on motivation are discussed. In this part, mainly the answers of the question "*How computer simulation based instruction affects the motivation of students?"* are analyzed. The most frequently opinion (f=21) was that computer simulation is interesting. Some students said that computer simulation interesting because it contains practical activities; others said that because it contains attractive diagrams; while others justified that it is technology based instruction. Some of these opinions were as follows: "*Simulation increases the circle of interest for learners"* S24, "*Students always interest using technology so that they become happy with their lessons"* S13, "*Computer simulation is more interesting than traditional method. The participation of students is high because they can do everything with their hands"* S34. The next most frequently view (f=14) in this category was that simulations focus students' attention on learning. That is, simulation helps the teacher to capture students' attention when explaining something and when giving instructions. Students also focus their attention when doing activities. Learners told that they do not lose their interest and awareness for a long time while doing simulations. Some of such views were: "*Simulation always keeps the attention span for hours*" S6, "*It makes students active participants and aware physically and mentally when they are doing simulations*"S29, "*When the teacher shows students computer simulations all of them are listening"* S7.

Other opinions of students towards the sub-theme 'Motivation' include that simulations increase the motivation of students because it is technology based method; contains beautiful diagrams; and acts like a game. All these factors affect the motivation of students towards simulation and as a result towards learning. Some of students' views were: "*Yes, it is modern technology and it increases the interest" S4*, "*Simulation increases the interest of students because it has beautiful diagrams*" S16, *"Simulation is very interesting, has nice pictures and it is like a game*"S20.

4.3.2. Areas where it Seems that Simulations were the Most Effective

In order to investigate whether computer simulation is more effective in some areas than others from students' point of view, students were asked for which topic or topics of light they thought that computer simulation was the most effective and which other physics topic they would recommend their physics teacher to use computer simulations. In this section the answers of the questions 5 and 6 (see Appendix 4) are analyzed and their interpretations are based on students' views.

4.3.2.1. Sub-topics of Light

Table 4.12. Students' opinions about the effectiveness of simulation on the different sub-topics of light

Sub-topic	Frequency(f)
Colors	16
Image formation by lenses and mirrors	11
Reflection of light	9
Refraction of light	6

When the answers of students to the question '*Which topic(s) was computer simulation based instruction the most effective? Explain why'* are analyzed, it was found that students were different in the topics they have chosen by looking from different points of view but almost every topic is chosen by some students. Most of the students justify their comments that these topics are so difficult that they could not understand well with the absence of hands on activities.

The most frequently (f=16) chosen topic was colors. Students justify their opinions that colors need visual and when they see the results of the color addition through simulation they understand. Some answers of students to that question were as follows: "*Colors, because when I saw Red color + Green = Yellow, it put in my mind* *great impact*." S29, "*Colors, because colors needs to see how we add and see what result is and student is so interest when see that*".S7, "*Colors, because I can see how the colors are added each one to another and their results*". S34. The next frequently (f=11) chosen topic was image formation by lenses and mirrors. Some students claimed that the image formation by lenses and mirrors are difficult to distinguish whether they are real or virtual but when they did these with simulations they understood. Some of students' opinions about images and related topics were as follows: "*Images were the most effective, because real image and virtual image were confusion before simulations*" S16, "*Images, because image formation is not easy but when we did it with simulations we understood"* S4, "*Image formation, because I easily understood and got more information and experiences when compared to other lessons"* S23.

Similarly, some students claimed that computer simulation was the most effective when learning reflection of light and related topics. They told that when they were learning reflection of light through simulations, some physical laws were proved experimentally and this subtopic is mostly related to what always see in the real world. Some of their opinions were as follows: "*The law of reflection was the most effective because the existence of the law of reflection has been proved by using computer simulation method"* S5, "*This method is effective for all sub-topics but I prefer to be the most effective reflection method because it completely matches the lecture method and also mostly this sub-topic is one of the famous real life examples"* S3. Other students claimed that computer simulations were most effective when learning refraction of light. Students told that refraction of light and related concepts are so difficult that oral explanation is enough to be understood and highlighted that these concepts need hands on activities which can be provided by simulation. Some of their opinions were: *"Light, especially refraction of light, because the simulation programs show more information about refraction of light than real lab"*S40, "*Refraction, refractive index is difficult to understand. Theory and hand drawing is not enough to make the lesson understood*" S17, "*Refraction of light, because this topic contains a lot of difficult concepts but when used simulation easily understand*"S19.

By combining these students opinions, computer simulations are effective when teaching all sub-topics of light because they provide real like activities, visual aids, proofs of physical laws etc. When students see the results of an experiment which matches a prescribed physical law in a text book they become satisfied and as a result they understand the concept well.

4.3.2.2. Other Physics Topics

Table 4.13. Students' opinions about effectiveness of simulations towards other physics topics

Sub-topic	Frequency(f)
Electricity	18
Magnetism	15
Forces	8
Motion	3
Sound	2

When the answers of students to the question '*Which topic(s) other than light would you recommend your teacher teach through computer based simulations? Explain why you choose these topics'* are analyzed, it was found that students' recommendations towards the different topics were different but most of the students justified their choices. The most frequently chosen topic was Electricity (f=18). Some students claimed that electricity is difficult and that they confused with the physical laws and the diagrams but if they could get the chance to learn with simulation they would be better. Students also told that simulation programs provide all electrical components and places where these components can be arranged. Some of their opinions were: "*I recommend my physics teacher, teach the topic about electricity because computer simulation sight how to connect circuits including battery, resistors, ammeters, voltmeters, lamps, switches, wires etc and also which connect to series and parallel"*S14, "*I think electricity, because students confused* *the diagrams when we were learning electricity*" S10, "E*lectricity, because when teacher teaches us* $R_1 + R_2 = R_T$ *and* $I_T = I_1 + I_2 + I_3$, *I did not understand well."* S29.

Some other students (f=15) recommended that computer simulations would result positive outcomes in teaching magnetism and related topics. They told that magnetism contains a lot of abstract concepts and needs to be taught with practical activities and that simulations would simplify the understanding of this topic. Some of their opinions include: *"I recommend magnetism because its concepts are abstract"* S4, *"magnets, because we cannot understand concepts of magnetic flux and magnetic forces"*S37, *"Magnetism, because it is very difficult to understand when teacher use traditional method but if the teacher use this method I think it would be easy to understand how magnetism works*" S32.

Similarly, some other students recommended that simulations would be very convenient when teaching Forces. These students told that Forces have difficult concepts and there is confusion between forces and motion and though that simulations would treat these misconceptions. Opinions of few of such students were: "*Forces will* als*o suitable to computer based simulation because it is hard to show students real lab More about Forces"S*40. "*I will recommend my teacher to teach simulation in Forces because students misunderstand force towards the motion"* S31. "*Forces, because what you done is more effective than what you see"* S6.

Combining all these opinions, it is obvious that students appreciated the use of computer simulations in learning physics. The topics of electricity and magnetism that students recommend the most frequently is thought that students faced difficult when learning and think that if they were taught with simulations they would learn the concepts in a better way. According to students' opinions, these topics contain a lot physical laws, diagrams and abstract concepts that simulation activities can simplify. We conclude that computer simulation can provide real like activities which help students understand scientific concepts.

5. DISCUSSION, CONCLUSION AND RECOMMENDATIONS

In this study the effects of computer simulations supported by 5E learning cycle model on students' academic achievements and their attitudes towards physics were investigated. Academic achievement test and attitude scale towards physics in pretest-posttest experimental design were used. Besides these, students' opinions towards using simulations in learning physics, in semi-structured interview, were also determined and interpreted. According to the results of independent samples t-test in pretest scores with respect to achievement test, there was no significant mean score difference between the groups. After the implementation of the study, the results of t-test revealed that there is significant mean difference between the groups and that the experimental group who were exposed to the instruction based on simulations with 5E learning cycle were more successful than the control group who were exposed to traditional physics instruction. Eta squared of 0.11 was calculated which is above the medium value of effect size.

The appreciable academic achievement gain in the experimental group is thought to be: students' greater engagement in the lessons as compared with the traditional classes; their active participation in the class activities by constructing their own understandings of knowledge; using students' prior knowledge and building the new knowledge on that basis; conducting real-like experiments and proving physical laws and facts by themselves through virtual experiments; their interest and willingness of doing activities on computers which develops positive attitudes towards learning physics; and the group discussions which give students chances to learn from each other. The integration of simulations with 5E learning cycle model which encourages students to be actively engaged, explore knowledge through thinking, explain the observed concepts, extend their findings to the real world under guidance and evaluation of the teacher also contributes a lot to the achievements of the experimental group. Thus, computer simulation with an appropriate teaching method has positive effect on students' academic achievements. This finding supports the studies conducted by Bayrak (2008); Jimoyiannis and Komis (2001); Gok(2011); Sarı and Güven (2013); Chen and Howard (2010). There are also studies that showed positive effects of 5E learning cycle model on students' academic achievements over traditional instructions (Akar, 2005; Sadi & Çakıroğlu, 2010; Cardak, Dıkmenlı & Sarıtaş, 2008; Campbell, 2005; Yalçın & Bayrakçeken, 2010).

In parallel to the achievements, there is an increase in attitudes of students in the experimental group who exposed to computer simulations supported by 5E learning cycle model. An eta squared of 0.076 is calculated which is almost a moderate value effect size. This effect is thought to be the active participation of students in the experimental group in the teaching learning process, hands on activities which simplifies learning, simulation which make abstract concepts visual and understandable way and the increasing students' interest of using computers in recent years. When students' opinion and views regarding the use of simulations in the learning environment were analyzed it was found that simulations have positive impacts on their learning and most of students think that simulations are useful and contributed a lot to their academic achievements. Students expressed their opinions that simulations have the advantages such as making time sufficient by giving results of activities in a short time, harmless and no risk that activities can be done by trial and error, can be used not only in the class but also in the home. Students also expressed their views that simulations increase understanding, simplify learning, encourage active participation and group discussions, provide hands on activities, permanent learning and associates the knowledge to the real life. From the point of view of motivation, students also state that simulation makes lessons interesting, focuses their attention on learning, provides beautiful diagrams and so they enjoy when doing simulations on computers. About 92% percent of students in the experimental group recommend their physics teacher use simulations in teaching physics lessons where as 8% of the students see simulations irrelevant and cannot replace real equipment. Students also suggested that simulations are more effective in some topics than others even though they were different in their selections. These opinions show that computer simulations have positive effects on students believes and perceptions towards learning physics. Researchers such as Sarı and Güven 2013; Chen and Howard 2010; Bozkurta and Ilik 2010; and Gok 2011, also argued that computer simulations have positive effects on students' attitude.

When we look the literatures reviewed in the study, there were many studies asserting that computer simulations have positive effect on students’ academic achievements in science education as well as motivation. Rutten, Joolingen and Van der Veen (2012) conducted a meta-analysis in which the findings from 510 articles, that are published between the years of 2001-2010 on ERIC, Scopus and ISI Web of Knowledge’ databases, are combined and analyzed. These reviewed articles investigated the effects of simulations on science teaching. All reviewed studies in which simulations were used to replace or enhance traditional methods revealed positive outcomes. The studies in which simulations were used as preparatory lab training also showed positive impacts during the real laboratory. Yesilyurt (2011) also performed meta analysis research aimed to reach common judgments of 54 different evaluable findings from 25 studies about effectiveness of computer simulations, carried out from 2002 to 2011 in Turkey. Researchers concluded that Computer Assisted Instruction method has an important level of superiority. Similarly, Liao & Chen (2007) carried out a meta analysis in Taiwan, and concluded that computer simulation instruction has moderately positive effects on students achievements compared to traditional instruction. Tekbiyik & Akdeniz (2010) also carried out a meta-analysis study to determine the overall effectiveness of computer assisted instruction (CAI) on students’ achievement in science education from 2001 to 2007 in Turkey. 97% of 65 effect sizes from reviewed 52 studies showed positive results and favor in CAI where as only 3% showed negative and favor in traditional instruction. A grand mean effect size of 1.12 was calculated and interpreted that CAI has positive influence on students’ achievements. Furthermore, researchers also found that CAI is more effective in elementary than in other grade level and in physics than in Biology and Chemistry.

Gok (2011) in his research, the effects of physics concept learning with computer simulations and traditional physics learning without simulations on students’ achievement and attitude were compared. The course of the study was electricity and magnetism. When the result obtained from the data were evaluated, it was found that there was significant difference in conceptual test between groups and the treatment group which exposed to simulations are in favor. The study also revealed that courses with computer based activities have positive effect on students’ attitude. Sarı and

Güven (2013); Chen and Howard (2010); Bozkurta and Ilik (2010), also obtained the same results. On the other hand, Çepni, Taş and Köse (2006) in their study, found that computer assisted instruction has no significant effect on students attitude. Researchers argued that it needs long time to develop students' attitude towards science. In this study simulations with simplified software programs were used. The children's increasing interest of using computers in recent years could also be one factor for developing positive attitudes.

Researchers such as Ulukök, Çelik and Sarı (2013); Zacharia (2007); Martinez-Jimenez et al.(2003); and Winberg and Berg (2007), used simulations as means of preparing students for laboratory activities in their studies and positive results were observed when students were exposed to real laboratories.

Similarly, Bayrak, Kanlı and İngeç (2007); Finkelstein et al.(2004); and Ünlü and Dökme (2011) in their studies investigated whether computer simulations can replace and has the same effect as real equipments. After analysing their findings researchers concluded that computer simulations are as effective as laboratory based learning on students' achievement and that can be used as an alternative method of teaching.

Recommendations

On the basis of the findings from this study and the literatures reviewed, it is recommended that:

- Similar studies should be carried out for different grade levels and for different topics with large samples so that the results of this study about the effects of computer simulations on students' academic achievements and attitudes can be generalized.
- Similar studies can be conducted to investigate the effectiveness of computer simulations supported by other learning approaches.
- Computer simulation is more effective when it replaces traditional methods and when used as a complement component with real equipment.

- Computer simulations can be used as an alternative when there is no real laboratory and for activities which are impossible to do in school laboratories.
- The success of computer simulation depends on how it is integrated with teaching methods and hence there is a need for teachers to be trained with modern teaching approaches which encourage students to actively participate the teaching-learning process so that they can deliver their lessons through simulations effectively.

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APPENDICES

Appendix 1: Instructional Objectives

Grade 11, Chapter 4: LIGHT

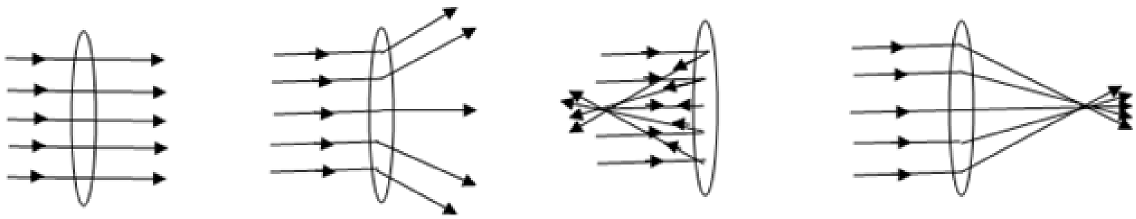
4.1 Light	4.1.1 To show that a beam is a collection of light rays 4.1.2 To state that a light is wave 4.1.3 To give evidence that light travels in straight lines
4.2 Reflection of Light and Mirrors	4.2.1 To verify, state and use the law of reflection 4.2.2 To observe and be able to describe the images formed in plane and curved mirrors 4.2.3 To show the positions of virtual images of plane mirrors using diagrams 4.2.4 To identify radius of curvature, centre of curvature, pole of the mirror, principle axis, focal point and focal length of curved mirrors 4.2.5 To locate the positions of images of curved mirrors with ray diagrams 4.2.6 To use and solve problems with the mirror formula 4.2.7 To describe some uses of plane and curved mirrors
4.3 Refraction of light and lenses	4.3.1 To describe an experimental demonstration of refraction of light 4.3.2 To state and apply Snell's law 4.3.3 To use diagrams and experiments to show the passage of Light through rectangular blocks, semicircular and prisms 4.3.4 To describe some examples of refraction (prisms, real and apparent depth etc.) 4.3.5 To explain total internal reflection and some uses of total internal(e.g. optic fibers, binoculars) 4.3.6 To observe and be able to describe the images formed by concave and convex lenses 4.3.7 To locate and calculate the positions of images formed by concave and convex lenses 4.3.8 To calculate power of a lens 4.3.9 To describe how human eye works 4.3.10 To describe some uses of lenses (e.g. camera, microscope, telescope, etc.)
4.4 Colors	4.4.1 To show what visible spectrum is and how it is formed 4.4.2 To describe primary colors, secondary colors and complementary colors and be able to distinguish from each other 4.4.3 To describe how colors can be produced (color addition and color subtraction).

Appendix 2

Light Concepts Achievement Test (LCAT)

Multiple Choice Questions

1. A parallel beam of light falls on a converging lens as shown. Which diagram shows what happens to the beam of light after passing through the lens?



A. B. C. D.

(Understanding / 4.1.1)

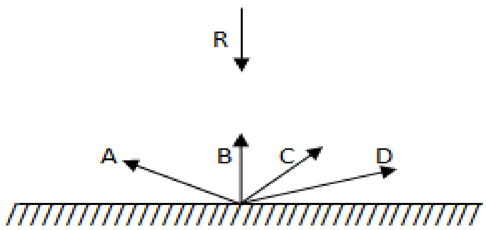
2. Light exhibits reflection, refraction, diffraction, interference and polarization. This shows that light
   A. Has a wave nature
   B. Has particle nature
   C. Is visible
   D. Is a form of energy

(Understanding / 4.1.2)

3. When a beam of light strikes an opaque object, the light cannot pass through it and as a result shadow is formed. This is because light travels
   A. At very high speed
   B. Faster in glass than in air
   C. In straight lines
   D. At low speed in solids

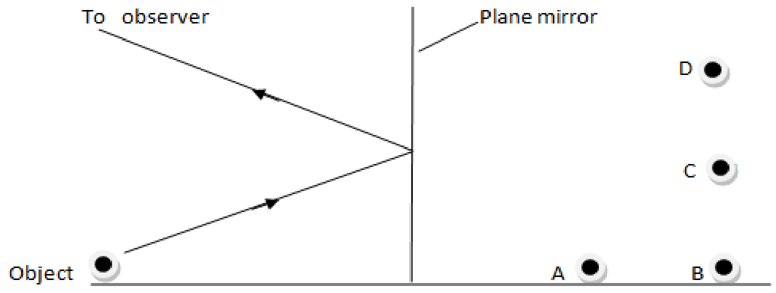
(Evaluation / 4.1.3)

4. A ray of light **R** strikes normally to a plane mirror as shown in the figure. Which of the rays A, B, C or D represents the correct reflected ray?



(Understanding / 4.2.1)

5. At which of the points A, B, C or D will the observer see the image of the object in the plane mirror

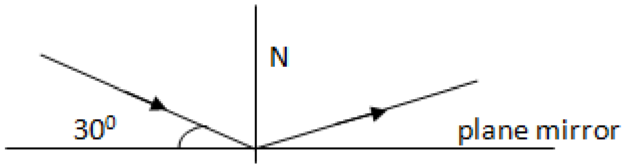


(Application/4.2.3)

6. Which of the following properties does **NOT** belong to images formed by a plane mirror? It is always
   A. Upright
   B. Virtual
   C. Magnified
   D. left right reversal

(Analysis/4.2.2)

7. The diagram shows a ray of light reflected from a plane mirror



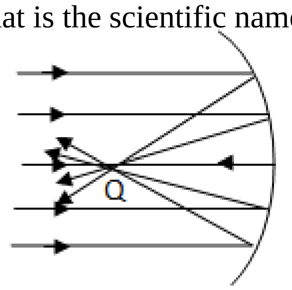
What is the angle of reflection?

A. 30^0
B. 45^0
C. 60^0
D. 75^0

(understanding/4.2.1)

8. The figure below shows parallel rays striking a concave mirror. The rays are reflected passing through the point Q. What is the scientific name of this point?

   A. Focal length
   B. Focal point
   C. Pole of the mirror
   D. Principle axis



(Recall / 4.2.4)

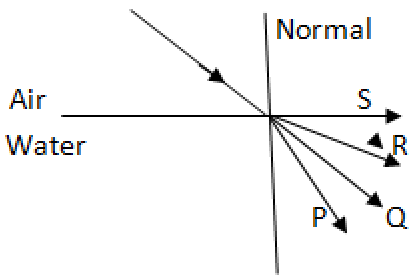
9. Change of direction of travel of light as it enters a new medium from another is known as
    A. Reflection
    B. Diffraction
    C. Refraction
    D. Dispersion

(Recall / 4.3.1)

10. Refractive indices of water and glass respectively are
    A. 1 and 1.5
    B. 2 and 2.25
    C. 1.33 and 1.5
    D. 2.25 and 2.42

(Recall / 4.3.2)

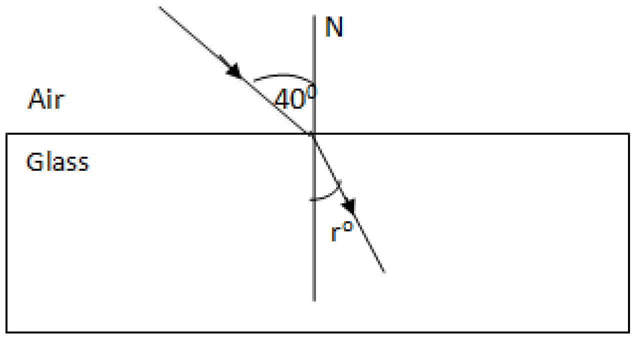
11. A ray of light strikes the surface of water at an angle as shown below. Which of the rays P, Q, R or S shows the correct refracted ray



    A. P
    B. Q
    C. R
    D. S

(Understanding /4.3.3)

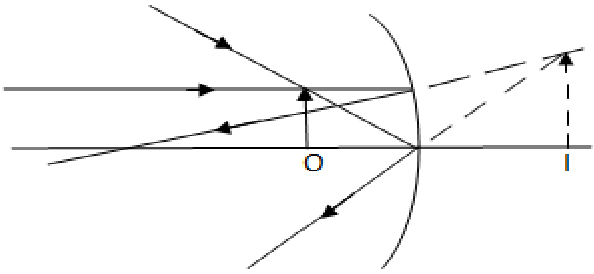
12. A ray of light enters a block made of glass (**n= 1.5**) at an angle of incidence of 40^0. What is the angle of refraction, to the nearest degree?



A. 20^0
B. 25^0
C. 30^0
D. 40^0

(Understanding/application/ 4.3.2)

13. The figure shows an object O placed in front of a concave mirror and the image I is formed behind the mirror as shown. Which of the following properties does **NOT** belong to the image?



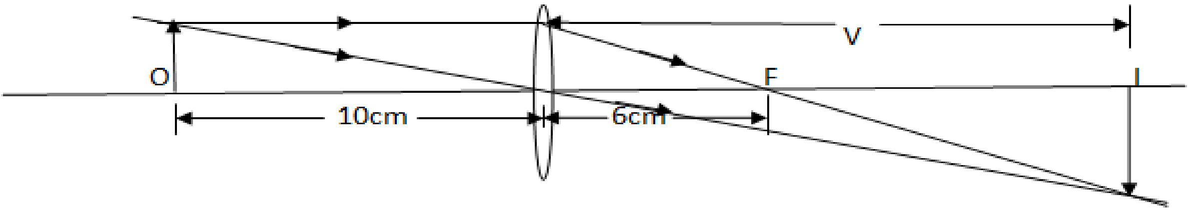
A. Real
B. Upright
C. Magnified
D. Virtual

(analysis/4.2.5)

14. Camera has a construction similar to that of human eye. Which part of the eye is equivalent to the film of the camera?
A. Cornea
B. Retina
C. Pupil
D. Iris

(Evaluation /4.3.10)

This diagram is for questions 15 and 16. An object is placed 10cm from a convex lens of focal length 6cm as shown in the figure.



15. How far is the image from the lens
A. 10cm
B. 12cm
C. 15cm
D. 20cm

(Application / 4.3.6)

16. Which of the following is **NOT** true about the image formed by the lens? It is
A. Real
B. Magnified
C. Inverted
D. Virtual

(Analysis / 4.3.6)

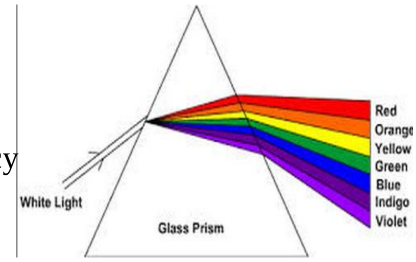
17. Refractive index of glass is 1.5. What is the critical angle of glass, to the nearest degree, ($I_C = \frac{1}{n}$) ?

A. 24^0
B. 42^0
C. 49^0
D. 63^0

(Application / 4.3.2)

18. Which of the following is **NOT** true? Dispersion of light when a ray of light is passed through a prism shows that

A. White light consists of components of colors
B. Different colors have different refractive indices
C. The prism contains many narrow equally spaced strips
D. Each color of light corresponds to one particular frequency



(Understanding / 4.4.3)

19. Which of the following is a primary color

A. Yellow
B. Cyan
C. Green
D. Orange

(Recall / 4.4.2)

20. Which of the following pairs of colors when added together give yellow color

A. Blue and Green
B. Red and Green
C. Blue and Red
D. Red and orange

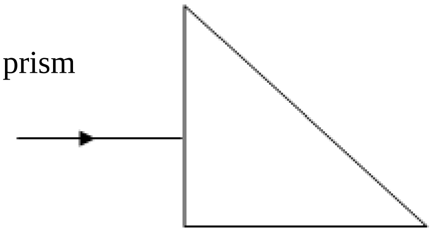
(Synthesis / 4.4.2)

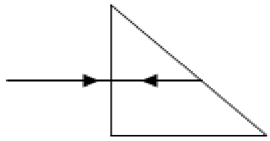
21. Grass contains a green pigment, chlorophyll. When light from the sun shines on grass it reflects green. What colors of light does the grass absorb

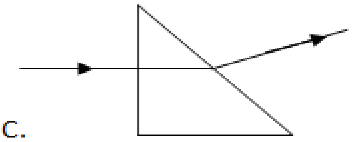
A. Green and Blue
B. Green and Red
C. Red and Blue
D. Green only

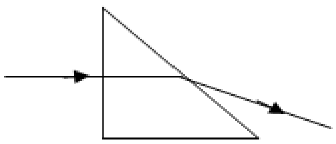
(Understanding/ 4.4.3)

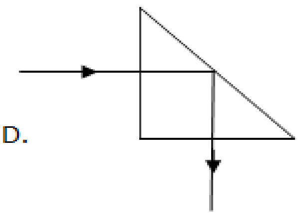
22. A ray of light is incident normally a 45^0, 45^0, 90^0 prism at one side. Which of the diagrams A, B, C or D correctly shows the continuation of the ray through the prism and the emergent ray



A. 

C. 

B. 

D. 

(Synthesis / 4.3.5)

23. A convex lens has a focal length of 40cm. What is the power of the lens in diopters?
   A. + 0.5D
   B. + 2D
   C. + 2.5D
   D. – 2.5D

(Application/4.3.8)

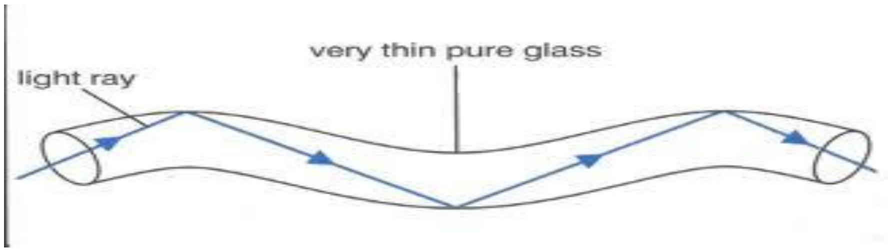
24. The amount of light entering the eye is controlled by
   A. The pupil
   B. The iris
   C. The cornea
   D. The lens

(Recall / 4.3.9)

25. Which of the following is **NOT** true about the power of a lens
   A. The shorter the focal length the greater the power of the lens
   B. Convex lenses have positive power
   C. The shorter the focal length the smaller the power
   D. Unit power of a lens is diopter

(Analysis / 4.3.8)

26. Telecommunication companies propose using light pipes (optic fibers) to carry telephone signals between various locations. Light can travel through the pipes



A. Because they are coated with silver
B. By many total internal reflections
C. As long as they are straight
D. Because laser light cannot travel well though air

(Application / 4.3.5)

27. Convex mirrors are used as rear view mirrors in cars. These mirrors are chosen for this purpose rather than plane mirrors because convex mirrors
    A. Produce upright diminished images
    B. Produce virtual images
    C. Give wider field of view than plane mirrors
    D. Are cheaper than plane mirrors

(Application / 4.2.7)

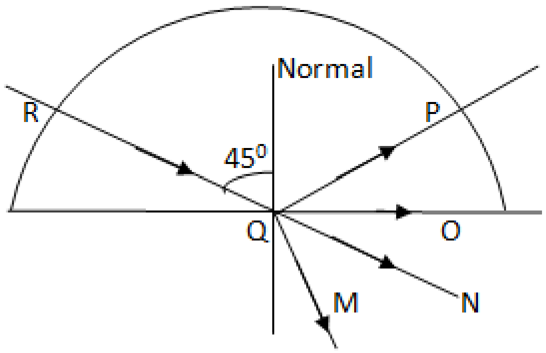
Answer Key

QNo	Correct Answer
1.	D
2.	A
3.	C
4.	B
5.	B
6.	C
7.	C
8.	B
9.	C
10.	C
11.	A
12.	B
13.	A
14.	B
15.	C
16.	D
17.	B
18.	C
19.	C
20.	B
21.	C
22.	D
23.	C
24.	B
25.	C
26.	B
27.	C

Questions Removed From the Test

13) A ray of light enters a semicircular glass block as shown in the figure below. At R the ray does not change direction because it is normal to the surface. At Q the ray strikes at an angle of incidence of 45^0. Which path M, N, O or P will it follow after leaving Q, given that **critical angle of glass is 42^0?**

A. M
B. N
C. O
D. P



(Understanding / analysis / 4.3.3)

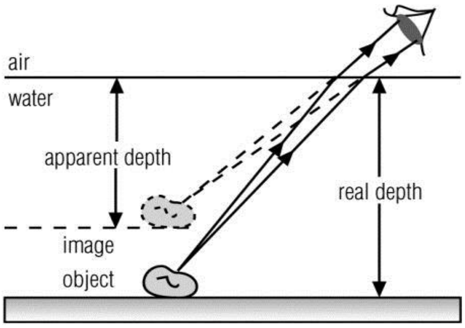
27) Speed of light in air is $3 \times 10^8 ms^{-1}$. What is the speed of light in glass, given that the index of refraction of glass is 1.5

A. $0.8 \times 10^8 ms^{-1}$
B. $1.24 \times 10^8 ms^{-1}$
C. $2 \times 10^8 ms^{-1}$
D. $2.25 \times 10^8 ms^{-1}$

(Recall + Application /4.3.2)

28) A pond 8m deep is full of water as shown. What would its apparent depth be, given that index of refraction of water is (n= $\frac{4}{3}$ or 1.33)

A. 4.5m
B. 6m
C. 7.2m
D. 7.5m



(Application/ 4.3.4)

Appendix 3

Attitude Scale towards Physics (ASTP)

Student No: ____________

Key options

1 Strongly disagree (SD)
2 Disagree (DA)
3 Neither agree nor disagree (NN)
4 Agree (AG)
5 Strongly agree (SA)

The developed questioner consists of two major parts with 20 questions.

1. 12 questions about physics lesson
2. 8 questions about physical experiments

Please read the items of the questioner carefully and using your opinion about physics lessons and physical experiments complete the following sheet.

For each item choose one and only one option e.g

S/no	Item	SD	DA	NN	AG	SA
1.			X			

Learning physics at school.
Do you agree with these views?

S/no	**Item**	**SD**	**DA**	**NN**	**AG**	**SA**
1.	We learn interesting things in physics lessons					
2.	I look forward to physics lessons					
3.	Physics lessons are exciting					
4.	I would like to have more physics lessons at school					
5.	I like physics lessons more than the others.					
6.	Physics lessons are boring					
7.	Physics lessons are difficult					
8.	I only fail in physics lessons					
9.	I get good marks from physics lessons					
10.	I easily learn physics topics					
11.	I feel helpless when doing physics home works					
12.	I understand everything lectured in physics lessons					

About experiments in physics lessons
Do you agree with these views?

S/no	Item	SD	DA	NN	AG	SA
13.	Physics experiments are exciting.					
14.	I like physics experiments because I don't know what will happen.					
15.	Physics experiments are useful because I can work with my friends					
16.	I like physics experiments because I can decide what to do myself.					
17.	I would like to have more experiments in the physics lessons.					
18.	We learn physics lessons better when we do physics experiments.					
19.	I look forward to doing experiments in physics lessons.					
20.	Physics experiments in the physics lessons are boring.					

Appendix 4

Effectiveness of Computer Simulation Evaluation Form (ECSEF)

The purpose of this form is to evaluate the effectiveness of computer based simulations and the impact of this method on learners. In order to determine how effective this method is, we are asking you few questions. First, thank you very much for your active participation of this valuable study and for the information you are giving us.

When you are answering these questions, think them carefully and express your opinion on the basis of what you have observed while participating the study.

1. What can you say about the advantages of computer simulation based instruction?

   ----

2. How computer simulation based instruction affect the motivation of students?

   ----

3. Is there a difference between computer simulations based instruction and traditional instructions? If your answer is yes, explain

   ----

4. Would you recommend your physics teachers to use computer based simulations while teaching physics lessons? If your answer is yes explain why

   ----

5. Which subtopic(s) was computer simulation based instruction the most effective? Explain why

   ----

6. What topic(s) other than light concepts would you recommend your teachers teach through computer based simulations? Say why you choose these topics

   ----

Appendix 5

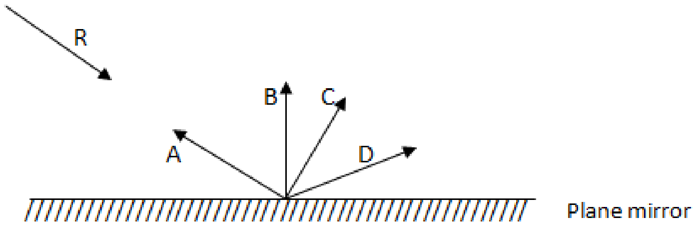
SAMPLE OF EXERCISES

Reflection of light and mirrors

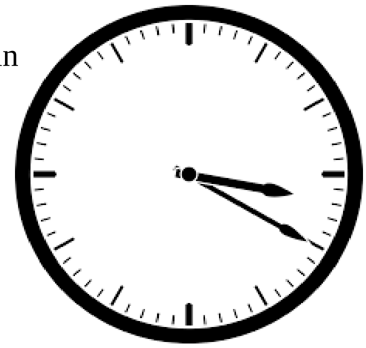
Part I: Choose the correct answer

1. An example for non-luminous object is ___________
   A. a candle C. the moon
   B. the sun D. an electric bulb

2. A ray of light **R** strikes a plane mirror at an angle as shown in the figure. Which of the rays A, B, C or D represents the correct reflected ray?



3. The figure at the right shows the image of a clock in a plane mirror. The image is as though the time is 3:20 at this moment. What is the correct time shown by the clock
   A. 8:20
   B. 8:40
   C. 9:20
   D. 9:40

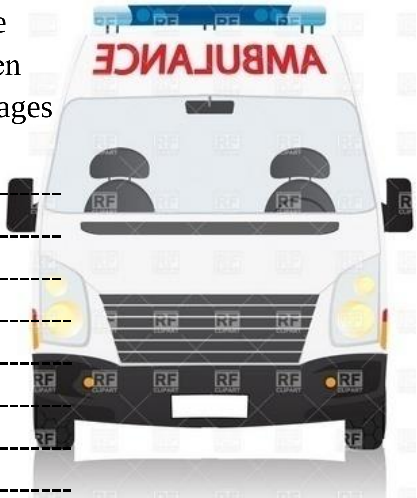


4. Dentists use ____________ mirror to focus light on the tooth of a patient
   A. Plane C. Convex
   B Concave D. Convex

5. The device used to see an object over an obstacle that can be used by double duck buses is known as
   A. Telescope C. Binocular
   B. Microscope D. Periscope

Part II: Problems

1. The figure at right shows an ambulance. The image of the word "ambulance" in a plane mirror is written at the front. Within your groups discuss the advantages of writing the ambulance in this wrong way.



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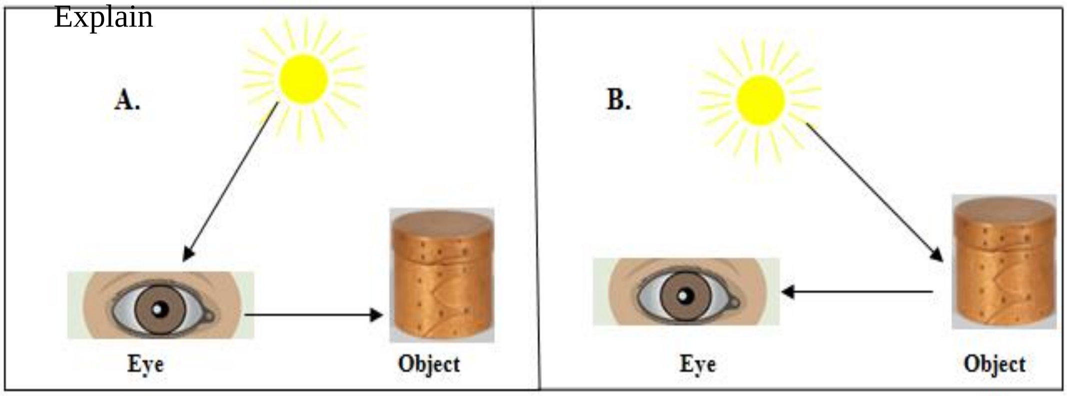
2. Write down the images of the words GREEN, LABORATORY, CHAIRMAN and the numbers 5463, 8792 in a plane mirror

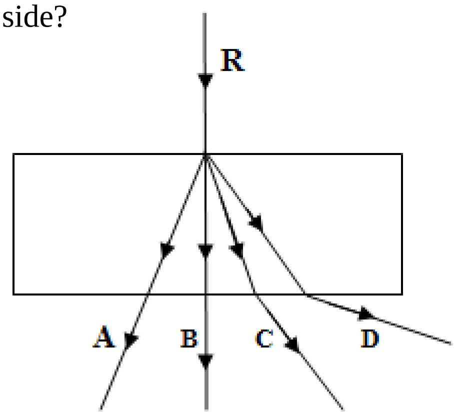
3. The figure shows two different representations of how we see objects through our eyes. In your opinion which part A or B is the correct representation? Explain



Refraction of Light and Lenses

Part I: Choose the correct answer from the options given in each case

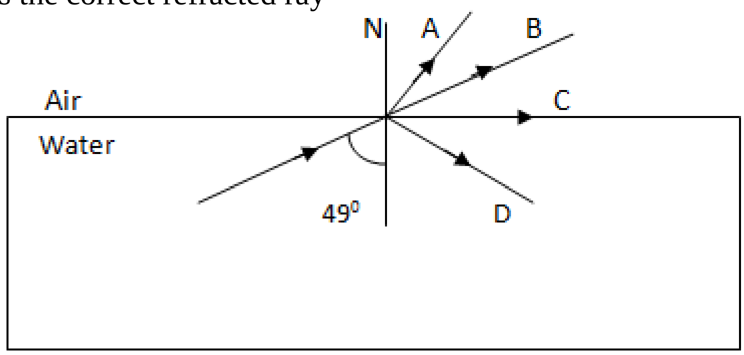
1. A ray of light R strikes normally a rectangular glass block. Which of the rays A, B, C or D represents the path of the ray through the block and out of the other side?



2. Speed of light in air is $3x10^{8}ms^{-1}$. If the speed falls to $2.25 \times 10^{8}ms^{-1}$ when it enters a new medium, what is the refractive index of that medium?
   A. 1.33 C. 2
   B. 1.5 D. 2.25

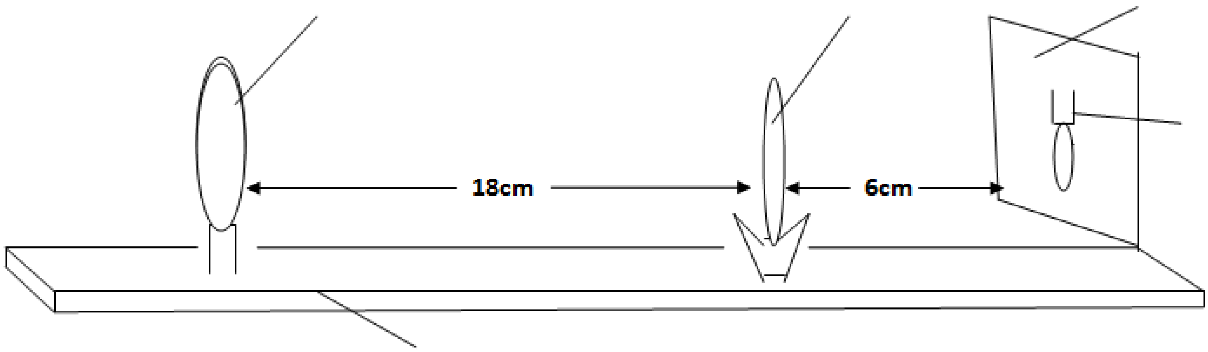
3. Which of the following is **NOT** true about lenses
   A. Thicker lenses have greater power for bending light
   B. Positive power means the lens is convex
   C. Lenses make use of the effect of reflection
   D. Lenses are used for image formation in camera, microscope etc.

4. A ray of light travels from water into air at an angle of incidence of 49^{0} which is the critical angle of water-air interface. Which of the rays A, B, C or D is the correct refracted ray



Part II: Questions and problems

1. A student wants to find the focal length of a lens. He uses the arrangement below



a. Label the components in the diagram, in the spaces provided

b. Work out the focal length of the lens, using the lens equation

----

----

c. List any three properties of the image formed

i. __________________________________
ii. __________________________________
iii. __________________________________

d. Write down any three devices that make use of convex lenses

i. __________________________________
ii. __________________________________
iii. __________________________________

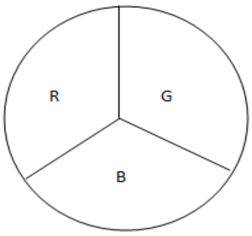
2. a) Ahmed looks a pool of water from above. He estimated the depth of the pool to be about 4.5m. Given that index of refraction of water is 1.33, work out the actual depth of the pool

b) Explain why the apparent depth of the pool is always less than its real depth. Illustrate you answer with ray diagram.

Colors of Light

Part I: Multiple Choice Questions

1. To print a text that is to appear yellow when viewed in white light, you would use an ink that absorbs ________________ light
   A. Red C. Blue
   B. Green D. Cyan
2. A circular disc is divided into three equal parts. The parts were painted with the colors red, green and blue. If the disc is rotated at a very high speed, what color would be seen on it?
   A. Black C. Cyan
   B. White D. Orange



3. Which of the following are the secondary colors
   A. Red, green and blue
   B. Cyan, yellow and magenta
   C. White, black and violet
   D. Orange, violet and indigo

Part II: Questions and Problems

1. A cloth is red in sun light. What would its color be if viewed with blue light? Explain
   ----

   ----

2. Why it is foolish to buy clothes at night while colored light shines on them. Discuss

   ----

