EFFECTIVENESS OF CONCEPTUAL CHANGE INSTRUCTION ON OVERCOMING STUDENTS' MISCONCEPTIONS OF ELECTRIC FIELD, ELECTRIC POTENTIAL AND ELECTRIC POTENTIAL ENERGY AT TENTH GRADE LEVEL

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ABSTRACT

EFFECTIVENESS OF CONCEPTUAL CHANGE INSTRUCTION ON OVERCOMING STUDENTS' MISCONCEPTIONS OF ELECTRIC FIELD, ELECTRIC POTENTIAL AND ELECTRIC POTENTIAL ENERGY AT TENTH GRADE LEVEL

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The purpose of this study was to investigate the effectiveness of the conceptual change text based instruction over traditionally designed physics instruction to overcome tenth grade students' misconceptions on electric field, electric potential and electric potential energy concepts. To provide conceptual change, conceptual change texts (CCT) were developed by the researcher. An Electric Potential and Electric Potential Energy Concept Test (EPEPECT) which consists of 10-items was developed and used to examine students' probable misconceptions. Physics Attitude Scale (PATS) was administered to the students to obtain valid information concerning how conceptual change text based instruction effect students' attitudes toward physics.

The subjects of this study included two tenth grade level classes from TED Ankara College Private High School in Ankara, Turkey, and a total of 37 students' scores were used for the statistical analysis. Students from one of the classes that were randomly assigned participated in traditional instruction and referred as the control group. Students from the other class participated in CCT based instruction and referred as the experimental group. EPEPECT and PATS had been administrated to both groups on two different occasions as pretest and posttest. According to the results of the study, statistically significant differences were found between conceptual change instruction and traditional method. Students taught with CCI showed a better scientific conception related to electric field, electric potential and electric potential energy and elimination of misconceptions than the students taught with traditionally designed physics instruction (TDPI). However, CCI did not increase the students' attitudes toward physics as school subject more than TDPI did. That is, conceptual change instruction was not effective in improving positive attitudes toward physics.

Keywords: Misconception, Conceptual Change Text, Conceptual Change Instruction, Traditional Method, Electric Field, Electric Potential, Electric Potential Energy

ÖZ

KAVRAMSAL DEĞİŞİM YÖNTEMİ İLE YAPILAN ÖĞRETİMİN ONUNCU SINIF ÖĞRENCİLERİNİN ELEKTRİKSEL ALAN, ELEKTRİKSEL POTANSİYEL VE ELEKTRİKSEL POTANSİYEL ENERJİ KONULARINDAKİ KAVRAM YANILGILARINI GİDERMEYE OLAN ETKİSİ

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Bu çalışmanın amacı; kavramsal değişim metinlerine dayandırılan öğretimin, geleneksel fizik öğretimi ile karşılaştırarıldığında onuncu sınıf öğrencilerinin elektriksel alan, elektriksel potansiyel ve elektriksel potansiyel enerji konularındaki kavram yanılgılarını gidermeye olan etkisini, araştırmaktır. Kavramsal değişimi sağlayabilmek için, araştırmacı tarafından kavramsal değişim metinleri hazırlandı. Öğrencilerin muhtemel kavram yanılgılarını belirlemek için, 10 sorudan oluşan elektriksel potansiyel ve elektriksel potansiyel

enerji kavram testi geliştirildi. Kavramsal değişim metinlerine dayandırılan öğretimin öğrencilerin fizik dersine karşı olan yaklaşımlarını nasıl etkilediğini geçerli bir şekilde belirlemek için fizik dersi tutum ölçeği uygulanmıştır.

Çalışmanın deneklerini, Ankara ilinde bulunan TED Ankara Koleji Vakfı Özel Lisesi'ndeki onuncu sınıf öğrencileri oluşturmuştur ve toplam olarak 37 öğrenciden alınan cevaplar istatistiksel analizlerde kullanılmıştır. Sınıflardan biri rastgele kontrol grubu olarak seçilmiş ve bu sınıftaki öğrencilere geleneksel öğretim metodu ile konu anlatılmıştır. Diğer sınıftaki öğrenciler kavramsal değişim metinleri kullanılarak hazırlanan yöntem ile konuyu öğrenmişler ve bu sınıfın oluşturduğu grup deneysel grup olarak tayin edilmiştir. Elektriksel potansiyel ve elektriksel potansiyel enerji kavram testi ile fizik dersine karşı olan tutum ölçeği her iki gruba da öntest ve sontest olarak iki ayrı zamanda uygulanmıştır. Çalışmanın sonuçlarına göre, kavramsal değişim metinleri kullanılarak hazırlanan yöntem ile geleneksel öğretim yönteminin sontest analizleri karşılaştırıldığında, iki yöntem arasında istatistiksel olarak anlamlı bir fark oluğu bulunmuştur. Kavramsal değişim yöntemi ile öğrenim gören öğrenciler, geleneksel yöntem ile öğrenim gören öğrencilere göre kavram yanılgılarını gidermede ve bilimsel olarak doğru kavramları oluşturmada daha başarılı olmuşlardır. Ancak kavramsal değişim metinleri kullanılarak hazırlanan yöntem, öğrencilerin fizik dersine karşı olan tutumlarını geleneksel yönteme göre daha fazla iyileştirmemiştir. Başka bir deyişle kavramsal değişim yöntemi

ile yapılan öğretim, öğrencilerin fizik dersine karşı olan tutumlarını arttırmada etkili olamamıştır.

Anahtar Kelimeler: Kavram Yanılgıları, Kavramsal Değişim Metni, Kavramsal Değişim Öğretimi, Geleneksel Öğretim Metodu, Elektriksel Alan, Elektriksel Potansiyel, Elektriksel Potansiyel Enerji

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PRECON:	Students' Electric Potential and Electric Potential Energy Concept Test Pretest Scores
PREATT:	Students' Physics Attitude Pretest Scores
PSTCON:	Students' Electric Potential and Electric Potential Energy Concept Test Posttest Scores
PSTATT:	Students' Physics Attitude Posttest Scores
EPEPECT:	Electric Potential and Electric Potential Energy Concept Test
PATS:	Physics Attitude Scale
MOT:	Methods of Teaching
TDPI:	Traditionally Designed Physics Instruction
CCI:	Conceptual Change Instruction
CCT:	Conceptual Change Text
DV:	Dependent Variable
IV:	Independent Variable
ANCOVA:	Univariate Analysis of Covariance
MANCOVA:	Multivariate Analysis of Covariance
MRC:	Multivariate Regression Correlation
df:	Degree of Freedom
N:	Sample Size
α:	Significance Level

CHAPTER 1

INTRODUCTION

Misconceptions are a troubling issue for teachers and students in high school science. This is especially true in physics due to its often abstract nature. Students arrive in the physics classroom with preconceptions and a short lifetime of experience that is often contradictory to accepted physics thinking. Such a combination usually leads to some problems for the students of various abilities. Even well meaning and competent teachers can complicate these problems. Too often teachers of physics consider their students to be “clean mental states” and act accordingly in order to fill their “empty vessels” (Marionni, 1989). The problem with this approach of course is that the vessels are not empty but contain preconceptions. Preconceptions of the natural world are popular conceptions rooted in everyday experiences. For example, people observing moving objects slowing (decelerating) mistakenly believe that the force responsible for the motion is getting “used up”. Such misconceptions are very common because they are rooted in the most common activity of young children, unstructured play. When children are exploring their surroundings, they will naturally attempt to explain some of the phenomena they encounter in their own terms and share their explanations. When children arrive at incorrect assumption these preconceptions are also misconceptions.

Even when the teachers consider the students knowledgeable they may fall into the dominance trap assuming that children's conceptions of the natural world are easily replaced by the lessons of the teacher. Not only inexperienced teachers fall victim to this trap and students' learning often suffers. Recent research has demonstrated that individual learners can be different; therefore teaching methodology should vary accordingly.

As a school subject physics is a difficult course for meaningful learning to construct. "Energy" is the one of the basic concepts of physics courses and it is one of the most abstract subjects for students. Although the students learn the word "energy" in their childhood and this word is used frequently by individuals in their daily lives, students' understanding about "energy" and the relationship between different kinds of "energy" are often contradictory.

The interest of this study was to see the effectiveness of the designed conceptual change texts in overcoming students' misconceptions about "electric field", "electric potential" and "electric potential energy". In the designed conceptual change texts the students' misconceptions were considered and designed accordingly, while in traditional instruction the misconceptions were not taken into account.

The study intended to improve the meaningful learning of students overcoming the students' misconceptions by using the appropriate conceptual change designs based on related effective strategies.

1.1 The Main Problem and Sub-problems

1.1.1 The Main Problem

The purpose of this study was to investigate the effectiveness of conceptual change instruction over traditionally designed physics instruction on overcoming 10^{th} grade students' misconceptions of electric field, electric potential and electric potential energy.

1.1.2 The Sub-Problems

Sub-Problem 1:

What is the effect of conceptual change instruction over traditionally designed physics instruction on overcoming 10^{th} grade students' misconceptions of electric field, electric potential and electric potential energy?

Sub-Problem 2:

What is the effect of conceptual change instruction over 10^{th} grade students' attitudes towards physics as a school subject?

1.2 Hypotheses

The problems stated above are tested with following hypotheses, which are stated in null form.

Hypothesis 1:

There will be no significant difference between the posttest mean scores of tenth grade students exposed to conceptual change instruction and those exposed to traditionally designed physics instruction on the population means of the collective dependent variables of electric field, electric potential and electric potential energy concepts posttest scores and physics attitude posttest scores when the effects of electric potential and electric potential energy concepts pretest scores, physics attitude pretest scores and gender are controlled.

Hypothesis 2:

There will be no significant difference between the posttest mean scores of tenth grade students exposed to conceptual change instruction and those exposed to traditionally designed physics instruction on the population means of the electric potential and electric potential energy concepts posttest scores when the effects of electric potential and electric potential energy concepts pretest scores, physics attitude pretest scores and gender are controlled.

Hypothesis 3:

There will be no significant difference between the posttest mean scores of tenth grade students exposed to conceptual change instruction and those exposed to traditionally designed physics instruction on the population means of the physics attitude posttest scores when the effects of electric potential and electric potential energy concepts pretest scores, physics attitude pretest scores and gender are controlled.

1.3 Definition of Important Terms

Some of the important definitions related to this study can be abbreviated as below:

<u>Conception</u>: Characterizations of categories of description reflecting person-world relationships. A conception is our understanding of a particular part of our natural worldview.

<u>Misconception:</u> Conceptions which are not consistent with the widely accepted scientific knowledge.

Conceptual Change: Learning process in which students change conceptions through capturing new ideas and knowledge and replacing the old with the new. Conceptual change learning is achieved by the following: acquisition of new information and reorganizing existing knowledge.

Electric Potential and Electric Potential Energy Concept Test (EPEPECT): Three-tire test composed of qualitative, conceptual questions designed to asses the misconceptions.

Physics Attitude Scale (PATS): Inquiry tool used to obtain valid and useful information concerning students' attitudes toward physics as a school subject.

Conceptual Change Text (CCT): Specially designed text by which is expected that students will more consciously comprehend the contrast between the scientific theory and common misconceptions, and thus will be inclined to exchange their misconceptions with scientific concepts.

1.4 Significance of the Study

Previous studies provide us with a rich literature about students' misconceptions relating some Physics topics. There are many studies concerning simple electric circuit concepts. However, no study investigating the misconceptions on "electric field", "electric potential" and "electric potential energy", which are among the most difficult and abstract topics in Physics high school curriculum. This study will investigate the effectiveness of conceptual change instruction on overcoming the students' misconceptions on electric field, electric potential and electric potential energy at 10th grade level. Although it is known that the students at that level are coming to the schools with some misconceptions, the study will search whether the students come with some misconceptions relating the topics electric field, electric potential and electric potential energy. In order to differentiate the misconceptions from lack of knowledge, specially designed concept test were developed and used. The concept test has the ability to distinguish misconceptions from lack of knowledge by means of asking the question whether the students are sure or not about their answers. The concept test is similar to three-tier tests and avoid strong criticize of two-tire tests, which were believed to overestimate the fraction of misconceptions (Eryılmaz & Sürmeli, 2002; Griffard & Wandersee, 2001).

CHAPTER 2

REVIEW OF LITERATURE

2.1 What is a Misconception and Conceptual Change?

While student misunderstandings across the curriculum is a very popular topic in staff rooms as well as in more academic settings, science teachers especially have many unanswered questions about misconceptions. What is a misconception? Is it merely a misunderstanding? Is a misconception different from a preconception? How does a student develop misconceptions and how can teachers help students confront and overcome their misconceptions? Are there different types of misconceptions and does the high school teacher need to know all of these answers to be effective teacher? This review will help answering the question "how can teachers help students overcome their misconceptions"?

Many educational researchers view learning as a conceptual change process which originates from the constructivist view of education (Chambers & Andre, 1997; Dykstra et al., 1992; Posner et al., 1982). In the constructivist view the most important ingredient in the process of learning is the interaction between the new knowledge and the existing knowledge.

Constructivists are interested in meaningful learning process, and much has been carried out in this respect. For a meaningful learning, there should be students' preconceptions to associate with the new concept. The process of meaningful learning starts with the interaction between the new knowledge and the learner's existing preconceptions. Meaningful learning is thus the subsuming of students' prior knowledge to the new knowledge.

A widely accepted perspective on the nature of learning is that it is a process of conceptual change. Learning is a process in which students change conceptions through capturing new ideas and knowledge and replacing the old with the new. Conceptual change or in other words, learning is achieved by the following: acquisition of new information and reorganizing existing knowledge. What then is a misconception? A common definition would describe a conception as characterizations of categories of description reflecting person-world relationships. A conception is our understanding of a particular part of our natural worldview. How well a person conceives or comprehends a concept or ideas in physics depend on the meaning they assign to the information as well as how they organize their knowledge of that particular domain. Misconceptions are conceptions which are not consistent with the widely accepted scientific knowledge.

Much of the conceptual change literature is built upon the Piagetian concepts of assimilation, accommodation and to a lesser degree cognitive dis-equilibrium. Assimilation is commonly used as the process whereby the learner is able to gain new knowledge by fitting new information into existing knowledge structures or schema. Accommodation however, requires changes in structure before the new information can become part of the learner's knowledge or in other words a change in conception (Dykstra et al., 1992 ; Posner et al., 1982). For accommodation to occur usually the learner enters a state of cognitive dis-equilibrium where the learner encounters information or an event that does not fit with existing beliefs (Dykstra et al., 1992; Posner et al., 1982).

In our curriculum the concepts are introduced in the primary grades, expended upon in middle school and refined in high school. Unfortunately there are years between these iterations of introduction, expansion and refinement, which permits plenty of time for confusion to enter the learner's knowledge. Schoolyard and backyard interpretations of classroom experience are often not, what was intended by the instructor. There are many types of misconceptions originating from diverse sources to confuse high school students. Fortunately, there are many student-centered approaches to challenging and overcoming such problems, some of which are innovative methodologies.

2.2 Common Types of Misconceptions

Tobias (1987) identified several types of misconceptions in the learning of science:

- Preconceived notions or preconceptions
- Factual misconceptions
- Vernacular misconceptions

Distinguishing between types of misconceptions will help the science teacher in identifying their students' difficulties. This is an essential first step in overcoming these problems (Eckstein & Shemesh, 1993).

Preconceived notions or preconceptions of the natural world are popular conceptions rooted in everyday experiences. For example, people observing moving objects slowing (decelerating) mistakenly believe that the force responsible for the motion is getting "used up" (Marionni, 1989). Such misconceptions are very common because they are rooted in the most common activity of young children, unstructured play. When children are exploring their surroundings, they will naturally attempt to explain some of the phenomena they encounter in their own terms and share their explanations. When children arrive at incorrect assumption these preconceptions are also misconceptions.

Factual misconceptions are falsities often learned at an early age and retained unchallenged into adulthood. For example, the idea that "lighting never strikes twice in the same place" is clearly false, but that notion is commonly hidden within the teachers' and students' belief systems (Committee on Undergraduate Science Education, 1996; Dykstra, Boyle &Monarch, 1992).

Vernacular misconceptions arise from the use of the words that mean one thing in everyday life and another in a scientific context. For example, the term "work" in the physics classroom refers to the result of multiplying a force measured in Newtons by the straight-line distance moved in meters. The introduction of the definition of work in a physics class can present many challenges to the teacher (Clement, 1987). The power (change in energy per unit time) concept is a similar example (Committee on Undergraduate Science Education,1996).

Conceptual misunderstandings arise when students are taught scientific information in a manner that does not encourage them to settle any cognitive dis-equilibrium (Dykstra, Boyle &Monarch, 1992). In order to deal with their confusion, students construct weak understandings. Consequently are very insecure about these constructed concepts.

2.3 Some Sources of Misconceptions

Misconceptions can result from deficiencies of curricula and methodologies that do not provide the students with suitable experiences to assimilate the new concept (Renner et al., 1990). It is rarely that misconceptions result from the lack of reasoning abilities that are necessary to assimilate the new concept. Recent research on students' conceptual misunderstandings of natural phenomena indicates that new concepts cannot be learned if alternative models that explain phenomenon already exist in the learner's mind. (Committee on Undergraduate Science Education, 1996; Tao & Gungstone, 1999).

Early misconceptions can bother a student's science learning until the misconception is confronted and overcome. Students can become confused in physics and miss-learn because of any number of factors. Language usage, everyday experience, analogies, metaphors, examination papers and textbooks can cause students difficulty in forming acceptable understandings of physics concepts, theories and laws. Somewhat surprisingly, textbooks have been found to be the most significant source of misconceptions in the physics classroom, textbooks can mislead students because of poor writing and/or poor editing (Ivowi & Oludotun, 1987)

Misconceptions often reflect a basic lack of understanding hidden beneath the ability to use equations to solve problems. Many students get through traditional assessments of scientific understanding by merely correctly identifying the known and unknown variables from the problem and then inserting them into the correct formula, which generates the correct answer. Unfortunately, the traditional instruction has little impact on removing deeply rooted misconceptions.

2.4 Identification of Misconceptions

Different methods such as interviews, open-ended questions, multiple-choice tests, inventories, two-tier multiple choice tests and etc. are used to identify students' misconceptions. In next section some of them will be clarified in details.

2.4.1 Interviews and Open Ended Questionnaires

Osborne and Gilbert (1980) used interview technique in the study to probe the nature of the students' views about force concept. The researchers concluded that this technique has some advantages as being applicable over a wide range and being enjoyable for both interviewer and interviewee. Moreover interview has advantage over written answers in terms of flexibility and depth of investigation. As a disadvantage on the other hand, they pointed out that the order of instances in interview may influence student responses and the analysis of interviews are time consuming and difficult. The major disadvantages of interviews are listed below (Wright, 2000):

1. Interviews provide indirect evidence of learning. Students report on their satisfaction with an educational experience and their preconceptions of what they have learned, how their skills have developed, or how their values have changed; but through an interview they cannot provide direct evidence of what they know or can do.

2. Since useful results depend on the interweaver's expertise, training of the researchers is required in these methods.

3. Interviews can also be challenging to administer.

4. Students must be contacted and they must agree to participate and appear for the interview.

5. The interview itself can take considerable time.

6. If a qualitative approach is taken, the conversation must then be transcribed

2.4.2 Multiple Choice Tests and Force Concept Inventory (FCI)

Hestenes and Halloun (1985) at Arizona State University began developing an instrument called the Mechanics Diagnostic Test (MDT) that measured not the students' initial knowledge of Newtonian force but the discrepancy between the students' common sense beliefs and their belief in the Newtonian force concept. In 1992, an improved version of the MDT was published as the Force Concept Inventory (FCI). The FCI is multiple-choice test which is designed to monitor students' understanding of the conceptual field of force and related kinematics. The value of these two instruments has led to the development of other multiple-choice concept tests in mechanics and other content areas of the introductory physics course. One of the other mechanics tests is the Force Motion Concept Evaluation (FMCE), an instrument similar to the FCI that looks at a smaller set of concepts and makes heavy use of graphical and pictorial representations. The FCI and the FMCE are the two most commonly used physics concept tests in use today.

Multiple-choice tests, as a method used in identification of misconceptions have many advantages. First of all they can be scored immediately and objectively. Moreover instructor can administer them easily and they are applicable to large number of students (Al-Rubayea, 1996). Ooesterhof (as cited in Çataloğlu, 2002) expressed that multiple-choice tests are better liked by the students than other measures and can give diagnostic information. However, there are also some criticisms to the multiple-choice tests. According to Rollnick and Mahooana (1999), multiple-choice tests have some disadvantages because they do not provide deep inside into the students' ideas on the topic and students very often give correct answers for wrong reasons. Today, the limitations as well as strengths of tests are widely acknowledged, and to overcome the problems Tamir (1989) and Wiggins & Mc Tighe (1998) (as cited in Treagust, 2006), recommended that specially created diagnostic tests that require an explanation of the answer are needed, precisely two-tier test items.

2.4.3 Two and Three-tier Tests in Assessing Misconceptions

In recent years two and three-tier diagnostic tests are used to asses the misconception of students. Treagust (as cited in Odom & Barrow, 1995) described the item format of two-tier multiple choice tests. The first tier of each multiple-choice item consists of a content question having usually two to four choices. The second tier of each item contains a set of usually four possible reasons for the answer give to the first part. The reasons consist of the designated correct answer, together with identified students' conceptions and/or misconceptions. The reasons are from the students' responses given to each open response question as well as information gathered from the interviews and the literature. When more than one alternative conception is given, these are included as separate alternative reason responses. Students' answers to each item are considered to be correct only if both the correct choice and correct reason are given. Sencar and Eryılmaz (2004) used the two-tier to diagnostic test to assign the misconception of the students. The first tier was a classic multiple choice question with a correct answer and some distracters. The second tier provides some reasons for the given answer for the first tier. The reasons were consisted of a correct reason and some misconceptions formed by the help of the related literature.

Three-tier tests are very similar to the two-tier tests. As a difference from two-tier tests, three-tier tests have one additional tier which asks students confidence about the answer of the former two-tiers (Çataloğlu, 2002). Eryılmaz and Sürmeli (2002) developed a three-tier test to assess students' misconceptions on physics topic "heat and temperature". They started their research by investigating the definition of misconception. According to the literature, misconceptions are conceptions which contradict with the widely accepted scientific knowledge.

However, in the previous misconceptions studies, objective multiple choice tests were used to asses misconceptions of the students. In these tests all wrong answers were treated as misconceptions. But in fact some wrongs might be because of lack of knowledge rather then misconception and assuming all wrongs as misconceptions questions the validity of objective tests by overestimating results. In three tier tests, the first tier is a classic multiple choice question. The second tier presents some reasons for the first tier. Finally the third tier asks the student whether he or she is sure or not for the given answers. If the student answer the first tier incorrectly, next gives the related reason for the answer, and finally the student is sure about the answers for the first two tiers, then it is assumed student to have a misconception. At the end of the study researchers compared the percentages of students having a misconception according to first tier, first two tiers and all three tiers. They found that 46% of the students had a misconception according to the first tier, 27% had a misconception according to the first two tiers and only 18% had a misconception according to all three tiers. Thus, the researchers concluded that three-tier tests assess misconceptions more valid than one-tier or two-tier tests and differentiate between misconception and lack of knowledge.

2.5 Approaches to Achieve Conceptual Change

The students bring various conceptual frameworks to the class that for a meaningful learning, their alternative conceptions need to be considered through the instruction. Their preconceptions and misconceptions could be so deeply rooted that conventional instruction may be somewhat inadequate to promote conceptual change. Different teaching strategies need to be used to achieve conceptual change in students.

The model of conceptual change developed by Postner, Strike, Hewson and Getzog (1982) suggests that four conditions are necessary for an accommodation occur in an individuals' understanding.

1. There must be dissatisfaction with existing conceptions. Scientists and students are unlikely to make major conceptual changes until they believe that less radical changes will not work.

2. A new conception must be intelligible. The individual must be able to grasp how experience can be structured by a new conception sufficiently to explore the possibilities inherent in it.

3. A new conception must appear initially plausible. Any new conception adopted must at least appear to have the capacity to solve the problems generated by its predecessors, and to fit with other knowledge, experience and help. Otherwise it will not appear a plausible choice.

4. A new conception should suggest the possibility of a fruitful research program. It should have the potential to be extended, to open up new areas of inquiry and to have technological and/or explanatory power.

Posner's conditions with some minor revisions have received wide acceptance by the scientific community.

Dykstra (1992) organized a three level taxonomy of conceptual change to exist;

- Differentiation, wherein new concepts emerge from existing, more general concepts, for example velocity and acceleration in kinematics.

- Class extension, wherein existing conceptions considered different are found to be cases of subsuming concept, for example being at rest and constant velocity from the Newtonian point of view.

- Reconceptualization, wherein a significant change in the nature of an relationship between concepts occur, for example, in the change from “force implies motion” to “force implies acceleration”.

The instructional strategy in which teachers are expected to lead their students through the following stages is proposed by Nussbaum & Novick (1982)

- An exposing event which requires a student’s interpretation based upon his or her existing conceptions,

- A discrepant event which creates a conflict between exposed preconceptions and newly observed phenomena which can not be explained,

- A learning support system which helps students’ search for a solution and encourages emerging accommodation.

Similarly four possible teaching strategies for conceptual change learning were suggested by Hewson and Hewson (1983).

- Integration
- Differentiation
- Exchange
- Conceptual Bridging

First strategy, integration, is the most commonly used method. The aim is to integrate new conceptions with existing conceptions and is based on the assumption that the students' existing conceptions are those, which the teachers have taught. Second strategy is to differentiate the student's existing conceptions about a given scientific phenomenon into more clearly defined, separate conceptions. The objective is to encourage the student to examine different aspects of the phenomenon. In doing so the student will realize that what was plausible in one situation is no longer plausible in a different, more complex situation. Third strategy is exchange. The aim is to exchange an existing conception for a new one, because they contradict one another. Since a student is not going to exchange a plausible conception for one which is seen to be implausible, it becomes necessary to create dissatisfaction with the existing conception as well as showing that the that the new conception has more explanatory and predictive power than the old. Fourth strategy is conceptual bridging where abstract concepts are linked with meaningful common experiences of the learner. In a study done by Hewson and Hewson (1983) where these teaching strategies were applied to the experimental group, they concluded that explicitly dealing with students' alternative conceptions caused a better acquisition of scientific concepts. They also agreed that taking into account of students' alternative conceptions is worthwhile since they adversely influence meaningful understanding of the learners if ignored.

2.6 Approaches to Challenge Misconceptions

Too often teachers of physics consider their students to be "clean mental states" and act accordingly in order to fill their "empty vessels" (Marionni, 1989). The problem with this approach of course is that the vessels are not empty but contain preconceptions. Student's naive theories or preconceptions may lead to misconceptions and thus may interfere with accepted concept development. Even when the teachers consider the students knowledgeable they may fall into the dominance trap assuming that children's conceptions of the natural world are easily replaced by the lessons of the teacher. Recent research has demonstrated that individual learners can be different; therefore teaching methodology should vary accordingly (Novak,1998; Tao & Gungstone, 1999).

Students confronting misconceptions through verbalization of understanding is common to many stepwise approaches to teaching and learning strategies for conceptual change. If students can grasp their difficulties verbally, they are a step closer to overcoming them. This requires teachers to place a greater emphasis on listening in the classroom when having the students verbalize their conceptual understandings. In a well-managed classroom, peers may constructively criticize each other's statements and thus each other's understanding. Students can refine each others sample answers to problems. This method will also sharpen student's critical thinking skills.

Secondly, having students make verbal statements of understanding to clarify and confront misconceptions is very productive. Brown and Clement (1991) emphasize student oral and written explanation of their conceptual understanding as a method of teachers' isolating misconceptions. Peers may criticize each others statements constructively and thus criticize each others understanding through this process. In doing so, the students can refine each others sample answers to problems. This process will also sharpen students' critical thinking skills.

While it is not a common practice within physics education, answering essay style questions requires students to review and reorganize their knowledge of the concept at hand in order to explain their understanding of the domain. Setting essay assignments that ask students to explain their reasoning help students identify misconceptions. In short answer or essay type questions, students cannot hide their conceptions behind formula as they have to demonstrate their understanding in order to answer the question. (Committee on Undergraduate Science Education,1996).

The concept map has been a very popular topic in this literature for at least 15 years. They were first developed in the early 70's as a research instrument in science education. By 1990, concept maps had gained such popularity in the science community that a special issue of the Journal of Research in Science Teaching was dedicated to discuss their uses and effectiveness (Markham, 1994). Since early 70's, they have been used in several science and meta-cognitive studies to explore and evaluate learning; in numerous science classrooms to teach and assess concepts; and in science teacher education classes to promote better teaching techniques. Concept maps illustrate the relationships between ideas in a knowledge domain as lines graphically linking keywords, which represent concepts in the domain. Concept maps illustrate in a hierarchical manner, the conceptual structure of a given portion of curriculum.

In a similar fashion the drawing of free body diagrams is useful in helping students overcome misconceptions, especially in mechanics when considering Newton's third law (Maloney, 1990).

Computer simulations run within a constructivist classroom will bring the students to question their own conceptions. Computer based labs have also demonstrated the ability to promote proper conceptual development through activity-based learning. Simulations can help students learn abut the natural world by having them see and interact with underlying scientific models that are not readily inferred from first hand observations.

Analogical reasoning as a tool for helping students overcome misconceptions were described by many researchers. Evidence presented by Clement (1993) suggests that using bridging analogies caused a greater gain in student understanding than a control. Although more time was used in teaching the units involved, gains were significantly greater than in studies testing the effect of increased class time. Black & Solomon (1987), for instance, investigated students' use of analogies for electric current. They found that the analogies presented helped students to learn. Shapiro (1985) interpreted successful use of analogies in his study, stating that hey helped to modify the existing cognitive structure. Gentner and Gentner (1983) reported that analogies aided problem solving in the area of the electric circuit. Analogical reasoning has been refined for use in the classroom and is expanded nicely in the bridging analogies strategies. The teachers' correct use of bridging analogies can help the student span the conceptual gap between anchor (a mastered concept) and target (misconceived) concepts. A teacher can help a student move conceptually from anchor to target by using a bridging analogy.

These and many other related approaches can promote conceptual change. The most proper one should be selected considering the local conditions. In our country where the class sizes are large, easily developed "refutational texts" or closely related "conceptual change texts" can be used.

Conceptual change text design is a teaching-learning strategy quite similar to the refutational text approach. Both strategies are based on Posner et al.'s (1982) conceptual change model. The major difference between the refutational text model and conceptual change text involves whether students are asked explicitly to make a prediction about a situation. In the refutational text model, common misconceptions are contrasted to scientific conceptions, but the student is not asked to make a prediction about a common situation before the refutation is given. In the conceptual change model, students are asked explicitly to predict what would happen in a situation before being presented with information that demonstrates the inconsistency between common misconceptions and the scientific conception. The aim of this strategy is to activate students' own preconceptions about the situation without being influenced by others' alternative conceptions. By this method it is expected that students will more consciously comprehend the contrast between the scientific theory and common misconceptions, and thus will be inclined to exchange their misconceptions with scientific concepts.

2.7 Misconceptions in Electricity

Compared to other areas of physics such as mechanics, electricity, thermodynamics, etc, where we have a lot of results of Physics Education research available, the field of electrostatics in electricity has been much less explored in this sense. Electricity due to its nature is the most abstract concept in physics. There are many reasons why electricity concepts are so much confusing for the students. Main reason is the difficulty to give a unique and concrete definition of electricity. Many terms about electricity are not directly inferred from observation, but they are rather mentally constructed to represent the events that occur under suitable conditions.

Moreau & Ryan (1985) argued that although many introductory textbooks contain excellent treatments of electrostatics and electric circuits, an important connection between these two topics is often overlooked, or at least not emphasized, namely that the electric potential in circuits is exactly the same as the electrostatic potential and to expect students themselves to make the connection back to electrostatics is perhaps too much.

Heald (1984) claim that there is a peculiar discontinuity in the usual presentation of the first two major electrical topics in standard introductory physics courses. In electrostatics, attention focuses explicitly on the electric charges residing on conductors and on the electric fields existing in the space external to the conductors. Then in the next lecture (or chapter), education proceed to electric circuits and students' attention focuses on batteries, resistors, hookup wire, and eventually capacitors.

Chambers and Andre (1997) used a text-based conceptual change approach in electricity concept. They investigated relationship between gender, interest and experience in electricity, and conceptual change manipulations on learning fundamental direct current concepts. They concluded that conceptual change text approach leads to better conceptual understanding of concepts than traditional didactic text.

There are many studies in the literature concerning student misconceptions about electricity and its features. However studies that tackle learning difficulties in electricity mainly focus on direct current circuits (Duit, 1993) and do not link these difficulties with electrostatic concepts. The concept Potential difference, for instance is one of the hardest to learn when studying basic electric circuits (Eylon & Ganiel, 1990) keeps a direct relation with the concepts of electric field and Potential taught in electrostatics.

In a survey done with university level students in France and Sweden (S. Raison et al., 1994) concluded that for most of the students, electrostatics and electric circuits are two unconnected subjects. A lot of students think that current is the cause of the field, reversing the cause and the effect.

An important misconception to notice is that many students consider the electric field to have a static nature, in the sense that the field exists in the space and applies forces on charges, and it does not change even when a new charged particle enters the region. Indeed, from an interview by Bagno et al. (1994), when the students were given the statement *"A charged particle enters a region* *with a constant electric field. The field in this area changes because of the new charge,"* 40% of the students answered incorrectly, from which 82% of them were saying that *"the electric field is a "property" of the region-its task is to apply force on a charge in it."* The authors (Bagno et al., 1994) explain this misconception by reference to the presentations of the most textbooks, which support this perception of the students, since the electric field, a difficult and non-intuitive concept, is presented merely as a force applier. They also notice that in general problems from the textbooks deal with static situations such as: *"four charges are fixed in the four corners of a rectangle; find the resultant electric field,"* and do not illustrate the dynamic nature of the electric field. Even in the problems in which charged particles are entering a region with a constant electric field, students are almost never asked about the new field (they are usually asked about the path of the particle, its velocity, etc). Chabay and Sherwood (1995) have made an attempt to develop a dynamic conception of electric fields in their recent instructional materials. They included and emphasized also problems in which the students are required to find the new electric field after an electric charge entered into a region with a constant electric field.

When the students surveyed by Bagno et al. (1994) were asked whether the statement *"at the point where the electric field is zero, the electric potential is also zero"* is true or not, 62% of the students chose incorrect answers. The authors offer several explanations for this. It seems that many students don't differentiate between concepts of potential and potential difference.

S. Tornkvist (1993) in one of their interviews asked the students to draw the field lines that can account for a given force vector in a given point. Only 13% of the students considered an inhomogeneous field as the answer to this question, although they have been given such fields in previous questions. 79% of the students drew straight equidistant field lines. The authors think that an explanation for this could be the heavy emphasis in textbooks on the homogeneous electric field between two parallel capacitor plates.

Common student misconceptions in Electric Field, Electric Potential (Voltage) and Electric Potential Energy derived from articles of researchers who were stated above are summarized by Hapkiewicz (1992) as below:

1. Electric Potential Energy and Electric Potential (Voltage), all the same thing.
2. A Potential difference is only on plates of a capacitor and not in region between.
3. High Voltage by itself is dangerous.
4. There is no connection between Voltage and Electric field.
5. Electric potential is the amount of electricity that a material can allow.
6. Electric Potential is the potential of the electricity to become Potential Energy.
7. Electric Potential is the Potential Energy generated in an electric field.

Most studies showed that the teaching methodology has been an underlying factor to grasp the meaning of scientific concepts deeply. In this study effect of conceptual change on overcoming 10^{th} grade physics students' misconceptions on electric potential and electric potential energy concepts will be investigated.

CHAPTER 3

METHOD

3.1 Experimental Design

In the previous chapters, the problem and hypotheses of the study were presented, related literature was reviewed and importance of the study was stated. In this chapter, population and sampling, description of variables, development of measuring tools, procedure, and methods used to analyze data and assumptions and limitations of the study will be explained briefly.

Table 3.1 Research Design of the Present Study

Group	Pre-test	Treatment	Post-test
EG	EPEPECT,PATS	CCI	EPEPECT,PATS
CG	EPEPECT,PATS	TDPI	EPEPECT,PATS

In the study non-equivalent pretest-posttest control group design was used. The EPEPECT and PATS were given as pre-test and post-test to both groups of students.

3.2 Population and Sample

All tenth grade science students in Turkey were the target population in this study. However, since the data collection from this population is extremely difficult, all tenth grade science students in TED Ankara College Foundation Private High School were identified as accessible population. The school is located in Ankara, capital city of Turkey. It is a private school and most of the students belong to a high socio-economic status. This is the population for which the results of this study will be generalized. The population being sampled in this study was 237 tenth grade science students who take physics course. The sample size of this study consisted of 37 students from two science classes in TED Ankara College Foundation Private High School. Sample size was 15.6 % of the accessible population. The study was carried out during the spring semester of the 2005-2006 academic year. Classes were randomly assigned as experimental group, which was taught with conceptual change instruction, and the control group which was taught with traditionally designed physics instruction. The data used in the analysis of hypotheses were obtained from 18 students in control group and 19 students in experimental group. Two different and experienced instructors taught groups during this study.

3.3 Variables

There are six variables involved in this study, which are categorized as dependent and independent variables. There are two dependent variables (DVs) and four independent variables (IVs). IVs are divided in two groups as covariates and group membership. Table 3.2 presents all the characteristics of these variables.

Table 3.2 Identification of the Variables

TYPE OF VARIABLE	NAME	TYPE OF VALUE	TYPE OF SCALE
DV	PSTCON	Continuous	Interval
DV	PSTATT	Continuous	Interval
IV	PRECON	Continuous	Interval
IV	PREATT	Continuous	Interval
IV	MOT	Discrete	Nominal
IV	Gender	Discrete	Nominal

3.3.1 Dependent Variables

The DVs of this particular design are students' Electric Potential and Electric Potential Energy Concept Test Posttest scores (PSTCON) and students' Physics Attitude Posttest Scores (PSTATT). PSTCON and PSTATT are related to physics as measured by Electric Potential and Electric Potential Energy Concept Test (EPEPECT) and Physics Attitude Scale (PATS), respectively. They are continuous variable and measured on interval scale. Students' possible minimum and maximum scores range from 0 to 16 for PSTCON and 57 to 120 for PSTATT, respectively.

3.3.2 Independent Variables

The IVs of the present study are collected in two groups; Set A and Set B. Students' electric potential and electric potential energy concept pretest scores (PRECON) and physics attitude pretest scores (PREATT) and gender are considered within Set A as covariates. Methods of teaching (MOT) (Conceptual change instruction and traditional method) are included in Set B as group membership. In set A, the PRECON and PREATT are considered as continuous variables and measured on interval scale. The students' gender is determined as discrete variable and measured on nominal scale. In set B, the MOT (Conceptual change instruction and traditional method) is considered as discrete variable and measured on nominal scale. The students' gender was coded as one for female and two for male.

3.4 Measuring Tools

In this study, two measuring tools were used. These are Electric Potential and Electric Potential Energy Concept Test (EPEPECT) and Physics Attitude Scale (PATS).

3.4.1 The Electric Potential and Electric Potential Energy Concept Test (EPEPECT)

The Electric Potential and Electric Potential Energy Concept Test (EPEPECT) was constructed in order to determine the students' qualitative understandings and misconceptions about electric field, electric potential and electric potential energy concepts. The test was designed in English by the researcher, because the instruction language in TED Ankara College Foundation Private High School was English. A simple grammar structure and vocabulary was used to eliminate factors that might prevent students from responding. Test covers physics content related to the electric field, electric potential and electric potential energy taught in the tenth grade which is the same in all schools which follow the general curriculum of Ministry of Education.

Before development stage of the EPEPECT both the general and behavioral objectives were stated (see Appendix A). Then the literature was reviewed and expert judgments' were taken into account to assess the students' probable misconceptions related to the electric field, electric potential and electric potential energy concepts. Distracters of each item were constructed due to instructional objectives and students' misconceptions related to electric field, electric potential and electric potential energy concepts (See Table 3.3). All items of EPEPECT were composed of qualitative, conceptual questions designed to encourage students to think about the given phenomenon. Test consists of 10 multiple-choice items in two parts. The first part was a classic multiple choice question with both a correct answer and correct reason or a distracter followed by misconception derived from related physics content. The reasons were consisted of either a correct reason or some misconceptions formed by the help of the related literature. Last alternative of the first part also included a blank, in order to give the chance of students who can not see their reasons among the other alternatives and has their own explanation about the related physics concept.

Table 3.3 Classification of Students' Misconceptions Probed by EPEPECT

Students' Misconceptions	Test Item No
Electric potential energy and electric potential (voltage) are all the same thing.	**4 (c),4(d),5(a),5(c),9(d), 10(a),10(b)**
A potential difference is only on plates of a capacitor and not in region between.	**6(b),9(c)**
High voltage is dangerous under any conditions.	**1(a),1(d),1(d),2(c),2(d)**
Electric potential at any point exist only when charged particle exist at that point.	**6(a)**
There is no connection between voltage and electric field.	**7(c),9(b),10(b)**
Equipotential means equal electric field or uniform electric field.	**7(a),7(b),**
Voltage flow through a parallel conductor plate.	**6(d)**
It takes work to move a charge with constant speed on an equipotential line.	**7(b)**
Charges move by themselves even there is no net force acting on them.	**4(a),8(d)**
There is no connection between electric potential energy and work.	**3(a), 3(b), 3(c),8(a),8(c),10(c)**

Finally the second part asks the student whether he or she is sure or not for the given answers. If the student answers the first part incorrectly, which include the related reason for the answer, and finally the student is sure about the answers for the first part, then it is assumed student to have a misconception. The test was designed in that way in order to assess misconceptions more validly and differentiate between misconception and lack of knowledge. In first look the test look like having properties of three tier tests but in different design. It was prepared in that different form in order to asses students' misconceptions avoiding the critics done by Griffard and Wandersee (2001). In 1987 the researchers investigated the effectiveness of a two-tier instrument in one of the biology concepts developed by Haslam and Treagust.. The test was given to the students by requesting from them to think aloud while they were answering the items. They found that, unnecessarily wording of distracters caused students to make mistakes. They concluded that it is not certain whether these mistakes were due to misconceptions of the students or unnecessarily wording of the test. Moreover, these unnecessarily wording can cause create a new misconception in students' mind. They also stated that students consider the second tier as a distinct multiple-choice item and finalized their choice on the basis of whether it logically follows from their response to the first tier. Therefore, two-tier test seemed to measure the students' test-taking skills rather than the misconceptions.

Possible EPEPECT scores range from 0 to 30, with lower scores indicating low misconception and higher scores great misconception in related physics content. All responses for each item of EPEPECT were evaluated and coded considering the following strategy. Whatever the response in first part (true or false alternative), if the student checked " I do not know" in the second part, the response for that item was coded as 0 which means that there is no existing misconception. If the response of the first part was true and the student checked "I am sure" in the second part, the item was coded as 0 again, indicating no existing misconception. But if the answer of the first part was true and the student checked "I am not sure" in the second part, the item was coded as 1 indicating an existing misconception. If the response of the first part was false and the student checked "I am not sure" in the second part, the item was coded as 2, indicating that relatively greater misconception exists. Finally if the answer of the first part was false and the student checked "I am sure" in the second part, the item was coded as 3, which indicates the greatest possible misconception assessed by the test. The answer of students who preferred to write their own explanations and reasons in the blank alternative of the first part of the test were evaluated in the same manner by comparing their reason with the widely accepted scientific knowledge. Since the possible scores for each item could change between 0 and 3, possible EPEPECT scores could range from 0 to 30, with lower scores indicating low misconception and higher scores great misconception in related physics content. The responses were coded gradually in order to assess misconceptions more valid and differentiate between misconception and lack of knowledge. The expert judgment about the content validity of the test was considered before implementation of the study. The test is reproduced in original form in Appendix B1.

3.4.2 Physics Attitude Scale (PATS)

In order to determine the students' attitudes toward physics as a school subject, an attitude scale developed by Sancar (1998) was used. The reliability coefficient of test which was tested in previous studies was computed as .88. The purpose of this inquiry tool was to obtain valid and useful information concerning both EG and CG students' attitudes toward physics as a school subject. PATS was administered as pre and post-test to 37 both EG and CG students instructed by CCI and TDPI respectively. The attitude test was in Likert type scale including 24 items. When responding to a Likert questionnaire item, respondents specified their level of agreement to a statement. Five-point response scale was used (Strongly Agree, Agree, Neutral, Disagree, and Strongly Disagree). Since a Likert scaling is bipolar scaling method, measuring either positive or negative response to statements, response to each positive statement was valued from 5 for Strongly Agree and 1 for Strongly Disagree. Response to each negative statement on the other hand was valued from 1 for Strongly Agree and 5 for Strongly Disagree. After the questionnaire was completed, item responses were summed to create a score for a group of items because response to a single Likert item is normally treated as ordinal data, but when responses to several Likert items are summed, they may be treated as interval data. Possible PATS scores range from 24 to 120, with lower scores indicating negative attitude and higher scores positive attitude towards physics.

3.5 Validity and Reliability of the Measuring Tools

In order to establish the face and content validity, EPEPECT and PATS were examined by one English and four Physics teachers from TED Ankara College Foundation High School, one instructor from the department of Secondary School Science and Mathematics Education at METU, and two METU Secondary School Science and Mathematics Education graduate students according to the content and format of the instrument. All these people were explained about the main purpose of test and then they checked the measuring tool according to given criteria of appropriateness of items to the grade level, appropriateness of the format, representativeness of content by the selected items. Suggestions were taken into consideration for the revision of instrument.

The reliability analysis as performed according to the PSTCON and the value of alpha was calculated as .690. According to the related literature, what a reliability coefficient based on misconception scores must be at least as to indicate a valid and reliable misconception test is not known. Therefore the result of analysis was interpreted as an achievement type test result. Similarly, reliability analysis was also performed for the PSTATT and internal reliabilities were calculated as .78. Since it was directly taken from previous study, no change was performed on the items of the tests. As a result, the validity and reliability estimates for EPEPECT and PATS imply that the scores obtained on these tests are valid and reliable. The test is reproduced in original form in Appendix B2.

3.6 Teaching/Learning Materials

In this study, the students in the control group were instructed by the traditional method. Namely, they attended the lectures, and studied from their standard textbooks.

3.6.1 Conceptual Change Texts (CCT)

The treatment in the experimental group added the conceptual change texts (CCT) as a supplementary learning material. For the topics covered during the two and a half week treatment period, the EG students were asked to study from these texts in addition to their standard textbooks. CCT were designed by the researcher based on Posner et al.'s (1982) conceptual change model which suggest that four conditions are necessary for an accommodation occur in an individuals' understanding.

1. There must be dissatisfaction with existing conceptions. Scientists and students are unlikely to make major conceptual changes until they believe that less radical changes will not work.

2. A new conception must be intelligible. The individual must be able to grasp how experience can be structured by a new conception sufficiently to explore the possibilities inherent in it.

3. A new conception must appear initially plausible. Any new conception adopted must at least appear to have the capacity to solve the problems generated by its predecessors, and to fit with other knowledge, experience and help. Otherwise it will not appear a plausible choice.

4. A new conception should suggest the possibility of a fruitful research program. It should have the potential to be extended, to open up new areas of inquiry and to have technological and/or explanatory power.

All of the conceptual change texts were designed based on the instructional objectives of the course (see Appendix A). The purpose was to inform students about their misconceptions, stress the scientific concepts are more rational for a given situation, and suggest to replace these newly learned concepts with their existing conceptions. They were designed to promote conceptual understanding on electric field, electric potential and electric potential energy in the students' minds. A conceptual text sample can be seen in Appendix C.

The content coverage of each CCT corresponded to one class hour of instruction. The CCT for a given class-hour was distributed to the students at the beginning of each class-hour by requesting from them to concentrate to the question asked by CCT. After the students discussed and think about the response of the question they were advised to read the all of CCT. The situations presented in the texts were also discussed in the classroom by the guidance of the teacher.

3.7 Procedure

The study started with identifying the keywords and detailed review of the literature. After that, Educational resources Information Center (ERIC), International Dissertation Abstracts (DAI), Social Science Citation Index (SSCI), Science Direct and search engine Google were searched systematically. Furthermore, Turkish research studies were searched by means of METU, YÖK and Bilkent University libraries. Results of the studies and content of the articles were compared with each other.

Next, the measuring instruments were developed by the help of the findings from the literature. EPEPECT were tested during the 2004-2005 academic year in TED Ankara College. Results of the study were analyzed with the help of my advisor who is specialist in physics education. The recommendations of my colleagues and Physics teachers were also considered. Necessary changes were done and EPEPECT were revised according to the findings.

After necessary permission has been granted from the administration of the school the study was carried out during the spring semester of the 2005-2006 academic year. Two classes from TED Ankara College Foundation Private High School were used as subject. The target population was the 10^{th} grade students in TED Ankara College Foundation Private High School. One of the classes was randomly assigned as experimental group, which was taught with conceptual change instruction, and the other was assigned as control group, taught with traditionally designed physics instruction.

The self developed EPEPECT and PATS was administered one week before the treatment start to both groups to determine if these two groups were equivalent in terms of these parameters. One class hour was given to students to complete EPEPECT and PATS. The necessary instructions and explanations were done before students began to answer the questions. Students were told that the results of those tests would not affect their physics grades.

One week after the administration of the pre-test, instruction related to electric field, electric potential and electric potential energy concepts started in both the control and the experimental groups. Two different teachers lectured the groups.

Duration of one physics class session was 45 minutes in the school. During the treatment, each class was exposed to the same amount teaching time and took the same materials except conceptual change texts for the experimental group. Before delivering the conceptual change texts, a first part of the text, which consists of a question related to the subject was read and discussed in the classroom. Five conceptual change texts were given to 18 students of the experimental group. They were designed by the researcher based on Posner et al.'s (1982) conceptual change model which suggests that four conditions are necessary for an accommodation occur in an individuals' understanding. The conceptual change text was developed in a way that addresses the most common misconceptions about electric field, electric potential and electric potential energy. It consists of information that focuses inconsistencies between misconceptions about related content and scientific knowledge. It also includes examples and figures to activate the misconceptions about subject area. The scientific knowledge and explanations of this text has a kind of properties that are plausible and intelligible. Conceptual Change Texts (see appendix C) in the study used the identified the misconceptions about electric field, electric potential and electric potential energy and try to correct them by giving analogies, examples, figures and scientific explanations .In this way, in the first case, students were expected to be dissatisfied with existing conceptions, then corrected them by giving analogies, figures, and examples. Analogies, figures and examples were selected and created in a way that they are focused on the target misconception in order to change the misconception to the scientific conception. In physics class-hours, this function of the conceptual change text was supported by discussions that dissatisfy the students' misconceptions and give the plausible, qualitative and intelligible explanations for the natural phenomena. After reading the text, the new concepts, or scientific concepts and the misconceptions were discussed by the teacher and students in the experimental group.

The students in control group were instructed by traditional method, attending the lectures and studying from their standard textbooks. The students in experimental group on the other hand were supplemented with conceptual change texts as a learning material in addition to their standard textbooks. The teacher having experimental group was trained and informed how to use conceptual change texts during her instruction. Normally one conceptual change text was covered during one hour of instruction. After the conceptual change texts were presented the content was discussed in the classroom by the guidance of the teacher.

On the other hand, traditionally designed physics instruction was used in control group by applying the traditional lecture method. Traditional teaching method was based on explanations, quantitative questions and textbook. Therefore, the misconceptions were not taken into the account and only explanations, definitions and concepts were presented on the blackboard. In addition to this, quantitative problems from textbooks were solved. The content was covered during the period of two and a half weeks. After the teaching period of the content, EPEPECT and PATS were administered to both groups once again as a post-test.

3.8 Analysis of Data

MS Excel and Statistical Package for the Social Sciences (SPSS) were used for the statistical analysis. The data obtained in this study were analyzed in two parts. In the first part, descriptive statistics and in second part, inferential statistics were used.

3.8.1 Descriptive Statistics

The mean, median, mode, standard deviation, skewness, kurtosis, minimum, maximum values and the histograms were presented for the variables according to the results of control and experimental groups. In order to test the null hypotheses, all statistical computations were done by using statistical package program (SPSS).

3.8.2 Inferential Statistics

In order to test the hypotheses, statistical technique named multivariate analysis of covariance (MANCOVA) was used since it incorporates two or more dependent variables in the same analysis.

3.9 Assumptions and Limitations

The assumptions and limitations of this study which were considered by the researcher are given below.

3.9.1 Assumptions

1. One of the assumptions is that all the subjects participated in the study honestly responded to the items of the tests.
2. Another assumption is that the classroom teacher was not biased during the study.
3. There is no instructor effect of the study, because two different instructors participated.
4. There was not pre-test treatment interaction.
5. Students from the experimental and control groups did not interact and shared CCT during the administration of the texts.

3.9.2 Limitations

1. The study was conducted only to the two classes from TED Ankara College Foundation Private High School.
2. The content area was limited to the Electric Field, Electric Potential and Electric Potential Energy.

CHAPTER 4

RESULTS

This chapter is divided into two different sections. First section deals with descriptive statistics and the inferential statistics. In this section descriptive comparison of traditionally designed physics instruction and conceptual change instruction for students' pretest and posttest scores and inferential statistical results produced from testing three null hypotheses are presented. Finally, the last section summarizes the findings of the study.

4.1 Descriptive and Inferential Statistics

4.1.1 Descriptive Statistics

Table 4.1 presents descriptive statistics related to the students' Electric Potential and Electric Potential Energy Concept Test Pretest Scores (PRECON), students' Physics Attitude Pretest Scores (PREATT), students' Electric Potential and Electric Potential Energy Concept Test Posttest Scores (PSTCON), and students' Physics Attitude Posttest Scores (PSTATT) for the experimental and control groups. Students' scores on the Electric Potential and Electric Potential Energy

Concept Test (EPEPECT) could range from 0 to 30 in which higher scores mean greater misconception in Electric Field, Electric Potential and Electric Potential Energy . As shown in Table 4.1, the experimental group showed a mean decrease of 2.45 from pretest to posttest, which means that misconceptions of students in experimental group decreased. On the other hand, the mean of the control group increased slightly; it increased from the mean value of 10.32 to 12.37 from pretest to posttest, which means that misconceptions of students in control group increased. The change of mean for the control group was 2.05 points. Table 4.1 also presents some other basic descriptive statistics of participants like mean, median, standard deviation, skewness, kurtosis, minimum and maximum values.

Similarly, descriptive statistics related to scores on the Physics Attitude Scale (PATS) were also categorized according to the experimental and control groups as in Table 4.1. Students' scores on the PATS could range from 24 to 120 in which higher scores mean more positive attitudes toward physics, lower scores mean more negative attitudes toward physics. As shown in Table 4.1, mean for the PSTATT in the experimental group was slightly higher than that of students instructed by traditional method. Mean of the experimental group increased slightly from pretest to posttest. However, mean of the control group decreased slightly from pretest to posttest. Moreover, the experimental group showed a mean increase of 1.72 points. The control group showed a mean decrease of 0.95 points. As shown in Table 4.1, for the experimental and control groups, the value of skewness and kurtosis for each pretest and posttest were between –2 and +2 which can be assumed as approximately normal as suggested by Kunnan (as cited in Ağazade, 2001).

Table 4.1 Basic Descriptive Statistics Related to the Electric Potential and Electric Potential Energy Concept Scores, Physics Attitude Scores

	Experimental Group		Control group	
	Pretest	Posttest	Pretest	Posttest
Scores on Electric Potential and Electric Potential Energy Concept Test				
N	18	18	19	19
Mean	6.39	3.94	10.32	12.37
Standard Deviation	4.89	3.17	4.52	2.99
Skewness	1.24	0.27	-0.029	-0.708
Kurtosis	1.57	-1.17	-0.520	-0.831
Range	19	9	16	9
Minimum	0	0	2	7
Maximum	19	9	18	16
Scores on Physics Attitude Scale				
N	18	18	19	19
Mean	94.28	96.00	90.58	89.63
Standard Deviation	13.63	16.38	17.12	16.60

Table 4.1 (continued)

Skewness	-0.004	-0.353	-0.67	-0.39
Kurtosis	-1.493	-0.902	-0.061	-0.484
Range	40	55	62	60
Minimum	75	65	54	57
Maximum	115	120	116	117

Figure 4.1 and Figure 4.2 show the histograms with normal curves related to the PSTCON and PSTATT for the control and experimental groups. These are also an evidence for the normal distribution of the dependent variables (DVs).

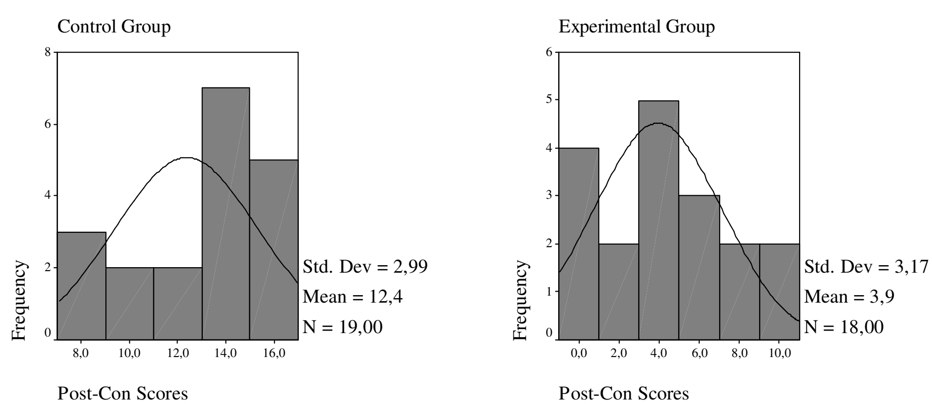

Figure 4.1 Histograms with normal curves related to PSTCON for the control and experimental groups

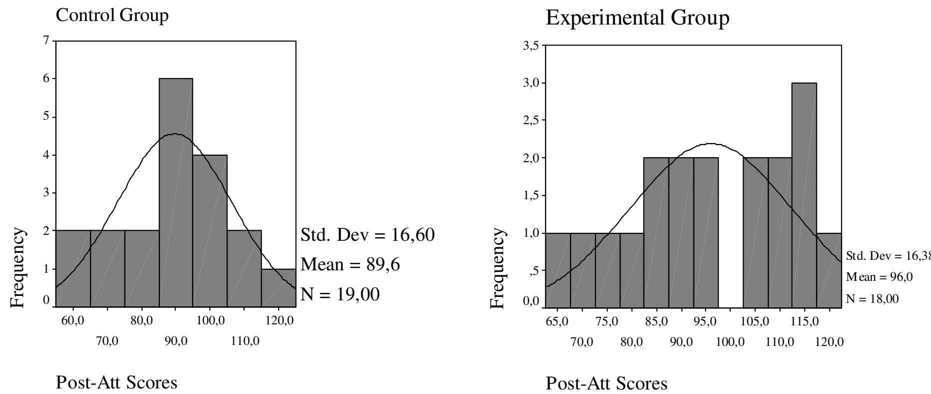

Figure 4.2 Histograms with normal curves related to PSTATT for the control and experimental groups

4.1.2 Inferential Statistics

This section deals with the determination of the covariates, the clarifications of multivariate analysis of covariance (MANCOVA) assumptions, the statistical model of MANCOVA, the analyses of the hypotheses and the follow-up analysis.

4.1.2.1 Determination of Covariates

PRECON, PREATT and gender were pre-determined as potential confounding factors of the study. To statistically equalize the differences among the experimental and control groups, these variables were included in Set A as covariates. All pre-determined IVs in Set A correlated with two DVs (PSTCON and PSTATT). Table 4.2 presents the results of these correlations and their level of significance. As seen in the table, two of the IVs in Set A, PRECON and PREATT had significant correlations with at least one of the DVs of PSTCON and PSTATT. However, gender did not have significant correlations with the DVs. Hence, PRECON and PREATT were determined as covariates for the following inferential analyses.

Table 4.2 Significance Test of Correlation between Independent Variables and Dependent Variables

Variables	Correlation Coefficients	
	PSTCON	PSTATT
Gender	-.109	.041
PRECON	.329*	-.001
PREATT	-.222	.915*
PSTCON		-.275
PSTATT	-.275	

*Correlation is significant at .05 level (2-tailed)

Table 4.3 indicates the correlation between covariates. As seen in the table none of correlation value is greater than.80. So there was no significant correlation among covariates. There was no multicollinearity among covariates.

Table 4.3 Significance Test of Correlation between Covariates

Variables	PRECON	PREATT
PRECON		-.068
PREATT	-.068	

*Correlation is significant at .05 level (2-tailed)

4.1.2.2 Assumptions of Multivariate Analysis of Covariance

MANCOVA has five assumptions: Normality, homogeneity of regression, equality of variances, multicollinearity and independency of observations. All the variables were tested for all the assumptions. For the normality assumption, skewness and kurtosis values were used. The skewness and kurtosis of scores on the PSTCON and PSTATT were in acceptable range for normal distribution as stated in descriptive statistics. Homogeneity of regression assumption means that the slope of the regression of a DV on a covariate must be constant over different values of group membership. Table 4.4 indicates the results of Multivariate Regression Correlation (MRC) analysis of homogeneity of regression. For this analysis, three new interaction terms were produced. These interaction terms were prepared by multiplying the group membership with the covariates of the PRECON and PREATT separately. After that, three different blocks were produced. Covariates were set to Block A, group membership was set to Block B and interaction terms were set to Block C. Then MRC was performed to test the significance of R^2 change using enter method for each of three DVs.

Table 4.4 presents the results of the MRC analysis of homogeneity of regression. As shown in Table 4.5, for PSTCON, contribution of Block C is not significant (F (2,31) = 0.520, p = .600). For PSTATT, contribution of Block C is not also significant (F (2,31) = 0.595, p = .558). So the interactions (Block C) can be dropped. In other words; there was no significant interaction between the covariates and group membership. This means that the homogeneity of regression assumption is validated for this model.

Table 4.4 Results of the MRC Analysis of Homogeneity of Regression

Model	Change Statistics				
PSTCON	R^2 Change	F Change	df1	df2	Sig. F Change
Block A	.148	2.963	2	34	.065
Block B	.531	54.782	1	33	.000
Block C	.010	.520	2	31	.600
PSTATT					
Block A	.841	90.236	2	34	.000
Block B	.014	3.123	1	33	.086
Block C	.005	.595	2	31	.558

Table 4. 5 indicate the Box's Test of Equality of Covariance Matrices. As seen from the table, the observed covariance matrices of the DVs were equal across groups.

Table 4.5 Box's Test of Equality of Covariance Matrices

Box's M	0.073
F	0.023
df1	3
df2	245669
Sig.	.995

Levene's Test of Equality was used to determine the equality variance assumption. As Table 4.6 indicates, the error variances of the selected DVs across groups were equal.

Table 4.6 Levene's Test of Equality of Error Variances

	F	f1	f2	Sig.
PSTCON	.274	1	35	.604
PSTATT	.552	1	35	.462

As shown in Table 4.3, there were correlations between covariates. However, the correlations between these covariates were smaller than .80. So the assumption of multicollinearity was also supplied.

Independency of observation was also examined. Independency assumption was met with the observations of the experimental and control groups by the researcher. It was observed that all participants did their tests themselves.

4.1.2.3 Multivariate Analysis of Covariance Model

The DVs of the study are the PSTCON and PSTATT. The variables of the PRECON and PREATT are covariates of the study. Table 4.7 presents the results of MANCOVA. As shown in Table 4.7, methods of teaching (MOT) explained 64.0 % variance of model for the collective DVs of the PSTCON and PSTATT.

Table 4.7 Multivariate Test Results

Effect	Wilks' Lambda	]	Hypothesis df	Error df	Sig.	Eta Squared	Observed Power
Intercept	.71	6.4	2.0	2.0	005	.29	.78
PRECON	.93	.151	2.0	2.0	.329	.07	1.00
PREATT	.15	0.0	2.0	2.0	.000	.85	1.00
MOT	.37	7.81	2.0	2.0	.000	.64	1.00

4.1.2.4 Null Hypothesis 1

There will be no significant difference between the posttest mean scores of tenth grade students exposed to conceptual change instruction and those exposed to traditionally designed physics instruction on the population means of the collective dependent variables of electric potential and electric potential energy concepts posttest scores and physics attitude posttest scores when the effects of electric potential and electric potential energy concepts pretest scores, physics attitude pretest scores and gender are controlled.

MANCOVA was conducted to determine the effect of the MOT on the collective DVs of the PSTCON and PSTATT. As seen in Table 4.7, this null hypothesis was rejected (λ= 0.37, p= .000). Significant differences were found among conceptual change instruction and traditional method on the collective DVs of the PSTCON and PSTATT.

In order to test the effect of the methods of teaching on each dependent variable, an univariate analysis of covariance (ANCOVA) was conducted as follow-up tests to the MANCOVA. Table 4.8 indicates the results of the ANCOVA.

Table 4.8 Test of Between-Subjects Effect

Source	DV	Type III Sum of Squares	Df	Mean Square	F	Sig.	Eta Squared	Observed Power
Corrected model	PSTCON	671.2	3	223.7	23.4	.000	.68	1.0
	PSTATT	8465.6	3	2821.9	65.0	.000	.86	1.0
Intercept	PSTCON	126.6	1	126.6	13.2	.001	.29	.94
	PSTATT	.142	1	.142	.0	.955	.00	.05
PRECON	PSTCON	2.950E-02	1	2.950E-02	.0	.956	.00	.05
	PSTATT	102.8	1	102.8	2.4	.133	.07	.32
REATT	PSTCON	15.2	1	15.2	1.6	.216	.01	.23
	PSTATT	8024.1	1	8024.1	184.7	.000	.69	1.0
MOT	PSTCON	524.7	1	524.7	54.8	.000	.62	1.0
	PSTATT	135.7	1	135.7	3.1	.086	.09	.40
Error	PSTCON	316.1	33	9.6				
	PSTATT	1433.7	33	43.4				
Total	PSTCON	3518.0	37					
	PSTATT	328055.0	37					
Corrected Total	PSTCON	987.3	36					
	PSTATT	9899.3	36					

4.1.2.5 Null Hypothesis 2

There will be no significant difference between the posttest mean scores of tenth grade students exposed to conceptual change instruction and those exposed to traditionally designed physics instruction on the population means of the electric potential and electric potential energy concepts posttest scores when the effects of electric potential and electric potential energy concepts pretest scores, physics attitude pretest scores and gender are controlled.

As seen in Table 4.8, the second null hypothesis was rejected. ($F(1, 33) = 54.8$, $p = .000$). In other words, conceptual change instruction was effective in decreasing the PSTCON. Students instructed by conceptual change instruction had lower misconception scores than the students instructed by traditional method.

4.1.2.6 Null Hypothesis 3

There will be no significant difference between the posttest mean scores of tenth grade students exposed to conceptual change instruction and those exposed to traditionally designed physics instruction on the population means of the physics attitude posttest scores when the effects of electric potential and electric potential energy concepts pretest scores, physics attitude pretest scores and gender are controlled.

As seen in Table 4.8, the third null hypothesis was not rejected (F (1, 33) = 3.1, p = .086). That is conceptual change instruction was not effective in improving positive attitudes toward physics more than traditional method did. This statistic therefore did not provide support for this research hypothesis.

Table 4.9 presents the adjusted means of the experimental group and control group for DVs of the PSTCON and PSTATT and independent variable of the MOT. All inferential analyses were performed on these adjusted means. When we compared the adjusted means with prior means, we realized that covariates decreased the differences between the mean of the control group and that of the experimental group.

Table 4.9 Means and Adjusted Means of the Experimental and Control Groups

DV	Methods of Teaching	Means	Adjusted Mean
PSTCON	Experimental Group	3.9	4.0
	Control Group	12.4	12.3
PSTATT	Experimental Group	96.0	94.9
	Control Group	89.6	90.7

4.2. Summary of Results

In the light of the findings, obtained by statistical analyses, the following results could be summarized as follows:

1. There was not significant correlation between the gender and each DV of the PSTCON and PSTATT.
2. There was not a significant correlation between the PSTCON and PSTATT.
3. There was a significant positive correlation between the PRECON and PSTCON. However, no significant correlation was found between the PRECON and PSTATT.
4. There was a significant positive correlation between the PREATT and PSTATT. However, no significant correlation was found between the PREATT and PSTCON.
5. The mean of EPEPECT scores for the experimental group from pretest to posttest changed drastically, but that of the control group changed very little.
6. The mean of PATS scores for the experimental and control groups from pretest to posttest changed very little.
7. CCI were effective for decreasing students' Electric Field, Electric Potential and Electric Potential Energy misconceptions.
8. CCI did not increase the students' attitudes toward physics more than traditional method did.

CHAPTER 5

CONCLUSIONS, DISCUSSION AND IMPLICATIONS

The main goal of this study was to investigate the effectiveness of conceptual change instruction over traditionally designed physics instruction on overcoming 10^{th} grade students' misconceptions of electric field, electric potential and electric potential energy. Last chapter consists of seven sections. The first section is summary of the experiment, second one is about the conclusions of the study and discussion of the results is presented in third section. In forth and fifth section the internal and external validity of the study is given. Finally, implications of the study and recommendations for further studies are presented.

5.1 Summary of the Experiment

The study was carried out during the spring semester of the 2005-2006 academic year. The sample of the study was chosen from accessible population. The sample size of this study consisted of 37 students from two science classes in TED Ankara College Foundation Private High School. Sample size was 15.6 % of the accessible population. The experimental research method was a pretest and protest control group design, lasting three weeks. Classes were randomly assigned as experimental group, which was taught with conceptual change instruction, and the control group which was taught with traditionally designed physics instruction. The data used in the analysis of hypotheses were obtained from 18 students in control group and 19 students in experimental group. Electric Potential and Electric Potential Energy Concept Test (EPEPECT) and Physics Attitude Scale (PATS) were administered to both groups as pretest and posttest.

5.2 Conclusions

The sample of the study chosen from the accessible population was a sample of convenience. Hence, there was a limitation with regard to generalizing the results of this research. However conclusions drawn here can be applied to an extended population of similar private high schools.

Students taught with CCI showed a better scientific conception related to electric field, electric potential and electric potential energy and elimination of misconceptions than the students taught with TDPI. However CCI did not increase the students' attitudes toward physics more than TDPI did. That is conceptual change instruction was not effective in improving positive attitudes toward physics.

5.3 Discussion of the Results

When the results of this research are compared with those of the previous ones, this research supports most of the findings of previous ones. For instance, as can be seen from the basic descriptive statistics of misconception test scores, most of students have misconceptions related to electricity.

According to the results of the study, statistically significant differences were found between conceptual change instruction and traditional method. Students taught with CCI showed a better scientific conception related to electric field, electric potential and electric potential energy and elimination of misconceptions than the students taught with TDPI. However, CCI did not increase the students' attitudes toward physics as school subject more than TDPI did. That is, conceptual change instruction was not effective in improving positive attitudes toward physics.

The statistical result of the SPSS calculated R^2 as .62 for PSTCON, and .09 for the PSTATT. The observed value of effect size were calculated by using formula $f^2 = R^2/(1-R^2)$ for each dependent variable (DV). Effect sizes are 0.24 and 0.09 for the PSTCON and PSTATT, respectively. The treatment effect sizes measured here are between medium and high effect size. So, our result for the PSTCON was of practical significance for similar populations of TED high school students. Therefore, the results of this study provide an evidence for conducting similar studies with different samples and topics. Multivariate analysis of covariance (MANCOVA) calculated power as 1.00, which was higher then the preset value.

Misconceptions often reflect a basic lack of understanding, therefore, when teaching physics concepts the teacher should focus on these misconceptions and make the scientific concepts as concrete as possible. It is not enough for students to become aware of their existing ideas but also they should change their incorrect conceptions by interacting with teachers and peers. For this purpose, the present study used conceptual change texts based on Posner et al.'s (1982) conceptual change model which suggest that four conditions are necessary for an accommodation occur in an individuals' understanding. According to conditions the conceptual change texts asked questions to activate prior knowledge. It helped students consider the pre-existing ideas and created a conflict between the students' misconceptions and scientific knowledge by demonstrating inconsistencies between them. This conflict caused students to be dissatisfied, this dissatisfaction enabled conceptual change text to restructure the compatible knowledge of students in experimental group and realize their misconceptions. In addition, the dissatisfaction also opened the way for the conceptual change text to explain why some of the students' ideas are not true and why scientific ones are true by giving examples and evidences within its content. The conceptual texts helped the individual to grasp how experience or question asked in first part can be structured by a new conception. By the help of the conceptual texts a new concept appears initially plausible and at least had the capacity to solve the problems generated by its predecessors. Designed texts had the potential to be extended and open up new areas of inquiry and explanatory power.

Findings of the study were in agreement with these of Chambers and Andre (1997), who used a text-based conceptual change approach in electricity concept. They investigated relationship between gender, interest and experience in electricity, and conceptual change manipulations on learning fundamental direct current concepts. They concluded that conceptual change text approach leads to better conceptual understanding of concepts than traditional didactic text. In this study, conceptual change text instruction promoted the acquisition of new conceptions as a consequence of the exchange and differentiation of the existing conception and integration of new conceptions with existing conceptions.

Moreover Ocak (2000) investigated the effect of conceptual change instruction on overcoming students' misconceptions of Mechanical Energy. She used quasi-experimental study with 61 students. According to the t-test and ANCOVA data analysis, students instructed with conceptual change texts had a better understanding than the students taught with traditionally designed physics instruction.

In addition, Şahin (2002) investigated the effect of conceptual change instruction on overcoming students' misconceptions of Heat and Temperature. She used quasi-experimental research study with 57 students. According to the Mann-Whitney U Test data analysis, students instructed with conceptual change texts had a better understanding than the students taught with traditionally designed physics instruction.

Findings of the study were in agreement with these of Yalvaç (2000), who investigated 6^{th} grade level students' understanding of electricity concept by designing conceptual change text using analogies and tried to evaluate this teaching strategy. According to the results of data analysis he concluded that the students instructed with conceptual change texts had a better understanding than the students taught with traditionally designed physics instruction.

On the other hand in traditionally designed physics instruction was based on the teacher explanations of scientific phenomena, logical presentation of knowledge, some quantitative examples given in the textbooks. Students' previous ideas and misconceptions related to the electric field, electric potential and electric potential energy were not considered in this instruction. As a result, this situation may become a reason why students who were instructed with conceptual change texts had lower misconceptions than the students who were instructed with traditional designed method. The traditional instruction has little impact on removing deeply rooted misconceptions (Brown & Clement, 1987).

As a result, it was confirmed that conceptual change text design lead to a better conceptual understanding of electric field, electric potential and electric potential energy concepts. Conceptual change texts used in this study were designed to make the students faced with their probable misconceptions and to replace these probable misconceptions with scientific explanations of related concepts. They helped students to consider their prior knowledge and produce dissatisfaction, provide a correct understandable explanation, which is plausible for them.

As it was mentioned before, the data in this study shows no significant difference in improving attitude towards physics. Some probable causes might be identified. Firstly, the electricity unit is thought at 10th grade after the unit of mechanics, and is by far more abstract topic. Therefore this abstract nature of the electricity unit might prevent the students of achieving more positive attitudes toward physics. Moreover, the students of experimental group were taught with conceptual change text instruction for only three weeks, which may not have been a long time period to show a difference in attitude of students between the two teaching methods. As a result, whatever the cause of the lack of difference in attitude toward physics between two groups, this study support that conceptual change text instruction is effective on overcoming the students' misconceptions.

5.4 Internal Validity

The internal validity of the study refers to the degree to which observed differences on the dependent variable are directly related to the independent variable, not to some other (extraneous) variable (Fraenkel & Wallen, 1996). Possible threats to internal validity and the methods used to deal with them are discussed in this section.

In this study not the individuals but the groups were randomly assigned. The individuals in each group have its own characteristics and capabilities. Therefore, many subject characteristics such as, gender, PRECON, PREATT, could be regarded as potential confounding variables of the study. As shown in table 4.2, most of the variables were included in the covariate set to statistically match subjects on these factors. The statistical analysis indicated that PRECON and PREATT were covariates. Moreover, there are some factors such as students' previous physics and English course grades, cognitive development and problem solving skills but those factors were assumed to be equal for all students.

History and location threats were controlled by administering the tests to a both groups approximately at the same time. Situations for both groups were tried to be similar, there were no remarkable differences in physical conditions of classrooms and locations that might affect the students' responses of two classes. Both groups were arranged to take pre and post tests nearly at the same class hour of the day. Mortality, another threat to internal validity, were controlled by itself, there were not missing data so there were no need to replace missing data with the mean of sample. Data collector characteristics and data collector bias were assumed to be controlled by training the teachers to ensure standard procedures under which the data were collected. Pretest posttest effect was reduced by the time delay between two tests (three weeks) and if it somehow affected the results, its effect was assumed to be equal for both groups. One of the most important threats to internal validity in this study might be implementer effect, because the experimental and control groups' teachers were not the same. The researcher attempted to control this by training the teachers to standardize the conditions under which the treatments were implemented, and the researcher also made assistance and observations throughout the study. Finally, confidentiality was not a problem for this study because all the students were informed about those findings from their answers would be used only for the statistical outcomes of this study, and anyone else apart from the researcher would not know anything about their responses. One of the biggest threats to internal validity, which was not controlled in this study, might be Hawthorne effect.

5.5 External Validity

The external validity of a study is determined by the extent to which the results of the study can be generalized. There are two types of external validity, population validity and ecological validity. Population validity is related to the degree to which a sample represents the population of interest. And, ecological validity is the degree to which results of a study can be extended to other settings or conditions (Fraenkel &Wallen, 1996).

The population being sampled in this study was 237 tenth grade science students who take physics course. The subjects of this study consisted of 37 students from two science classes in TED Ankara College Foundation Private High School. Sample size was 15.6 % of the accessible population. Since more than 10 % of the accessible population was included in the study, the outcomes of this study can be generalized to the accessible population.

The CCT instruction was conducted in TED Ankara College Foundation Private High School classrooms. Therefore treatment and all testing procedure took place not in conventional classrooms. Therefore, the need for considerable caution must be emphasized in case someone wants to generalize the findings of this study to another population.

5.6 Implications

Enlighten with previous studies, the following suggestions can be offered according to the findings:

1. Teachers must also consider the students wrong answers as well as their correct answers. The wrong answers can give clues about the students' alternative conceptions. Considering these clues enhance the probability of students to overcome their misconceptions.

2. Some times the design of the study may lead alternative conceptions to be created by the students. Students may gain misconceptions during the instruction. Teachers must design their lectures so that to minimize these misconceptions which may occur during instruction.

3. Educators should know that different teaching strategies need to be used to achieve conceptual change in overcoming misconceptions of students.

4. The objectives of the subject-matter should be stated considering students' preconceptions and probable alternative conceptions.

5. Conceptual change text instruction helps to students to be faced with their misconceptions and overcome these misconceptions. Teachers must be informed about conceptual change text instruction and its design.

6. The teachers should differentiate between misconception and lack of knowledge. Two and three-tier tests or specially designed concept tests as one which was used in this study have the ability to distinguish misconceptions from lack of knowledge. Teachers should know the basic differences between those two before design their learning materials.

7. Curriculum developers should know the most common faced misconceptions in each specific topic and should design the textbooks and curriculum based on these facts.

5.7 Recommendations for Further Research

On the basis of findings, there are several recommendations offered by this study. They can be listed as below:

1. For the further research, sample size could be increased to obtain more accurate results.

2. This study examined students of one of the private high schools in Ankara. Future study could examine the effect of conceptual change text instruction on overcoming students' misconceptions and attitudes of students' toward physics as a school subject in other public schools. This will increase the ecological validity of the study.

3. Future research could perform similar design of that study using different physics topics.

4. Students' attitudes toward conceptual change text instruction could be investigated.

5. What a reliability coefficient based on misconception scores must be at least as to indicate a valid and reliable misconception test is not known. Therefore future study could be done to answer that question.

6. For further studies; effectiveness of conceptual change text instruction could be compared with the effectiveness of other instructional methods such as refutational texts, use of analogies, concept mapping, computer based instruction and etc. for overcoming the misconceptions in a subject- matter area.

7. Each student has personal interests and many extracurricular experiences when entering the physics course. Therefore teachers must be aware of students' prior knowledge or preconceptions about a subject. Lecture materials can be designed in such a way to prevent these preconceptions to turn into misconceptions.

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APPENDIX A

INSTRUCTIONAL OBJECTIVES

General Objectives:

- Ability to understand the basic concepts of electric field
- Ability to understand the basic concepts of electric potential
- Ability to understand the basic concepts of electric potential energy

Behavioral Objectives:

- To define electric field operationally
- To determine the electric field due to one or more point charges
- To draw and explain electric field patterns for different charge configurations
- To define electric potential energy operationally
- To define the electric potential energy difference between two points in an electric field
- To define electric potential operationally
- To define electric potential difference operationally
- To solve problems involving electric potential difference and electric potential energy

- To define electric potential difference in terms of work done moving a unit charge
- To distinguish potential from potential difference
- To recognize the units of potential
- To calculate the potential difference between two points in a uniform electric field and state which one is at higher potential
- To solve problems involving potential in uniform electric fields
- To define the electric potential due to a point charge at a distance
- To describe a parallel plate capacitor
- To define equipotential surfaces
- To define electric potential energy
- To define the relationship between the work and electric potential energy
- To recognize the units of electric potential energy
- To explain why a charged object in a electric field is considered to have electric potential energy
- To state the law of conservation of energy in a parallel plate capacitor
- To apply conservation of energy to determine the speed of a charged particle that has been accelerated through a specified potential difference
- To state that there are a variety kinds of energy
- To give examples to kinds of energy
- To find the electric potential energy of a charge

APPENDIX B

INSTRUMENTS

There were two instruments which were used in this study. EPEPECT and PATS. EPEEPECT had been designed by the researcher himself and PATS was designed by Dr. Mehmet Sancar.

B.1. ELECTRIC POTENTIAL AND ELECTRIC POTENTIAL ENERGY CONCEPT TEST (EPEPECT)

B.2. PHYSICS ATTITUDE SCALE (PATS)

ELEKTRİKSEL POTANSİYEL VE ELEKTRİKSEL POTANSİYEL ENERJİ KAVRAM TESTİ

Adı:

Soyadı:

No:

Sınıfı:

Cinsiyeti:

Bu test Elektrik Ünitesi'ndeki Elektriksel Potansiyel ve Elektriksel Potansiyel Enerji konularındaki kavram yanılgılarınızı ve bulunduğunuz düzeyi belirlemek için hazırlanmıştır. Test İngilizce olarak hazırlanmış ve 10 sorudan oluşmaktadır. Testi cevaplarken aşağıdaki noktaları gözönüne alınız.

- Her soru, *a,b,c,d* ve *e* seçeneklerinden oluşturulmuştur.Her sorunun bir tane doğru seçeneği olup bu doğru seçenek *a, b,c,d* seçeneklerinden bir tanesidir.
- Her sorunun son seçeneği, yani *e* seçeneği boş bırakılmıştır. Eğer sizce sorunun doğru yanıtı *a,b,c,d* seçeneklerinden birinde yoksa ve kendinize göre farklı bir cevabınız veya açıklamanız varsa, bu açıklamanızı *e* seçeneğine kendi cümlelerinizle yazınız.
- Her sorunun altında aşağıda örneği gösterilen bölüm bulunmaktadır.

Which of the following best represents the reasoning of your answer?

☐ I am sure ☐ I am not sure ☐ I do not know

Bu bölümde, verdiğiniz cevaptan ne kadar emin olup olmadığınız, veya cevabı bilip bilmediğinizin belirlenmesi amaçlanmaktadır**.** Her soruyu okuduktan sonra bu bölümü de mutlaka doldurunuz. Bu bölümü verilen bilgiye uygun olarak doldurunuz.

- Diyelim ki 1. sorunun cevabını *a* seçeneği olarak buldunuz, işaretlediniz ve cevabınızdan eminsiniz, o zaman " ☐ I am sure " seçeneğini işaretleyiniz .

- Diyelim ki 1. sorunun cevabını *a* seçeneği olarak buldunuz, işaretlediniz ama cevabınızdan emin değilsiniz, o zaman " ❑ I am not sure " seçeneğini işaretleyiniz.

- Diyelim ki 1. soruyu okudunuz ve cevabı hakkında hiç bir fikriniz yok, o zaman da, sorunun hiç bir seçeneğini işaretlemeden altındaki "❑ I do not know " , seçeneğini işaretleyiniz.

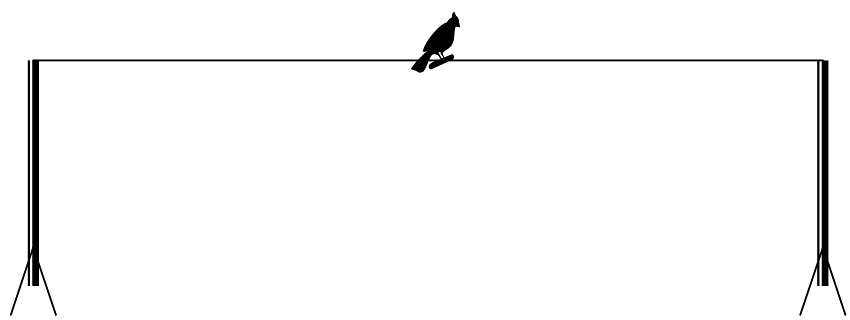
- Bu bölümdeki size en uygun 3 seçenekten bir tanesinin mutlaka işaretlenmesi ve boş bırakılmaması gerekmektedir.

- Sınav süresi 45 dakikadır.
- Adınızı, soyadınızı, numaranızı, sınıfınızı ve cinsiyetinizi ayrılmış olan yere yazmayı unutmayınız.

ELECTRIC POTENTIAL AND ELECTRIC POTENTIAL ENERGY

CONCEPT TEST

1. In your daily life you have probably witnessed birds sit on high voltage electricity transmission wires. **Which of the following alternatives is the best comment for this phenomenon?**



a) Birds, which stay on electricity transmission wires, do not get hurt because the voltage in wires is not high enough.

b) Birds do not get hurt because there is no electric potential difference on electricity transmission wires.

c) Birds do not get hurt because there is very small and negligible electric potential difference on their legs.

d) Birds get hurt because the high voltage in electricity transmission wires is dangerous.

e)

Which of the following best represents the reasoning of your answer?

❑ I am sure ❑ I am not sure ❑ I do not know

2. A boy is hanging on parallel conducting metal plate as it is shown in Figure 1 and Figure 2. In Figure 1 hands of the boy are hanging on the same plate, the plate with potential of 220 Volt. In Figure 2 on the other hand, the hands of the boy are hanging on different plates, the one with potential of 0 Volt and the one with potential of 220 Volt. **If the legs of the boy are not in contact with the ground**, **what can be said about the safety of the boy in the two figures?**

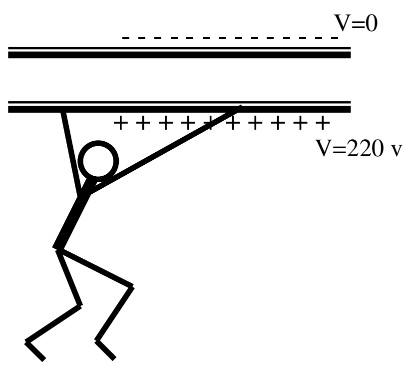


Fig.1

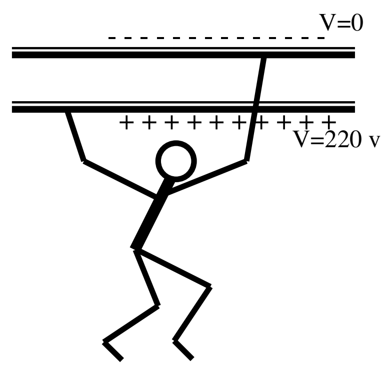


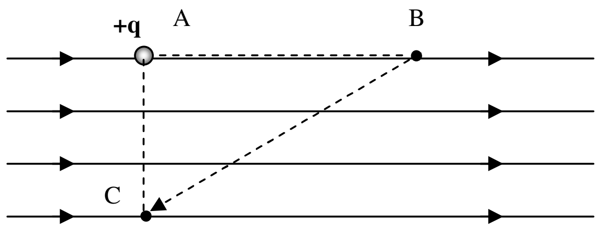
Fig.2

a) The boy is safe both in Fig.1 and Fig.2, because there is no metal wire connecting metal plates, which will transmit electric current and damage the boy.
b) The boy is safe in Fig.1 because there is no potential difference between the hands of the boy and high voltage itself is not dangerous.
c) The boy is in danger in both Figures, because there is high voltage between parallel metal plates.
d) The boy is danger in both Figures, but the danger in Fig.1 is greater because the potential difference between the hands of boy in Fig.1 is greater.
e)

Which of the following best represents the reasoning of your answer?

☐ I am sure ☐ I am not sure ☐ I do not know

3. A positively charged particle **+q** is initially at point A in a uniform electric field. Parallel arrowed lines show the direction of uniform electric field**.** A positive charge is moved at a constant speed along the path ABC. **Which of the following is a true comment for the work done on the positive charge along the path ABC?** (The effect of gravitational force is ignored)



a) Since the electric field is uniform, the electric potential of all points are equal, and no net work is required to move a charge with constant speed on equipotential line.

b) There is no work done on **+q** charge when it moves with constant speed from A to B. However it's electric potential energy decreases, because the electric potential energy of a charge can change even when there is no work done on it.

c) There is positive work done on **+q** charge when it moves with constant speed from B to C but its electric potential energy does not change.

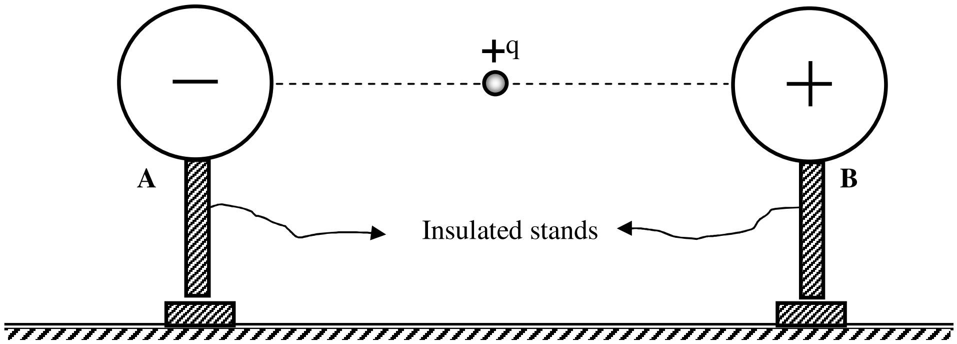
d) There is negative work done on **+q** charge when it moves with constant speed from A to B and positive work done on **+q** charge when it moves with constant speed from B to C. Since the net work done on **+q** is zero the electric potential energy of the charge will not change after the path ABC is completed.

e)

Which of the following best represents the reasoning of your answer?

☐ I am sure ☐ I am not sure ☐ I do not know

4.



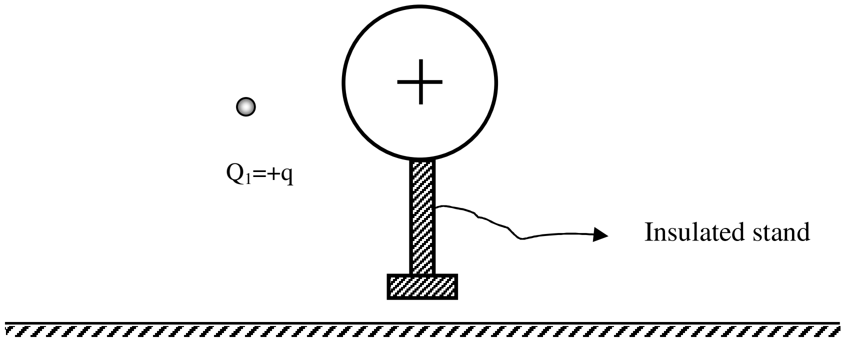
A charge +q is placed for a moment between the fixed positively and negatively charged spheres **A** and **B** as it is shown. The fixed positively and negatively charged spheres **A** and **B** are insulated from the surface with the help of fixed insulated stands. **If the effect of the gravity is ignored, find which of the given alternatives best represents the motion of the charge +q, when it is released?**

a) The test charge will move towards negatively charged sphere **A** by itself even when there is not any repulsive or attractive force acting on it.
b) It will move towards negatively charged sphere **A,** converting its electric potential energy to kinetic energy.
c) It will move towards negatively charged sphere **A,** converting its electric potential to work.
d) It will move towards the negatively charged sphere **A,** but its electric potential and electric potential energy will not change.
e)

Which of the following best represents the reasoning of your answer?

☐ I am sure ☐ I am not sure ☐ I do not know

5.



The charge Q_1=+q is placed momentarily at some distance from the center of large and fixed positively charged sphere as shown in the figure. The fixed positively charged sphere is insulated from the surface with the help of fixed insulated stand and the effect of gravity is ignored.

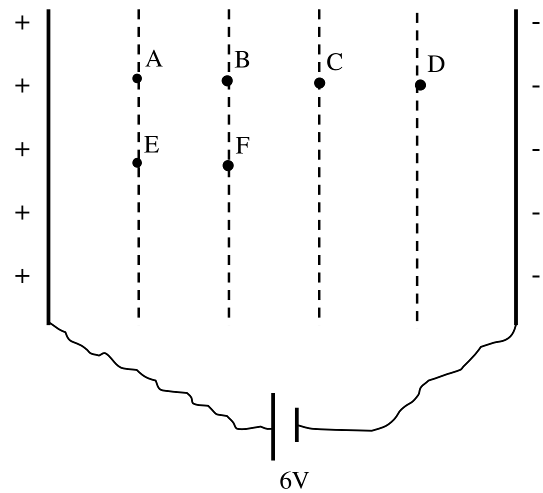
Now imagine that instead of the charge Q_1=+q, there was another charge Q_2=+2q, or in other words the original charge of Q_1=+q were doubled to +2q and named as Q_2. **Which of the following alternatives is the best comment and best comparison for the electric potential energies and electric potentials of charges Q_1 and Q_2 at that point?**

a) Both electric potentials and electric potential energies of charges Q_1 and Q_2 are equal, because electric potential and electric potential energy is the same thing.
b) Electric potential energy of charge Q_2 is twice the electric potential energy of charge Q_1, but they have equal electric potentials at that point, because the electric potential is the electric potential energy per unit charge.
c) Electric potential energy and electric potential of charge Q_2 is twice the electric potential energy and electric potential of charge Q_1, because electric potential and electric potential energy is the same thing.
d) Electric potential of charge Q_2 is twice the electric potential of charge Q_1, but they have equal electric potential energies.
e)

Which of the following best represents the reasoning of your answer?

☐ I am sure ☐ I am not sure ☐ I do not know

6. Two parallel conducting plates are connected to 6V battery as it is shown in the figure below. **Which of the following alternatives is a correct comparison for the electric potentials of the lettered points?**



a) Electric potentials of all lettered points are zero because there is no charge at these points.

b) Electric potential difference is only between the ends of the two plates, but there is no electric potential difference between any two points inside conducting plates.

c) Electric potentials of points A and E are equal and greater then electric potentials of other lettered points.

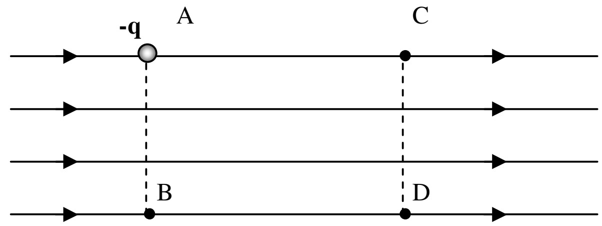
d) Electric potential flow from the left plate towards the right plate and the flow decrease when we move from point A to point D.

e)

Which of the following best represents the reasoning of your answer?

☐ I am sure ☐ I am not sure ☐ I do not know

7. A negatively charged particle **–q** is initially at point A in a uniform electric field. **If parallel arrowed lines show the direction of the electric field, find which of the following alternatives is true comment for the electrical properties of the charge –q and given points? (The effect of gravitational force is ignored)**



a) Since the electric field is uniform, the electric potential of all points are equal, which means that they are equipotential points.

b) Since electric potentials of points A and C are equal, which means that they are equipotential points, no work is required to move charge **–q** with constant speed from point A to point C.

c) Since there is no connection between electric field and electric potential, the potentials of the given points are not affected by whether the electric field is uniform or not.

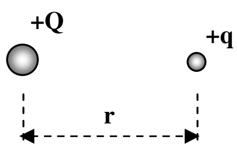
d) Since electric potentials of points A and B are equal, which means that they are equipotential points, no work is required to move charge **–q** with constant speed from point A to point B.

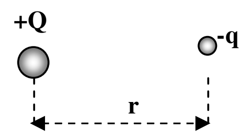
e)

Which of the following best represents the reasoning of your answer?

☐ I am sure ☐ I am not sure ☐ I do not know

8. Two test charges are brought separately near a charge **+Q**. First, test charge **+q** is brought to a point at distance **r** from **+Q**. Then this charge is removed and test charge **–q** is brought to the same point. **Which test charge has a greater electric potential energy at that distance?** (Assume that electric potential energy and electric potential is zero at infinity)





a) The electric potential energy of charge **+q** is greater than the electric potential energy of charge **–q**, because there is not any work done on charge **–q** bringing it near the charge **+Q**.
b) The electric potential energy of charge +q is greater because we did positive work to bring it close to the repulsive charge **+Q**.
c) The electric potential energy of both charges is equal, whether the work is required or not to bring charges to these points.
d) The electric potential energy of both charges is equal, because both charges can move by themselves.
e)

Which of the following best represents the reasoning of your answer?

☐ I am sure ☐ I am not sure ☐ I do not know

Please answer questions 9 and 10 according to the following figure and related explanation.

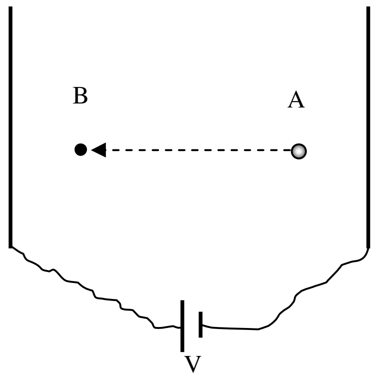


Fig.1

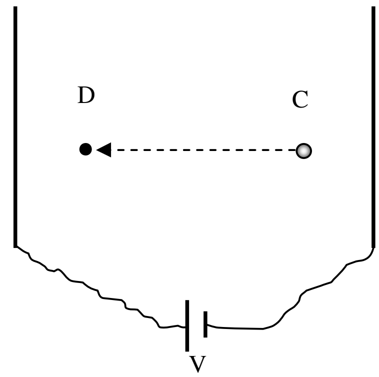


Fig.2

A negative charge **–q** that is in uniform electric field is moved from position A to position B between the plates of a charged conductor as it is shown in Fig.1. In Fig.2 on the other hand the positive charge **+q** is moved from position C to position D between the plates of a charged conductor. Ignoring the effect of gravity;

9. **Which of the following alternatives is a true comment about the change of the electric potentials of charges –q and +q, when they are moved from points A to B and points C to D respectively?**

a) The electric potential of both charges increases because electric potential is always higher near positive charges and lower near negative charges, regardless of the sign of the test charge.

b) The electric potential of both charges does not change because the electric potential does not change in uniform electric field.

c) The electric potential of both charges does not change because there is no electric potential in the inner side of the conducting plates.

d) Only the electric potential of charge **+q** in Fig.2 increases because we did positive work moving it from point C to D, increasing its electric potential energy.

e)

Which of the following best represents the reasoning of your answer?

☐ I am sure ☐ I am not sure ☐ I do not know

10. Which of the following alternative is a true comment about the change of the electric potential energies of charges –q and +q, when they are moved from points A to B and points C to D respectively?

a) The electric potential energy of both charges increases because their electric potentials increase.

b) The electric potential energy of both charges does not change because the electric potential in uniform electric field does not change.

c) The electric potential energy of both charges does not change because we did not work moving them between given points.

d) Only the electric potential energy of charge **+q** in Fig.2 increases because we did positive work moving it from point C to point D.

e)

Which of the following best represents the reasoning of your answer?

☐ I am sure ☐ I am not sure ☐ I do not know

FİZİK DERSİ TUTUM ÖLÇEĞİ

Açıklama: Bu ölçekte fizik dersine ilişkin tutum cümleleri ile her cümlenin karşısında TAMAMEN KATILIYORUM, KATILIYORUM, KARARSIZIM, KATILMIYORUM, ve HİÇ KATILMIYORUM olmak üzere beş seçenek verilmiştir. Her cümleyi dikkatlice okuduktan sonra kendinize uygun seçeneği işaretleyiniz.

	Kesinlikle katılıyorum	Katılıyorum	Kararsızım	Katılmıyoru	Kesinlikle Katılmıyoru
1.Fizik dersini severim.					
2.Fizik dersi beni korkutur.					
3.Fizik desine girerken büyük bir sıkıntı duyarım.					
4.Fizik dersi benim için ilgi çekicidir.					
5.Fizik dersi olmasa öğrencilik hayatı daha zevkli olur.					
6.Derslerim içinde en sevimsizi fiziktir.					
7.Fizik dersi sınavından çekinirim.					
8.Fizik dersinde zaman geçmek bilmez.					
9. Arkadaşlarımla fizik konularını tartışmaktan zevk alırım.					
10.Fiziğe ayrılan ders saatlarinin fazla olmasını isterim.					
11.Fizik dersi çalışırken canım sıkılır.					
12.Diğer derslere göre fizik dersine çalışmaktan daha çok hoşlanırım					
13.Fizik dersi eğlenceli bir derstir.					
14. Fizik ile ilgili kitapları okumaktan hoşlanırım.					
15. Fiziğin günlük yaşantıda önemli bir yeri yoktur.					
16. Fizik konularıyla ilgili daha çok şey öğrenmek isterim.					
17. Fizikle ilgili çözemediğim bir problemle karşılaştığımda çözünceye kadar uğraşırım.					
18. Yıllarca fizik okusam bıkmam.					
19. Fiziği öğrendikçe fizik dersine olan ilgim artıyor.					
20. Düşünce sistemimizi geliştirmede fizik öğrenimi önemlidir.					
21. Fizik dersi çevremizdeki doğa olaylarının daha iyi anlaşılmasında yardımcı olur.					
22.Fizik dersi seçmeli olsaydı, yine fizik dersini seçerdim.					
23. İleride sahip olmak istediğim meslek ile fiziğin bir alakası var.					
24. Fizik dersi somut (beş duyudan biri ya da birkaçı ile saptanabilen) bir derstir.					

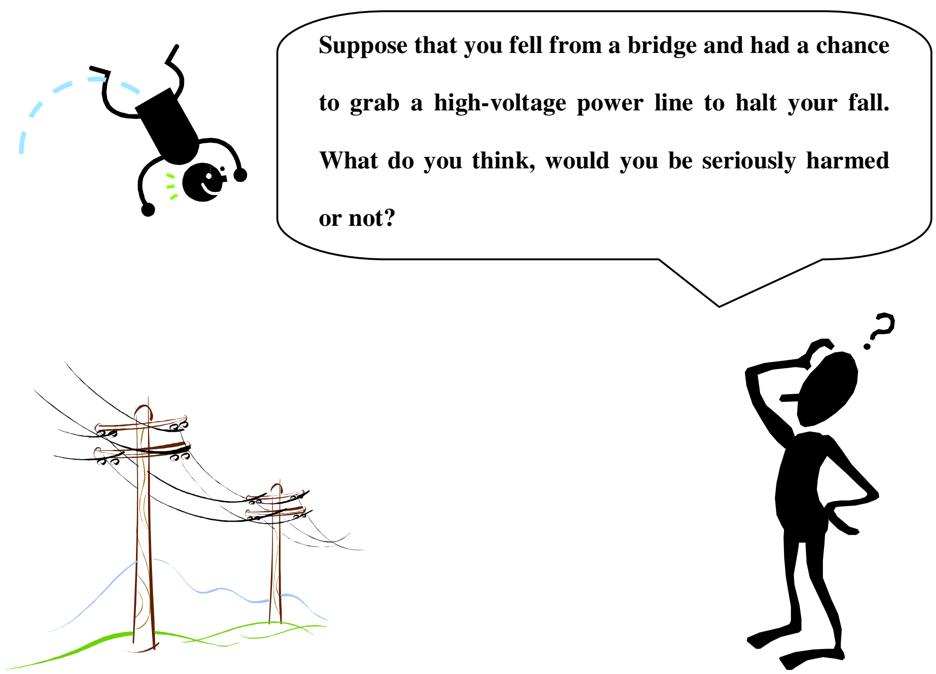
APPENDIX C

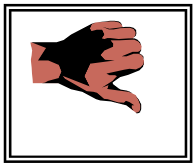
CONCEPTUAL CHANGE TEXT EXAMPLE

(CCT EXAMPLE)

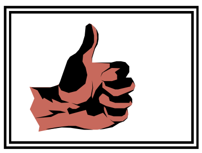
CONCEPTUAL CHANGE TEXT 3

What is high voltage? Is the high voltage harmful itself?





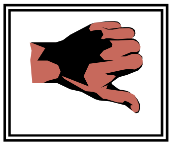
According to most of the students the answer is very simple. They believe that someone who grabs the power line will not only be seriously harmed, he will probably die. They said that, they will not prefer to grab a power line under any circumstances. This is wrong.



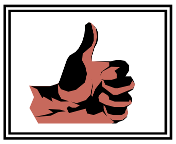
High voltage or electric potential is not harmful itself. For someone to receive a shock there must be a difference in electric potential between one part of its body and another part.

In our case when you fall from a bridge, as long as you touch nothing else of different potential, you will receive no shock at all. Even if the wire is thousands of volts above ground potential and even if you hang by it with two hands, no charge will flow from one hand to the other. This is because there is no appreciable difference in electric potential between your hands. If, however, you reach over with one hand and grab onto a wire of different potential, ZAP!!

The bird can stand harmlessly on one wire of high potential. What is the reason behind this safety?



Some of the students believe that the legs of the birds are not conductive. Some of them think that the wire is covered with insulated material which prevents electric current. They are incorrect.



Birds that sit on power lines don't get electric shocks because the electricity is always looking for a way to get to the ground, but the birds are not touching the ground or anything in contact with the ground. So there is no potential difference between parts of their body. Every part of their bodies is at the same high potential as the wire, and they feel no effects. The bird can stand harmlessly on one wire of high potential, but it had better not reach over and grab a neighboring wire.

BEWARE!! Don't touch a power line with any part of your body or any object. If your legs are not insulated enough there would be potential difference between parts of your body and you will be seriously harmed, it will be fatal mistake to be a connection between ground and power line.