# AN APTITUDE TREATMENT INTERACTION STUDY: THE EFFECT OF INQUIRY-BASED INSTRUCTION AND LECTURE INSTRUCTION ON HIGH SCHOOL STUDENTS' PHYSICS ACHIEVEMENT

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# ABSTRACT

## AN APTITUDE TREATMENT INTERACTION STUDY: THE EFFECT OF INQUIRY-BASED INSTRUCTION AND LECTURE INSTRUCTION ON HIGH SCHOOL STUDENTS' PHYSICS ACHIEVEMENT

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This study investigates the effect of methods of instruction (inquiry-based versus lecture instruction) and their interactions with students' cognitive styles (field-dependent, field-mixed, and field-independent) and with other independent variables on 11th grade students' physics achievement in and attitude toward electric circuits concepts in central district of Aydın.

Lesson plans, instructional materials were developed for the inquiry-based instruction. Teachers' regular classroom practices were accepted as lecture method. Physics achievement test, physics attitude scale, observation checklists, and GEFT were used as data collection instruments. Treatment was implemented to 298 11th grade students in central district of Aydın. Physics achievement test and physics attitude scale were administered to the students as pre and post tests while GEFT was administered only as pre test.

MANCOVA was used as statistical analysis method to analyze data. The dependent variables of this study were the achievement (PSTACH) and attitude (PSTATT) scores of the students. The covariate and gender were used to statistically equalize the students' characteristics. Group membership with respect to two groups (inquiry or lecture groups) was named here as “MOI; methods of instruction” (2 level categorical) and used as fixed factor of this study with the other group membership variables, students' physics achievement pretest scores (PREACH), physics attitude pretest scores (PREATT), School, previous physics course grades (PPCG), cognitive style (CoS, 3 level categorical), and the interaction terms of MOI*PREACH, MOI*PPCG, PREATT*MOI*PPCG*CoS, MOI*PPCG*CoS, PREACH*School, and PREACH*PREATT.

In general, inquiry instruction was effective than the lecture instruction with respect to PSTACH in electric circuits subject. However, there was not a significant difference in effectiveness of both methods in improving students' attitudes toward electric circuits subject. In essence, each method of instruction was not effective on improving students' attitudes toward electric circuits subject. Although, this study could not find any statistically significant interaction effect of MOI and other independent variables on students' PSTATT scores, practical significance was investigated for the interaction terms.

Keywords: Physics Education, Electric Circuits, Aptitude Treatment Interaction, Achievement, Attitude, Cognitive Style

# ÖZ

## BİR ÖĞRENCİ ÖZELLİKLERİ-UYGULAMA ETKİLEŞİMİ ÇALIŞMASI: SORGULAMA TEMELLİ ÖĞRETİM VE DÜZ ANLATIM METOTLARIYLA ÖĞRETİMİN LİSE ÖĞRENCİLERİNİN FİZİK BAŞARISI ÜZERİNDEKİ ETKİSİ

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Bu çalışma öğretim metotlarının (sorgulama temelli öğretim ve düz anlatım) ve bu metotların öğrencilerin bilişsel stilleri (alana bağlı, alan-orta, alandan bağımsız) ve diğer bağımsız değişkenler ile etkileşimlerinin Aydın'ın merkez ilçesindeki 11. sınıf öğrencilerinin elektrik devreleri konusuna ilişkin fizik başarısına ve bu konuya karşı tutumlarına etkisini araştırmaktadır.

Sorgulama temelli öğretim metodu için ders planları ve öğretim materyalleri geliştirilmiştir. Öğretmenlerin her zaman uyguladıkları sınıf pratikleri ise düz anlatım yöntemi olarak kabul edilmiştir. Veri toplama aracı olarak fizik başarı testi, fiziğe karşı tutum testi, gözlem kontrol listesi ve GEFT kullanılmıştır. Uygulama Aydın'ın merkez ilçesinden seçilen 298 11. sınıf öğrencisiyle yapılmıştır. Uygulamadan önce

ve sonra öğrencilere fizik başarı testi, fiziğe karşı tutum testi uygulanmıştır. GEFT ise sadeced uygulamadan önce uygulanmıştır.

Verileri analiz etmek için Çoklu Kovaryans Analizi (MANCOVA) kullanılmıştır. Bu çalışmanın bağımlı değişkenleri öğrencilerin fizik son test başarı puanları ve tutum son test puanlarıdır. Cinsiyet değişkeni öğrenci özelliklerini istatistiksel olarak eşitlemek için kovaryant olarak kullanılmıştır. İki gruba (sorgulama temelli öğretim ve düz anlatım) ilişkin grup üyeliği burada öğretim metodu (2 seviyeli kategorik) olarak adlandırılmış ve diğer grup üyeliği değişkenleri olan öğrencilerin fizik öntest başarı puanları, fizik ön test tutum puanları, okul, fizik dersinin önceki notu, bilişsel stil (3 seviyeli kategorik) ve MOI*PREACH, MOI*PPCG, PREATT*MOI*PPCG*CoS, MOI*PPCG*CoS, PREACH*School, and PREACH*PREATT etkileşim terimleri ile bu çalışmanın sabit faktörü olarak kullanılmıştır.

Genellikle elektrik devreleri konusunda öğrencilerin fizik son test başarıları açısından sorgulama yöntemi düz anlatım yöntemine göre daha etkilidir. Ancak, öğrencilerin elektrik devreleri konusuna karşı tutumlarını arttırmada iki grup arasında istatiksel olarak anlamlı bir fark yoktur. Gerçekte, iki öğretim metodu da öğrencilerin elektrik devreleri konusuna karşı tutumunu arttırmada etkili değildir. Bu çalışmada, öğretim yöntemi ve öğrencilerin tutum son test puanlarındaki diğer bağımsız değişkenler arasında istatistiksel olarak anlamlı bir etkileşim bulunmamıştır, ancak etkileşim terimlerinin pratik anlamlılığı araştırılmıştır.

Anahtar Kelimeler: Fizik Eğitimi, Elektrik Devreleri, Öğrenci Özellikleri-Uygulama Etkileşimi, Başarı, Tutum, Bilişsel Stiller

To My Family,

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| | |
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| ATI | Aptitude-Treatment Interactions |
| PREACH | Physics Achievement Pretest Score |
| PREATT | Physics Attitude Pretest Score |
| PPCG | Previous Physics Course Grades |
| CoS | Cognitive Style |
| MOI | Methods of Instruction |
| IV | Independent Variable |
| DV | Dependent Variable |
| PSTACH | Physics Achievement Posttest Score |
| PSTATT | Physics Attitude Posttest Score |
| GEFT | Group Embedded Figures Test |
| IT | Inductive Teaching |
| DT | Deductive Teaching |
| PACT | Physics Achievement Test |
| PATS | Physics Attitude Scale |
| CASTLE | Capacitor Aided System for Teaching and Learning Electricity |
| ERIC | Educational Resources Information Center |
| SSCI | Social Science Citation Index |
| DAI | Dissertation Abstracts International |
| JSTOR | Database of Journal Storage |

# CHAPTER 1

# INTRODUCTION

Science educators constantly try to describe the best way to maximize learners' achievement. In pursuit of this goal, they tend to find out the best teaching strategies which make students' success as great as possible. Various teaching strategies and methods are proposed to the science education community. Some of them are inquiry, discovery, lab studies, problem-based learning (Serin, 2009), learning cycle method (Ateş, 2005), anchoring analogies (Yılmaz, 2007), modeling instruction (Gökçe-Şahin, 2008), multiple intelligence based instruction (Gürçay, 2003), and several conceptual change strategies. However, for the last two decades, much emphasis is given to students' learning rather than to teaching methods (McCombs, 2003; Redish & Steinberg, 1999). Whichever method is used or believed to be efficient for students, unless students' understanding of the concepts is increased to the intended level, all the effort will be useless. Currently, science education researchers focus on to describe "How learners learn.", "How they construct meaning.", "How they link all the knowledge attained to each other." Unfortunately, there are obstacles on this struggle, regarding learners' individual characteristics. Since learners are not simple subjects that have definite characteristics, they are not described or expected to behave in the same predetermined or predicted manner under certain conditions.

There are important differences among learners and these differences affect learning outcomes significantly. So, investigating individual differences among learners constitute an important research area in education (Koran & Koran, 1984). Since, science educators are looking for the ways to maximize learning and to understand how learning has occurred; the way that individual differences modify treatment effects should be taken into consideration (Cronbach, 1957; Jonassen & Grabowski, 1993). Aptitude-Treatment-Interactions (ATI) studies investigate how individual differences modify treatment effects (Cronbach, 1957; Jonassen & Grabowski, 1993). Aptitudes which can be defined for the purpose of this study as any characteristic of the individual which functions selectively with respect to learning; that is which facilitates or interferes with learning from some designated instructional methods. These aptitude variables can be named as prior achievement, personality and stylistic characteristics, and motivational and attitudinal tendencies as well as traditional cognitive ability variables. Variations in structure, pacing, style, or modality of instruction as well as alternative curricula, different teachers or even different classroom instructional environments can be taken as treatment (Koran & Koran, 1984).

If one of the treatments is significantly better for one type of learners while the other type of the treatment is significantly better for the other type of learners, than there exists an interaction between learners' aptitude and the treatment. This interaction is shown by nonparallel regression slopes of aptitude on achievement for different instructional treatments (Cronbach & Snow, 1977).The basic assumption underlying ATI research can be stated as follows:

"There is no one best educational treatment or environment suited to some general, average individual, but different individuals thrive in different environments suited to their own characteristics and needs (Koran & Koran, 1984, p 795)."

Therefore, the main aim of ATI research is to match instructional methods or materials to selected learner characteristics. Moreover, matching treatments with relevant aptitudes is a very important point in ATI. Up to now, lots of interactions between different treatments and aptitudes have been reported. Among these aptitudes that give consistent ATI results have been general ability, anxiety, prior achievement, and achievement orientation (Snow, 1977, cited in Koran & Koran, 1984). In science education, mostly compared treatments have been inductive vs deductive instruction, lecture vs lab, teacher centered vs learner centered instruction (Cronbach & Snow, 1977; Jonassen & Grabowski, 1993).

Most of ATI studies have been conducted with aptitude and treatment variables which are related trial and error. However, in order to get consistent results and build a reliable theory these variables should be related according to theoretical conceptions. Three models for matching aptitudes and treatments have been proposed. In fact, the relevant aptitude and treatment variables should be selected according to these models. These are

- Remedial Model: This model aims to change learner capabilities rather than design treatments.
- Compensatory Model: This model aims to match the suitable treatment that does something for the learner that he/she cannot do for him/herself with the learner characteristics.
- Preferential Model: This model aims to design treatments to capitalize on strongly developed learner aptitudes (Koran & Koran, 1984).

Additionally, in ATI studies the researcher may try to match aptitudes to treatments under conditions in which either aptitude or treatment variable is of primary interest (Cronbach & Snow, 1977).

Moreover, the research results about the interaction of various treatments with various aptitude variables provide an insight for selection of relevant aptitude variables for this research. According to previous ATI research results, the more the required information processing instruction performs for the learner, the better it is for low ability learners. Therefore, while low ability students benefit more from programmed instruction, advance organizers in the form of preliminary abstracts or summaries, deductive methods and simple diagrams, figures, symbolic constructions, high ability students usually benefit more from inductive methods, highly verbal and abstract conceptual treatments (Koran & Koran, 1984). Additionally, field-independent learners achieved best with deductive instruction, and field-dependent learners performed best in instruction based on examples (Davis, 1991; Messick, 1994). Lastly, research findings have shown that the higher level of the level of prior achievement, the less the instructional support required to accomplish the given task (Abramson & Kagen, 1975; Salomon, 1974; Tobias, 1973; Tobias & Frederico, 1984; Tobias & Ingber, 1976).

Not only teaching methods are offered to maximize science achievement, but also curriculum reforms are made and resultantly teacher education curricula are revised. In line of these efforts, Turkey has undergone some reform movements in its elementary and secondary school curricula. The overall reform is toward a more student-centered, inquiry-based curricula and more science literate society from a traditional teacher-centered and content-based curricula. Previously, physics was taught deductively, teacher firmly introduced the subject and its general characteristics and then solved fundamental examples of mostly related quantitative problems. This way, students are passive learners in the classroom; they are supposed to sit and listen to teacher and solve the given problems correctly. There are few lab activities, field trips, if any. By the new secondary physics curriculum, lessons will be mostly context-based, daily life related, and learners will become more active both mentally and physically, they will share the responsibility of learning. Lessons should be student-centered, and more importantly inquiry-based methods will be used mostly. Up to this point, everything seems theoretically normal, since the above discussion shows that there is not any magic method that fits all type of learners. Therefore, physics educators, implementers, and administrators should have been informed about the comparative effects of inquiry-based and lectured physics instructions on learners, especially focusing on their individual differences, before the implementation of new curriculum.

In line with these intentions, several instructional methods have been offered to increase students’ physics achievement and understanding (Bonwell & Eison, 1991, cited in Sencar-Tokgöz, 2007; Crouch & Mazur, 2001; Duch, 1996; Keyser, 2000). The basic and common characteristic of these methods is that they are student-centered, mostly inductive, and inquiry-oriented or inquiry-based. Teaching inductively starts with real-life applications as the context for learning. A central tenet of the inductive approach is starting with the application first. This is not something new; in fact, the approach is known by many names: case-based teaching, inquiry-based learning, problem based learning, project-based learning, discovery learning, and the list goes on. Inductive approaches are well established teaching and learning methods. The inquiry approach requires that people are actively involved and work together in teams to solve a challenge. To involve people is to connect and engage them. Active involvement means taking that connection and engagement to a heightened level of change evoking motion and action (Friere, 1970).The inquiry approach sometimes requires that people be given some initial structure to help them get started. They may need an initial process to assist them in working through the challenge. In these methods, teacher is a guide in accessing knowledge rather than being the supplier of knowledge. Learners make their own conceptualizations, and construct their own meanings. Learner centered inductive methods take care of students' interests and learning styles, promote critical thinking and provide learners with communication skills. Individualized learning systems, inquiry, discovery, problem based learning small group discussions and cooperative learning can be examples of learner centered instructional methods (Turkish Ministry of Education, Science Curriculum for 6., 7., and 8th grades, 2005).

The topic of simple electric circuits is a difficult subject for students to achieve and understand meaningfully. In physics education literature, there are various studies that support this situation (McDermott & Shaffer, 1992; Shipstone, von Rhöneck, Jung, Karrqvist, Dupin, Joshua, & Lieht, 1988). In addition, students' preconceptions, prior experiences of the subject, attitudes toward physics and electricity, socio-economic levels, age, gender, individual differences, and teaching method can be considered as the other potential reasons for students' failure of "Simple Electric Circuits" concepts. In this study, the last two factors individual differences and teaching methods are taken into consideration. In fact, an inquiry-based inductive method is supposed to be more useful in increasing students' achievement and attitude than a lecture-based deductive method is. Also, in line with the assumption that there is not a single method that suits all the learners; individual differences, namely cognitive style (field-dependency, field-independency), are considered, in the current study. The differential effect of teaching methods on students' achievement and attitude with respect to their cognitive styles is the focus of the current study.

As previously indicated, students' attitudes toward the learned subject influence their achievement and learning. Attitude can be defined as "a general and enduring positive or negative feeling about some person, object, or issue" (Petty & Cacioppa, 1981, p. 7, cited in Abell & Lederman, 2007). Also, effective science instructions, like hand-on science activities, laboratory work, field study, and inquiry-oriented lessons, have potential to increase learners' attitude toward science. Gender, classroom, teacher, family, friends, curriculum can be listed as the other potential factors to influence students' attitudes toward science (Osborne, Simon, & Collins, 2003). In this study, the effect of inquiry-based instruction vs lecture methods on students' attitudes and the effect of their interaction with students' cognitive styles on their achievement and attitudes are investigated.

To sum up, the purpose of this study is to investigate the effects of methods of instruction (lecture versus inquiry) and its interaction with students' cognitive styles (field-independent versus field dependent) on eleventh grade students' achievement in and attitudes toward simple electric circuits concept.

## 1.1 The Main Problem

The main problem of this study is stated as follows;

What is the effect of methods of instruction (lecture versus inquiry) and its interaction with students' cognitive styles (field-independent versus field dependent) and other independent variables on eleventh grade students' achievement in and attitudes toward electric circuits unit in central district of Aydın?

## 1.2 Hypotheses

The problem stated above will be tested with the following hypotheses, which are stated in null form.

### Null Hypothesis 1

There is no significant effects of methods of instruction, (MOI; lecture versus inquiry) and its interaction with students' cognitive styles (CoS; field-independent, field-mixed, field-dependent) and other independent variables (physics achievement pretest scores, PREACH; physics attitude pretest scores, PREATT; previous physics course grades, PPCG; school, age, and gender) on the population means of the collective dependent variables of eleventh grade students' achievement posttest scores (PSTACH) and attitude towards electric circuits unit posttest scores (PSTATT).

### Null Hypothesis 2

There is no significant effects of methods of instruction (lecture versus inquiry) and its interaction with students' cognitive styles (field-independent versus field dependent) and other independent variables on the population means of eleventh grade high school students' physics achievement posttest scores.

Null Hypothesis 3

There is no significant effects of methods of instruction (lecture versus inquiry) and its interaction with students' cognitive styles (field-independent versus field dependent) and other independent variables on the population means of eleventh grade high school students' physics attitude posttest scores.

1.3 Definition of Important Terms

PREACH, PREATT, PPCG, CoS, school, age, gender and MOI are the independent variables (IVs) of this study. Seven IVs; the PREACH, PREATT, PPCG, CoS, gender, school, and age are taken as covariates. Students' physics achievement posttest scores (PSTACH) and physics attitude posttest scores (PSTATT) are the dependent variables (DVs). Following terms are necessary in understanding this study.

Gender: It is the fact of being male or female. This information is collected from students with a specific item in the test booklet, at the time of pre-testing.

Students' age: Students' dates of birth, are collected from students with a specific item in the test booklet, at the time of pre-testing.

PPCG: Students' physics course grades in the previous semester are collected from students with a specific item in the test booklet, at the time of pre-testing.

PREATT: It is measured by Physics Attitude Scale (PATS) before the study begins.

PSTATT: It is measured by the PATS after the treatment.

PREACH: It is measured by Physics Achievement Test (PACT) before the study begins.

PSTACH: It is measured by the PACT after the treatment.

CoS: Students' cognitive styles are measured to find out whether they are field-dependent or field-independent learners. This measurement is done before the study begins. Group Embedded Figures Test (GEFT) (Witkin, Oltman, Raskin, & Karp,1971) is used to determine the cognitive style of the students.

Methods of Teaching (Lecture Teaching (LT) versus Inquiry Teaching (IT)): In this study, two methods of teaching are compared, lecture versus inquiry teaching. In classes where inquiry teaching is employed, sequence of the lesson goes from observation of specific instances to attaining generalizations about scientific principles. Students should be presented with a real-life case or an initiating problem most of those are presented as a form of hands-on activity. Then they are asked to get involved in the solution process both mentally by hypothesizing and drawing conclusions, and physically by observing phenomenon, collecting data, and discussing the possible results. Most of the time students work in groups or teams. Teachers should be a guide to students when students need scaffolding (Farrell, Henderson, & Boutilier, 2008). In an inquiry class, teacher is not the one to conclude the results of the activities.

Lecture teaching follows a reverse sequence. Teacher presents the general principle or concept firstly, then the general characteristics of that principle or concept is presented (Su, Su, & Goldstein, 1994). Throughout the lesson, extensive amount of drill and practice exercises are offered to students until they get the adequate understanding or proficiency of principle or concept. Students are mostly passive in the classroom. If there is lab or hands-on activities, these aim the verification of the previously learned principle and are in a cookbook style, all of the steps are explained in detail (Bilica & Flores, 2009). Students just follow the instructions and get the predetermined right result.

## 1.4 Significance of the Study

This study investigates the effect of two basic approaches to science education within an educational system that has long been known for its traditional teacher-centered trends in teaching. The Turkish Educational System has been dominated by teacher centered and deductive teaching methods. Nowadays, a movement which aims to make learning more meaningful and related to daily life for students is on course. In accord with this movement science curricula have been revised giving more importance to student-centered and inquiry-based teaching methods. However, there is need for studies which investigate the effect of these teaching strategies alone; while investigating, they should also be compared according to students' individual differences.

This study investigates the impact of inquiry-based and lecture teaching methods on eleventh grade students' achievement in and attitudes toward electric circuits unit and their interaction with student aptitudes, namely cognitive styles, gender, school type, and prior physics achievement and attitude toward physics. This study can provide insights for the Ministry of Education in Turkey. This study may assist curriculum developers in evaluating their programs for improved student performance in science. Also, research in this area may increase the physics teachers' awareness of the impact of implementing different techniques to teach physics. Therefore, there exists a need for studies that look at the effects of various aptitudes (students' cognitive and learning styles, prior achievement, general ability, anxiety, attitudes, etc.) and treatments (inductive vs. deductive approaches, inquiry vs. expository teaching, visual vs. textual presentations, and etc.) and interactions of these aptitudes and treatments on students' achievement in and attitude toward physics. This study answers some part of the need mentioned above by investigating the effect of interaction between inquiry-based vs lectured physics instruction and students' cognitive styles on students' physics achievement and attitude toward physics.

# CHAPTER 2

# REVIEW OF RELATED LITERATURE

This chapter provides the theoretical and empirical background for the current study. The first section explains why the electric circuits concepts were taken as the content of the study. Second section describes the aptitude treatment interaction studies. Since there is not a perfect method to teach physics to all students, suitable methods should be defined to increase students' physics learning considering their aptitude variable simultaneously. Third section describes the inquiry teaching as one of the treatment variables of this ATI study. Fourth section explains the cognitive style concept primarily focusing on the field dependency and field independency.

## 2.1 Electricity as a Physics Subject

Physics is usually seen by students a difficult task to deal with. Duit, Niedderer, and Schecker (2007) argued that the reason of this difficulty for students to perceive physics is its extraordinate abstraction level and idealization. The researchers mentioned that an everyday phenomenon should be cleaned before it can be analyzed physically. The everyday phenomenon cannot be explained through the direct observations but rather should be reconstructed with the assumptions of theoretical principles. The researchers also used an analogy for explaining this fact: "It is nearly impossible to calculate the path of a leaf falling from a tree; but it is easy to predict precisely the motion of a feather in an evacuated tube." (p. 620). Hence, the everyday experiences generally contradict with the explanations of physical explanations for students (Wandersee, Mintzes, & Novak, 1994). These are the seen as the possible reasons for students' difficulties and contradictions that cause them to have low interest in physics (Duit, Niedderer, & Schecker, 2007).

One of the topics in physics is electricity which includes a huge number of research studies. Particularly, the emphasis lies on simple electric circuits. It is obvious that simple electric circuits are neither simple for students in the early grades nor for the ones at the higher levels (Duit & von Rhöneck, 1998).

Engelhardt and Beichner (2004) developed a diagnostic instrument for the aim of understanding the misconceptions of students and illustrating their understanding. The name of the instrument was "The Determining and Interpreting Resistive Electric Circuit Concepts Test", DIRECT. There were two versions of DIRECT, v1.0 and v1.1. Both versions of DIRECT have 29 multiple choice items. In v1.0 the items were mostly qualitative. Also the number of alternatives is not equal for each item. On the other hand, in v1.1, each item has five alternative choices and it has more quantitative questions than the v1.1 has. The DIRECT v1.0 was implemented to 1135 and DIRECT v1.1 to 692 high school and university students. The sufficient evidences for internal reliability, content validity, construct validity, discriminative power and difficulty level were presented of both tests. They concluded that either version of DIRECT was useful in evaluating curriculum and instructional methods as well as in providing insight into students' conceptual understanding of DC circuits.

The researchers listed students' common difficulties in electric circuits and then explained the instrument development procedure. Students;

- Think that current is consumed (Arnold & Millar, 1987; Fredette & Lochhead, 1980; Karrqvist, 1987; McDermott & van Zee, 1984, as cited in Engelhardt & Beichner, 2004; Osborne; 1981; Shipstone, 1984).
- Think that battery is a source of constant current (Cohen, Eylon, & Ganiel, 1983; Dupin & Joshua, 1987; Licht & Thijs, 1990).

- Use terms interchangeably, often assigning the properties of current either to voltage, resistance, energy, or power (Heller & Finley, 1992; Jung, 1984, as cited in Engelhardt & Beichner, 2004; von Rhöneck & Völker, 1984, as cited in Engelhardt & Beichner, 2004).
- View schematic diagrams as a system of pipes within which flows a fluid that they refer as electricity (Johsua, 1984).
- Have difficulty in identifying series and parallel connections in diagrams (Caillot, 1984, as cited in Engelhardt & Beichner, 2004; McDermott & Schaffer, 1992).
- Do not understand and do not correctly apply the concept of a complete circuit.
- Believe that current travels around the circuit and is influence by each element as it is encountered and a change made at a particular point does not affect the current until the current reaches that point (Closset, 1984, as cited in Engelhardt & Beichner, 2004; Shipstone, 1984).
- Believe that current divides into two equal parts at every junction regardless of what is happening elsewhere (von Rhöneck & Grob, 1987, as cited in Engelhardt & Beichner, 2004;).
- Think that if one battery makes a bulb shine with a certain brightness, then two batteries would make the shine twice as bright, regardless of the configuration (Sebastia, 1993, as cited in Engelhardt & Beichner, 2004).
- Are reluctant to solve qualitative problems (Cohen, Eylon, & Ganiel, 1983; Millar & Beh, 1993; van Aalst, 1984, as cited in Engelhardt & Beichner, 2004).
- Fail to treat meters as circuit elements and recognize the implications for their constructions and external connections (McDermott & Schaffer, 1992).

And in their research, they found similar misconceptions, namely,

- Students assign the properties of energy to current, and then assign these properties to voltage and resistance.
- Students think that both voltage and resistance can only occur in the presence of a current.

- Students do not have a clear understanding of the underlying mechanisms of electric circuits.
- Students experience difficulty in translating schematic diagram of a circuit to the realistic representation, in identifying shorts within circuits, and connecting light bulb to a circuit.
- In the presence of more than one batteries connected in series or parallel, students experience difficulty in predicting the resulting voltage and current.

Hart (2007) compared the consensus models used in science to explain phenomena with the models used in science teaching. In general, the consensus models used among science community were useful when used in science education, however, in electricity topic, the consensus model of "electric field as the causal agent for electric current" was too abstract for the beginner science learners. Therefore more simple models were developed in the physics education literature like, electron-transport model (Lofts & Evergreen, 2007; Nardelli, 2006, as cited in Hart, 2007), bicycle chain model (Nuffield-Chelsea Curriculum Trust, 1993, as cited in Hart, 2007), water-flow model (Hewitt, 1987; Stannard & Williamson, 2006, as cited in Hart, 2007), rope model (Lofts & Evergreen, 2007, as cited in Hart, 2007), gravitational model (Halliday & Resnick, 1988; Storen & Martine, 2004, as cited in Hart, 2007), and moving crowds model (Gentner & Gentner, 1983, as cited in Hart, 2007).

Electron-transport model explains current in terms of the flow of electrons around a circuit. However, this model does not explain explicitly and provide sufficient explanation of how electrons are involved in the transport and distribution of energy around the circuit (Mulhall et. al., 2001; Stocklmayer & Treagust, 1994).

Before Millikan and Thomson discovered a particle called electron, the water flow model had been accepted, the electric was imagined as a fluid really flowing though wires. However, the model fails to illustrate how current and energy differ because the students generally cannot discriminate between water pressure and the rate of water flow. Also, gravitational model requires students to have a well-constructed understanding of forces of gravity and friction. After presenting these models, their potential advantages and mostly disadvantages and deficiencies were discussed. Hart (2007) asserted six criteria for a pedagogically useful teaching model. These criteria were as follows:

1. The model must be initially intelligible to students, and must then come to appear first plausible and finally, fruitful (Strike & Posner, 1985, as cited in Hart, 2007).
2. The causal mechanisms that the model supplies must be meaningful to the students, so that students can think about the model in their own terms (Heywood, 2002).
3. The model must allow common conceptual difficulties and misconceptions to be articulated and addressed (Gilbert et. al., 1998b).
4. The model must engage students' imaginations and intellects, in order to promote a rich classroom discourse (Heywood 2002) which students can freely participate in and contribute to. The teacher's role is to guide the "flow of discourse" (Mortimer and Scott, 2003, as cited in Hart, 2007), so that meaningful understanding is socially constructed in the classroom, misconceptions are addressed and conceptual confusions and difficulties clarified.
5. The model must enable students to move towards an understanding of the relevant consensus models of science.
6. The model should be overtly presented (Gilbert et. al., 1998b).

She had taught teachers instructing electric circuit concepts in their classes but not graduates of physics education department, electric circuit concept with "Moving Crowds Model" in a summer school. Then she collected 8 teachers' reflections about these lessons and concluded from these reflections that "Moving Crowds Model" was a useful tool for having beginner learners to visualize electron movement, distribution and transfer of energy, the concept of current, voltage, and resistance. This model was also fruitful, because it led students to ask how an electron knows how many resistors are in the circuit, and how much energy it should carry. Since the "Moving Crowds Model" did not provide a satisfying answer for these questions, there was a need for further explanations and it was the time to introduce "Electric Field" model to the students.

Borges and Gilbert (1999) made extensive interviews with individuals from various professions who are familiar with electricity either because of their profession or taken courses during education. The interviewees were nine first year students (age about 15) who had not studied electricity and magnetism yet, nine third-year secondary students and ten third-year technical school students (age 17-18) who had studied electromagnetism one year before, ten partially schooled practitioners in areas related to electricity who had no formal instruction in the subject, seven electrical engineers who had more than two years of work experience and eleven secondary physics teachers, most of whom had long teaching experience. They asked the same questions to all participants and gave them a bulb, a battery, and some wires and asked them to light the bulb on. At the end of the evaluation of interviews, they found four models to explain participants' conceptualizations about electricity and electric circuits: electricity as flow, electricity as opposing currents, electricity as moving charges, and electricity as a field phenomenon. The electricity as flow and electricity as opposing currents seemed to be developed before a formal instruction about the topic by just experiencing it in daily life, however, electricity as moving charges seemed to be developed during and after the secondary school, while the electricity as a field phenomenon model seemed to be developed by the individuals who had a university or college degree.

They suggested that these models provided insights for physics education that if the teachers were aware of the models that students probably had, they would use them to design instructions. They could make students feel conflict and disequilibrium by asking questions that their models were not adequate to produce answers. In fact, this suggestion was in accordance with the suggestion of Hart (2007) that using "Moving Crowds Model" to build up the base for electric circuit conceptualization and then to present the "Electric Field" model for introducing why the current was produced and how the electrons know the amount of energy they should carry.

Also, a definition for mental models was included in the article that "Mental models are internal representations of objects, state of affairs, of a sequence of events or processes, of how the world is like and of psychological and social actions. They enable individuals to make predictions and inferences, to understand phenomena and events, to make decisions and to control their execution." (p.96).

To understand the working model of a phenomenon Johnson-Laird (1983) mentioned that it should be developed. And in terms of constructing models, a simplification should be done; only certain parts of the system should be selected and the relations of those parts should be represented (Gilbert & Boulter, 1995, as cited in Borges, & Gilbert, 1999).

Hart (2007) put forward some teaching models useful for electric circuit instruction, however, with the knowledge of models that learners constructed, these teaching models would be more beneficial. Karrqvist (1985, as cited in Borges, & Gilbert, 1999) established six mental models among secondary school students:

1. Unipolar Model: named by Osborne (1981) and similar to sink model (Fredette & Lochhead, 1980). Current flows from positive end of the battery to the bulb and it is completely used up there. Current is not distinguished form energy and is consumed where the bipolarity of the circuit elements are not considered.

2. Two-component Model: Similar to clashing current model (Osborne, 1983) and model 1 (Shipstone, 1984). For the bulb light up, the positive and negative currents should travel form the terminals of the battery to the bulb and meet there and produce energy.

3. Closed Circuit Model: Bipolarity of the circuit elements and the necessity for a closed circuit are acknowledged, however, the current is considered as a consumed entity. This may be caused from not distinguishing from current and energy.

4. Current Consumption Model: Similar to sequence model (Shipstone, 1984), and attenuation model (Osborne, 1983). Current is consumed as it travels along the circuit elements but it does not consumed to the end, some of the current reaches back to the battery.

5. Constant Current Source Model: Similar to sharing model (Shipstone, 1984). Battery is accepted as the source of constant current. Current variation might be experienced only because the batteries are used up with time. Two bulbs will share the current no matter hoe they are connected, in series, or in parallel.

6. Ohm's Model: Similar to scientific view (Osborne, 1983; Shipstone, 1984). Current flow through the circuit and transmits energy without being consumed. The discrimination between current and energy is well done. Circuit is seen as a system, as a change in one point will affect the whole circuit.

Borges and Gilbert (1999) introduced seven aspects that should be involved in a learner's mental model of electricity:

1. differentiation of basic terms used to speak about electricity, like current, electricity and energy;
2. recognition of the bipolarity of batteries and other circuit elements;
3. recognition of the necessity of a closed circuit if a current is to circulate in it;
4. issue of the conservation or non-conservation of current;
5. effects of electrical resistance on current;
6. models for current circulation;

In the current study, the lesson plans applied in the inquiry-based teaching classes were mostly based on the CASTLE project. The lesson plans then were revised by two experts in physics education, three experienced physics teachers, three research assistant in Secondary Science Education Department in METU and also by the teachers of the treatment groups. Four lesson plans were prepared for four week treatment period. There were three 45-minute physics lessons in a week, and these lessons plans were applied in the first two lessons of inquiry groups. By this way, inquiry groups would be presented firstly with application of the principles and then they were presented with the definitions of related concepts, formulas and quantitative problems which to solve, they were going to use these previous information and their previous experiences.

The CASTLE Project was developed by Dr. Melvin S. Steinberg and his co-worker teachers in 1995 and revised through 10 editions up to year 2008. In this project they aimed to make students visualize electricity while they were learning. The CASTLE was the abbreviation for Capacitor Aided System for Teaching and Learning Electricity. In extent of this project, a guide book was written, Electricity Visualized, containing instructional materials, homework and quizzes for teachers. It tried to be an alternative for the textbooks by providing an introductory module not requiring prior knowledge of electricity for high school students. Also its target audience was physics teachers who wanted to engage students' interest through hands-on investigation, overcome misconceptions that inhibit learning and reasoning, and foster development of effective explanatory models. It included a series of experiments about electric circuits with light bulbs, batteries, and specially designed capacitors, since this topic provides a productive domain for hands-on inquiry and inquiry teaching.

The CASTLE included eleven lesson plans covering all electric circuits concepts, however the aim of this study was developing inquiry lesson plans in line with the eleventh grade physics curriculum offered by Ministry of Education. Therefore only four of these lesson plans were chosen and necessary revisions were made.

## 2.2 Aptitude-Treatment Interaction Studies

For the last two decades, we see the emphasis is given to students' learning rather than to teaching methods (Redish & Steinberg, 1999; McCombs, 2003). Whichever method is used or believed to be efficient for students, unless students' understanding of the concepts is increased to the intended level, all the effort will be useless. Currently, science education researchers focus on to describe "How learners learn.", "How they construct meaning.", "How they link all the knowledge attained to each other." Unfortunately, there are obstacles on this struggle, taking into consideration learners' individual characteristics. Since learners are not simply subjects that have definite characteristics, they are not described or expected to behave in the same predetermined or predicted manner under certain conditions.

There are important differences among learners and these differences affect learning outcomes significantly. So, investigating individual differences among learners constitute an important research area in education (Koran & Koran, 1984). Since, science educators are looking for the ways to maximize learning and to understand how learning has occurred; the way that individual differences modify treatment effects should be taken into consideration (Cronbach, 1957). Aptitude-Treatment-Interactions (ATI) studies investigate how individual differences modify treatment effects (Cronbach, 1957). The aptitude-treatment interaction (ATI) approach assumes that students differ in educationally important ways. These differences or "aptitudes" have been defined as "initial states of individuals that influence later developments, given specified conditions" (Snow, 1992). Aptitudes can also be defined for the purpose of this study as any characteristic of the individual which functions selectively with respect to learning; that is any characteristic which facilitates or interferes with learning from some designated instructional methods. These aptitude variables can be exemplified as prior achievement, personality and stylistic characteristics, and motivational and attitudinal tendencies as well as traditional cognitive ability variables. Variations in structure, pacing, style, or modality of instruction as well as alternative curricula, different teachers or even different classroom instructional environments can be taken as treatment (Koran & Koran, 1984).

If one of the treatments is significantly better for one type of learners while the other type of the treatment is significantly better for the other type of learners, than there exists an interaction between learners' aptitude and the treatment. This interaction is shown by nonparallel regression slopes of aptitude on achievement for different instructional treatments (Cronbach & Snow, 1977).

The basic assumption underlying ATI research can be stated as follows: "There is no one best educational treatment or environment suited to some general, average individual, but different individuals thrive in different environments suited to their own characteristics and needs (Koran & Koran, 1984, p 795)."

Most of ATI studies have been conducted with aptitude and treatment variables which are related trial and error. However, in order to get consistent results and build a reliable theory these variables should be related according to theoretical conceptions. Three models for matching aptitudes and treatments have been proposed. These are

- Remedial Model: This model aims to change learner capabilities rather than design treatments.
- Compensatory Model: This model aims to match the suitable treatment that does something for the learner that he/she cannot do for him/herself with the learner characteristics.
- Preferential Model: This model aims to design treatments to capitalize on strongly developed learner aptitudes (Koran & Koran, 1984).

In fact, the relevant aptitude and treatment variables should be selected according to these models. In this study however, none of these models are selected. This study, mainly aims to detect the significant interactions between independent variables and methods of instruction on students' electric circuits achievement and attitudes toward this subject. After maintaining an opinion about the interactions that have serious effects on achievement or attitude, a model can be used to provide solution or a better way for teaching. Additionally, in ATI studies the researcher may try to match aptitudes to treatments under conditions in which either aptitude or treatment variable is of primary interest (Cronbach & Snow, 1977).

The ATI approach assumes that students who differ in aptitude also differ in instructional approach that is most effective for them. Thus, a student low on prior achievement may do well in one instructional approach, whereas a student high in prior achievement may benefit from an alternative instructional approach (Peterson, 1988). Moreover, the research results about the interaction of various treatments with various aptitude variables provide an insight for selection of relevant aptitude variables for this research. According to previous ATI research results, the more the required information processing instruction performs for the learner, the better it is for low ability learners. Therefore, while low ability students benefit more from programmed instruction, advance organizers in the form of preliminary abstracts or summaries, deductive methods and simple diagrams, figures, symbolic constructions, high ability students usually benefit more from inductive methods, highly verbal and abstract conceptual treatments (Koran & Koran, 1984). Additionally, field-independent learners achieved best with deductive instruction, and field-dependent learners performed best in instruction based on examples (Davis, 1991; Messick, 1994). Lastly, research findings have shown that the higher level of prior achievement, the less the instructional support required to accomplish the given task (Abramson & Kagen, 1975; Salomon, 1974; Tobias, 1973; Tobias & Frederico, 1984; Tobias & Ingber, 1976).

Since Cronbach's (1957) initial conceptualization of the ATI model, much aptitude-treatment interaction research has been conducted. This research has been reviewed by Bracht (1970), Corno and Snow (1986), Cronbach (1975), Cronbach and Snow (1977), and Tobias (1981). One recurring theme in these reviews of ATI research is the difficulty of replicating ATI findings across studies and the small number of consistent ATI findings that have been obtained. However, based on Cronbach and Snow review (1977), a replicable pattern of ATI findings for students who varied in general ability have been identified. Students who were low in general ability did poorly and students who were high in general ability did well in treatments or teaching methods that had the following characteristics:

- Placed burdens of information processing on learners.
- Used elaborate and unusual explanations.
- Involved a “new” curriculum.
- Included discovery or inquiry methods.
- Encouraged learner self-direction.
- Were relatively unstructured and permissive.
- Relied heavily on words rather than pictures or other media.
- Were rapidly paced.

In contrast, students low in general ability did well in treatments or instruction that had the following characteristics:

- Relieved the learners of information processing demands.
- Simplified or broke down the task to be performed.
- Provided redundant tax information.
- Substituted other media such as pictures for words.
- Used simplified demonstrations, models, or simulations (Peterson, 1988).

Tobias (1981) reached similar conclusions for aptitude-treatment interaction studies in which the aptitude was measured by prior achievement of the students. After 10 years of further research, Snow (1986) suggested that the pattern of ATI findings still hold true for students low in ability or low prior achievement compared to students high in ability or high prior achievement.

Contrary to its potential insights for designing instruction, matching appropriate instruction to learner characteristics, and assigning students to treatments which are most beneficial for them, number of researches investigating interactions between students’ attitudes and treatments has been declining. Cronbach and Snow (1977) pointed to the methodological differences as the cause for that decline while Tobias (1982, 1987a, as cited in Tobias, 1989) related this decline to the difficulty in replicating and extending ATI findings.

Cronbach and Snow (1977) asserted about the methodology of the ATI studies that the treatment should last more than at least ten class periods in order to be informative. Also, depending on the researcher's sources, interest to find definitive conclusions, on the effort to maintain and install a treatment, and on the complexity of the task that is taught in the treatment, a period of habituation should be included in the planning of implementation. An interaction found at the end of the treatment that lasted for less than one month was prone to diminish in later months. Also, the treatments should be implemented for the same amount of time. Researcher should hold the duration of the treatments constant in order to reach meaningful conclusions effective results. Therefore in the current study, researcher tried to obey the suggestions above. The duration of implementation was four weeks, and the treatment was implemented for more than ten class periods in both experimental and control groups. Unfortunately, because the getting permission from the administrators took more time than expected, extra time for habituation could not be provided for students and teachers.

Additionally, it was suggested that at least a hundred subjects should be randomly assigned in one of the two treatment groups, in order to obtain and detect interaction effects. Cronbach and Snow (1977) declared that "It casts doubt on virtually all past reports that failed to reject a null hypothesis regarding ATI. Their sample sizes made Type-II errors highly probable. That is to say, the hypothesis of no interaction has often been accepted when an important interaction was present."

In this study, an ATI study was conducted, investigating the effects of interactions of different instructional methods (inquiry and lecture) with several student characteristics (physics course grades of previously taken physics courses, field independency-dependency of students, schools to which students were attending to, students scores of pretests of achievement test and attitude scale, and etc.) on students' achievement in and attitude toward electric circuits topic. In high schools, physics was taught mostly by lecture methods, although inquiry methods were getting popular and were considered a more appropriate way to teach science.

Since one of the promise maybe the main promise of ATI studies was that there was not only one specific best way to teach something to all students, this study aimed to investigate how students learn and how they develop attitudes under these two instructional methods, and whether their degree of learning and attitude development change differ under these two instructional methods when their aptitude variables were considered. Student differ in their properties that they bring into the classroom, and these differences may induce or hinder their learning when they interact with the method of instruction used in those classrooms. In the current study, students prior physics achievement, prior attitudes toward electric circuits, prior knowledge about electric circuits, and cognitive styles (field independency-dependency) were taken as the relevant and aptitudes, in light of the related literature.

## 2.3 Inquiry-Based Instruction

Inquiry has not got a definition that is comprised on. NSES in the USA explained and used the term “inquiry” under three titles: “scientific inquiry”, “inquiry learning,” and “inquiry teaching.” (Anderson, 2002; Lederman & Niess, 2000). Anderson (2002) stated that the term “inquiry” had been used in many different meanings in the materials provided by NSES. Basically, NSES used the term under three meanings: Scientific inquiry, Inquiry learning, and Inquiry teaching. “The ways in which scientists study the natural world and propose explanations based on the evidence derived from their work” was described as the scientific inquiry. Inquiry learning referred to active learning process into which the learners were engaged. It was active because students do the learning themselves, the responsibility of learning was on them. Nothing should be or could be done to students to make them learn. Inquiry teaching was the most problematic term, since NSES did not provide an operationalized definition for it, while using the term referring to different occasions. Sometimes it meant the learning activity presented to students in order to make them to develop knowledge and understandings of scientific ideas and of how scientists study. Frequently, it was used to describe the desired way of teaching in which students’ experiences were one of the main issues.

Also, it was not a strict formulation of teaching method; it could be scaled from partial inquiry to full inquiry.

The core elements of the inquiry science instruction covered the following items; personal engagement of students with phenomena, student concentration of key science concepts, and some level of student ownership of the learning experience (ISP, 2006).

Anderson (2007) claimed that "although the term constructivist is not used in the NSES, it is clear that what is called inquiry learning is very similar to what others call constructivist learning." He listed four basic elements that inquiry or constructivism carried with:

1. "Learning is an active process of individuals constructing meaning for themselves; significant understandings are not just received."
2. "The meanings of each individual constructs are dependent upon the prior conceptions this individual already has. In the process, these prior conceptions may be modified."
3. "The understandings each individual develops are dependent upon the contexts in which these meanings are engaged. The more abundant and varied these contexts are, the richer are the understandings acquired."
4. "Meanings are socially constructed; understanding is enriched by engagement of ideas in concert with other people."

Learner-centered teaching was said to be context-dependent; in this type of teaching the culture of the learning context was as important as the content (Brown, 2004; McCombs, 2003). The distinguishing features revealed from the comparison of learner-centered and teacher-centered education were nearly the same for the features in the inquiry-based and traditional, and constructivist traditional contrasts (Anderson, 2007; Brown, 2004).

Cognitive psychologists found that effective learning occurs mostly in environments in which students engaged actively and experience social interaction with other learners or with teacher. In line with this assertion, Hake (1998) had investigated the effect of interactive-engagement methods on students gain score in the classes implementing curricula based on physics education research. He concluded that "although classes at different institutions had widely different FCI scores (ranging from 25% to 75%); courses with a similar structure achieved a similar proportion of the possible gain" (as cited in Redish & Steinberg, 1999).

There were several attempts to distinguish inquiry-based instruction from traditional instruction. Anderson (2002) presented Table 2.1 for the differences between traditional and inquiry science teaching for several aspects, he compared two methods of instruction along a continuum, traditional-reform pedagogy.

Table 2.1 Traditional-Reform Pedagogy Continuum

| Predominance of Old-Oriented | Predominance of New-Oriented |
|---|---|
| Teacher role | |
| As dispenser of knowledge | As coach and facilitator |
| Transmits information | Helps students process information |
| Communicates with individuals | Communicates with groups |
| Directs student actions | Coaches student actions |
| Explain conceptual relationships | Facilitates student thinking |
| Teacher's knowledge is static | Models the learning process |
| Directed use of textbook, etc. | Flexible use of materials |
| Student role | |
| As passive receiver | As self-directed learner |
| Records teacher's information | Process information |
| Memorizes information | Interprets, explains, hypothesizes |
| Follows teacher directions | Designs own activities |
| Defers to teacher as authority | Shares authority for answers |
| Student work | |
| Teacher-prescribed activities | Student-directed learning |
| Completes worksheets | Directs own learning |
| All students complete same tasks | Tasks vary among students |
| Teacher directs tasks | Design and direct own tasks |
| Absence of items on right | Emphasizes reasoning, reading and writing for meaning, solving problems, building from existing cognitive structures, and explaining complex problems. |

In a study conducted by Clark (2005) "traditional lecture" was defined as the instruction in which one instructor provided all the content and presented the content in one-way delivery, either by self-presenting, or by textbook reading. Students simply took notes and read the material so that they could perform well in the examinations. Examinations required student to replay the material or repeat the information given in the lectures. There was only limited interaction between the teacher and the students in the lectures.

In the current study, while the inquiry instruction was planning, the principles listed below were taken into consideration. However, implemented inquiry instruction was not a full inquiry, since the students were investigating the previously described problem situations, with the provided materials and equipment, it was a partial or guided inquiry. Teachers played roles which were described in Table 2.1; students' role was a little bit different from the described one. In fact, they did not construct their own activities, they did not direct their own learning, and i.e. they followed an activity sheet. Although it was not a full inquiry, since students hypothesized, collected data, analyzed data, offered an explanation for why and how it had happened, and communicated their findings and conclusions to their friends, and then criticized their and others' investigations, the instruction was satisfied the basic tenets of the inquiry instruction. In the lecture group, the usual instruction was implemented by the teachers. There was not any modification or change in the usual and ongoing lecture procedures.

Scientific inquiry is no more simple as the general steps of making observations, asking questions, constructing hypotheses, collecting data, analyzing and interpreting them, reaching conclusions, communicating the results and finally deriving new questions in light of the previous explanations. This type of inquiry was experiment-driven and mostly depended on the senses. However, scientific investigations have moved far beyond the dimensions that our senses are able to detect. By the improving technology, measurements can be done with devices; also scientists make thought experiments and theory driven and model driven studies.

Scientific inquiry has shifted from a experiment driven understanding to theory driven and model driven approaches (Grandy & Duschl, 2007). In light of the developments in the scientific inquiry, science educations should renew its understanding of inquiry. Much more emphasis should be given to posing questions, investigating them, reaching conclusions and explanations line with a theory, or to proposing a model for explaining a scientific phenomenon and testing hypotheses which were stated considering that model (Grandy & Duschl, 2007). Students should learn how to explain, interpret, criticize and reach further research questions from their inquiries (Windschitl, Thompson, & Braaten, 2008). Remote and routine ways of scientific inquiry are no more illuminating and inspiring for science educators to have scientifically literate students.

In the current study, this aspect of inquiry was considered; students were asked to construct models explaining electric current flow in the wires, and etc. There were specific titles as “Model construction exercises – Model inşa alıştırmaları.” Explanation of the results, concluding from these results and communicating and criticizing them were explicitly emphasized in the inquiry instruction.

Inquiry had been used to name curriculum projects, specific teaching techniques and etc. Minner, Levy, and Century (2009), stated that inquiry learning along with discovery learning, teaching by problem solving, inductive methods, and hands-on exploration become commonplace terms in discussions of science education. Then they dealt with the inquiry terms as an umbrella term for all of the methods mentioned a sentence ago. However, Anderson (2002) set that there was a lack of inquiry definition in the literature about it. This absence of a precise definition was problematic, in fact, inquiry teaching might be defined differently by different researchers and the teaching method might be entitled with a different name rather than inquiry though it was an example of inquiry teaching. Additionally, according to Minner, Levy, and Century (2009), the lack of a shared definition of the term “inquiry-based instruction” have been impeded the researches and the application of their implications for educational settings both at the nation or school wide. Moreover, no matter how detailed it was explained in the methodology of the researches, it was difficult to generalize research findings about inquiry teaching when there was not a compromised definition of it.

Windschitl and Buttemer (2000) established three reasons that inquiry learning is more important than other methods to develop scientific literacy. “First, it engages the inquirers in a very personal way with their own learning-they have a stake in the outcome of their investigations because they are addressing their own questions. Second, it builds confidence in “science as a way of knowing.” And third, it gives students the experience of “being scientists,” emulating the behavior of scientists engaged in doing science.”

In science education or namely physics education literature, many models for implementing inquiry in the classrooms were suggested as an alternative to traditional methods. McDermott (1996) was one of the researchers who conceptualize inquiry based instruction; in her definition, interactive engagement and collaboration were two central concepts of inquiry instruction. Teacher got free of being the source of factual information and become a guide while extensive interaction between students was generated in the class. Moreover, inquiry was explained as having three components: abilities, procedures, and philosophy (Huffman, 2002, as cited in Anderson, 2007). This model of inquiry was represented as three concentric circles; circle of philosophy encompassing the circle of procedures, and it encompassing the circle of abilities. Abilities were figured as the innermost circle.

Minner, Levy, and Century (2009) investigated the question “What is the impact of inquiry science instruction on K-12 student outcomes?” They synthesized the findings from researches conducted between 1984 and 2002. They selected student understanding of science concepts and retention as dependent variables while selecting the student active thinking, student responsibility for learning, emphasis on the inquiry as indicated by inquiry saturation and methodological rigor as their independent variables. They defined inquiry according to the presentation of the science content, engagement of students, responsibility of learning assigned to students. They reported that “active thinking and emphasis on drawing conclusions from data” were significant predictors of students’ understanding of science concepts. Additionally they found that, for the studies comparing the effect of more than one treatment having different degrees of inquiry saturation on student outcomes, higher amounts of inquiry saturation especially with hands-on activities and emphasis on more student responsibility of learning yielded statistically better understanding when compared to their low level counterparts.

Tai and Sadler (2009) investigated the “interactive associations between the structure of the inquiry activities (number of student-designed projects and degree of freedom in laboratory exercises) and academic attainment (high school grades, standardized examinations, and advanced high school course-taking) in high school science with introductory college science course performance.” Their study includes a total number of surveys exceeding 8000 on three data sets of biology, chemistry, and physics. They pointed out as a major finding of ATI research that “higher achievers responded bettering less-structured learning environments, while lower achievers responded better to more-structured environments.” Additionally, they stated that “a balance must be struck between structure and autonomy in inquiry-type learning activities and the results suggest that decisions on the degree of instructional structure should include student attainment.”

In 1996, Stohr-Hunt concluded that students who experience hands-on activities either every day or once a week score significantly higher than the students who experience hands-on activities once a month, less than once a month, or never. She had listed several limitations of her study; two of them might be a limitation of the current study as well. If the students were not motivated to answer the questions in the test because they were of little importance to them, and they thought that answering the questions was meaningless since the results would not be used for course grade, or a requirement of school or state, the test results would not picture out the real situation. Also, as the second limitation, these studies might have in common; a paper and pencil test was not a suitable and appropriate tool for measuring science achievement when the students had engaged in hands-on science programs while learning.

In his 2002 dated article, Anderson discussed main issues about inquiry under the titles, "The use of inquiry in NSES as Scientific inquiry, Inquiry learning, and Inquiry teaching; Reviewing the literature as 'What is inquiry teaching?'; Does inquiry teaching produce positive results?; Is widespread inquiry teaching possible?; What barriers and dilemmas are connected with inquiry teaching?; How can teachers be helped in using inquiry teaching?". The article presented some positive results of inquiry teaching on various student outcomes. As cited in this article, Shymansky, Kyle, and Alport (1983) reported substantial effect sizes in favoring inquiry-oriented curriculum materials in cognitive achievement, process skills, and attitude to science. Additionally, the result of Wise and Okey's (1983) study was quoted in the article that an average effect size of 0.4 standard deviations in favor of inquiry-discovery teaching for cognitive outcomes. There were studies reporting positive results similar to the mentioned ones in the literature (Bredderman, 1982; Lott, 1983; Weinstein, Boulanger, & Walberg, 1982, as cited in Anderson, 2002). Haury (1993, as cited in Anderson, 2002) also drew similar conclusions for the effect of inquiry teaching on scientific literacy, science processes, vocabulary knowledge, conceptual understanding, critical thinking and attitudes toward science. Sincere and conclusive results were being reported about the positive impacts of inquiry teaching on various student outcomes (Heywood & Heywood, 1992; Huveyda, 1994, as cited in Anderson, 2002).

In spite of the positive results declared from inquiry researches, inquiry teaching could not be said to have a widespread usage in classroom settings. Anderson (2002) proposed two reasons for this; textbook usage was a very deep seated tradition among science educators, teachers thought that students should grasp the skills to learn from a book. Also, as the second one, frustration and problems encountered in the application of the inquiry science teaching was put forward.

In the Llewellyn's book "Teaching High School Science through Inquiry" (2005), he listed 10 items that teachers generally hide behind as an excuse for not using inquiry teaching:

1. I do not have enough classroom time to do inquiry. I can teach a lesson quicker through a lecture or a demonstration.

2. Students are accustomed to getting an answer from their teacher.

3. I have a final exam I have to teach.

4. Students do not have the skills to do inquiry.

5. I do not have enough supplies and equipment to do inquiry.

6. Students need to be told how to do a science experiment.

7. Inquiry is not a focus of the textbook I am using.

8. Inquiry is not an emphasis in our science department. Besides I have not had any professional development on teaching through inquiry.

9. When you teach through inquiry, you lose control.

10. I feel more comfortable teaching the traditional labs. That is the way I was taught.

Students tended to perceive student-centered, inquiry lessons as the lessons of low quality, because they thought that their teachers withdrawn from the responsibility to teach, to present the content, and left students on their own while learning (Akerlind & Trevitt, 1999, as cited in Clark, 2005; Clark, 2005). They misinterpreted the responsibility shift in inquiry lessons.

Kirschner, Sweller, and Clark, (2006) criticized inquiry instruction for not considering the studies about how people learn. They stated that without appropriate level of guiding students would lose their way and could not gain necessary knowledge and abilities. They defended guidance for students instead of open-inquiry and they claimed that there should be a difference between the epistemology and pedagogy of science. In this study, a guided inquiry was implemented and after students dwelled into inquiry activities, the content of the lesson was presented relating students' experiences to the content.

2.4 Cognitive style

Individuals differ in appearance; we have been used to these differences and we can recognize and describe persons according to these. Individuals also differ in other aspects those we cannot easily notice. Personality, level of intelligence, and, ways of attending, processing and interpreting knowledge are some dimensions that people differ. As all we have confronted in our daily life, some persons are tidy whereas some others are untidy, some are organized whereas the others were disorganized in their ideas, and some are good at science and mathematics, whereas some are good at social sciences and literature.

These differences and their sources have attracted attention since Ancient times. People tried to classify and define categories to describe and organize different characteristics of individuals. Types of personalities had been defined; people had been categorized to decide who would continue further education and who would be sent to vocational training.

In Personality: A Psychological Interpretation (1937), Gordon Allport was the first to use the term 'style' to adress individuals' idiosyncratic and different ways to process information. This construct of style is helpful and significant in many aspects; individuals will be more confident and aware of their capabilities, ways of attending, processing, and organizing knowledge which are most convenient for themselves, if they have known their styles. In fact, there are various constructs that scholars use to define and describe a person, such as personality, intelligence, temperament, and etc. One important construct is also worth to consider especially in learning contexts: Cognitive Style. Samuel Messick (as cited in Riding & Rayner, 1998) have defined cognitive style concept by the following paragraph:

"Each individual has preferred ways of organizing what he sees and remembers and thinks about. Consistent individual differences in these ways of organizing and processing information and experience have come to be called cognitive styles. These styles represent consistencies in the manner or form of cognition, as distinct from the content or the level of skill displayed in the cognitive performance. They are conceptualized as stable attitudes, preferences, or habitual strategies determining a person's typical modes of perceiving, remembering, thinking, and problem solving. As such, their influence extends to almost all human activities that implicate cognition, including social and interpersonal functioning." (1976, p 4-5)

Cognitive style theorists state that each individual acquires knowledge through different ways. Cognitive refers to the act of perceiving, judging, valuing, and storing into or recall from the memory that is involved in the information processing. Style is simply used in the same way as it is used in daily language. Cognitive style implies that each individual utilize personal characteristic style of him or her while he or she is learning, or gaining knowledge (Morgan, 1997).

One important point that should be emphasized is that an individual's cognitive style does not infer anything about that individual's level of intelligence; it is just an indication of the utilized ways, to which the individual is inclined, of acquiring new knowledge (Morgan, 1997).

### 2.4.1 Importance of Awareness about Cognitive Style

Based on the philosophy of John Dewey and the theories of Jean Piaget, educators realized that traditional didactic teaching and learning settings are not working well for every student, in fact they are quiet inappropriate for some pupils. They believe that the amount of opportunities that students have while learning should be increased. Supporting, Riding and his associates (1995) showed in a study with school age children that cognitive style, personality and school performance were related significantly to each other. They recommended that academic performance could be enhanced if learning materials and teaching methods were structured in accord with students' motivational and behavioral characteristics and ultimately their personalities. As one of the end products of this, open classroom structures, whole language studies, cooperative learning, small group assignments, individualized instruction and a various other innovative approaches have been developed and utilized in learning situations (Morgan, 1997).

Individual differences have been studied till at least for five decades. By investigating why individuals differ, they can understand themselves better and can be guided through more appropriate occupations. Additionally, performance of learners can be enhanced and improved by cognitive style studies, actually, these studies are helpful to create a sense of identity and "… we all perhaps need to know we matter, that we make a difference in our own life, and making this difference is quite simply, a matter of style!" (Riding, & Rayner, 1998, p 5). Moreover, cognitive style affects the way in which individuals represent, and think about, the social environment in which they live, and the situations they encounter. This in turn, is related to their personality (Morgan, 1997, p 142). Another drive for studying cognitive styles is the aim of increasing low income students' academic performance since they usually have experienced lower rates of success than their middle class agemates (Morgan, 1997).

### 2.4.2 Style vs Strategy

Cognitive style and learning strategy should be differentiated from each other. As mentioned earlier, a style is the fixed and in-built characteristic of an individual with a static nature. Learning strategies are the ways that individual has learned or developed him/herself to deal with the situations; they may vary in line with the situations' or tasks' requirements (Morgan, 1997). In the literature, the term 'learning style' is sometimes used to refer to learning strategies (Riding & Rayner, 1998).

In some situations, individuals' cognitive style is not compatible with the tasks, thus they should develop or learn some strategies to cope with this difficulty to complete the task. In such cases, they prefer one type of for instance representation of knowledge to another one, and they begin to find out ways, strategies, to translate the given type of representation to the preferred type. In the longer term, as they have much more learning strategies which can be called as cognitive tools, they have richer cognitive tool kit (Riding & Rayner, 1998).

### 2.4.3 Style vs Ability

It is useful and important to distinguish between style and ability, since they are often used together and sometimes interchangeably. However there are concrete differences between the two concepts; although they both affect the performance of learners on a given task, McKenna (1984; 592-4) stressed four properties of cognitive style that distinguish it from ability:

- Ability is more concerned with level of performance, while style focuses on the manner of performance.
- Ability is unipolar while style is bipolar.
- Ability has values attached to it such that one end of ability dimension is valued and the other is not, while for a style dimension neither end is considered better overall.
- Ability has a narrower range of application than style.

In completing a task, gaining knowledge, or learning, the performance of individuals are influenced by both their cognitive style and ability. The level of accomplishment increases as the ability increases, however the effect of individuals' cognitive style might be either positive or negative depending on the nature of the given task. In fact, for an individual at one end of a style dimension, a task can be found difficult, while, the same task can be found easier by another individual at the other end of the style dimension. In other words, in terms of style a person is both good and poor at task depending on the nature of the task, while for intelligence, they are either good or poor (Riding & Rayner, 1998).

2.4.4 Field-Dependence and Field-Independence

Psychology of perception exemplified by Witkin et. al. in the 1940s. Gestalt school psychologists' studies were influential for the experimental studies aiming to explore and find out the regularities of information processing. From these studies, the "field-dependence-independence" construct was derived. (Witkin et.al., 1962 as cited in Morgan, 1997; Witkin, 1964, as cited in Riding & Rayner, 1998; Witkin et. al., 1971; Witkin & Goodenough, 1981, as cited in Riding and Rayner, 1998).

In the Second World War, pilots had experienced difficulties in determining their orientations after flying through thick clouds. Witkin and Asch (1948a, 1948b, as cited in Morgan, 1997 and Riding & Rayner, 1998) studied this case and established that individuals differed with regard to consistencies of their decisions about the upright position of the objects in space. Later on, further researches led them to identify field-dependence-independence as a perceptual style. According to this style, individuals determine the upright position of an object depending on the surrounding context or field, however, some individuals depend on the "field" more, while some do to a lesser degree.

Extensive researches were completed on this issue, and this construct has been found to have implication on the non-perceptual tasks as well. Riding and Rayner (1998) explained the enlargement of the definition of the construct of field-dependency-independency in the following passage:

"This resulted in the construct being broadened to encompass both perceptual and intellectual activities and was referred to as the 'global-articulated dimension.' Later, with additional evidence on self-consistency, extending to the areas of body concept, sense of self, and controls and defenses, the construct became even more comprehensive and was labeled as 'psychological differentiation'"(p.21).

2.4.5 Assessment of Field-Dependency-Independency

Field dependency and field independency are the two ends of a continuum; individuals are not necessarily either field-dependent or field-independent, they fall in somewhere on the continuum, and this point might be closer to one of the ends, to either field-dependency or field-independency. Researchers used some techniques to find out the individuals' inclinations to be closer to either field-dependent or field-independent end (Morgan, 1997; Riding & Rayner, 1998).

The first method was the Rod and Frame Test. In this test, subject was placed in a completely darkened room in where there were only a luminous rod and a luminous frame and in a position that he/she was not able to determine his/her body orientation. Both the rod and frame can be rotated to the left or right. Subject was asked to orient the rod upright vertical position without touching the frame when the frame was set on a titled position previously. If the subject tilted the rod and made it aligned with the tilted surrounding frame, then he/she was labeled as field-dependent. If the subject oriented the rod upright without regard the position of the tilted frame, then he/she was classified as field-independent (Morgan, 1997).

The second technique was the Body Adjustment Test. In this test, there were a chair and a room instead of a rod and a surrounding frame. Both the chair and the room can be tilted again. When the chair and the room were tilted to the same degree, subject was asked to alter the position of the chair to the position where he/she would feel upright. Some individuals said that they were already in upright position and was named as field-dependent where the others altered the chair's position to the upright and were classified as field-independents. All subjects were successful in determining the upright position of the chair when their eyes were closed; the difference was caused by the existence or absence of the surrounding context, this time the tilted room (Morgan, 1997).

The assessment procedure was further carried in a paper-and-pencil form. The Embedded Figures Test (EFT) was developed based on the work of Thurstone (1944, as cited in Morgan, 1997) on the discrimination of the shape. After, different versions of EFT were developed, but, all versions were settled on the main idea of disembedding a figure from its surrounding field. The basic properties of different versions of EFT were listed in the following paragraph:

- Embedded Figures Test (EFT): a 12 item, individually administered test, made up of two sets of cards displaying complex figures and simple figures respectively.
- Children's Embedded Figures Test (CEFT): a 25 item, individually administered test which combines a series of simple and complex figures, and incomplete pictures requiring the subject to disembed or recognize embedded shapes. The test was norm-referenced with children from 5 to 12 years of age (Witkin et al. 1971).
- Group Embedded Figures Test (GEFT): a group-administered 25 item test for adults in which the format is very similar to the EFT (Witkin et al. 1971).

In the current study GEFT was used to assess students' cognitive styles. This test was developed by Witkin et al. (1971). Witkin and et al. had developed an Embedded Figures Test (EFT) which was administered individually and so inefficient for use with large groups. Therefore they developed the group administered version of this test as GEFT. The GEFT includes three sections; there are 7 figures in the first section, 9 items in the second and third sections. There are 6 simple figures named as simple form A, B, C, D, E, F, H, and G. These simple forms are embedded in 26 complex figures, and students are asked to find the simple forms in the complex figures and draw them on these complex ones. Students have 2 minutes for completing the first section, and 5 minutes each for completing the second and third sections. The GEFT is a speed test indeed and these time limits are especially important for administration. First section is for exercising only, to prevent students' errors and to provide them a warm up session. Second and third sections are scored only. The items are accepted as true if and only if students draw the exact simple form without extra or missing lines. Each true item is scored 1 and each wrong or missing item is scored 0. So the range of the possible scores is between 0 and 18. Also, there are important and useful instructions in the first page of the GEFT and before administration, examiner should read these instructions and be sure that students understand them. The GEFT should be in a booklet form and the simple forms should be printed at the back cover of this booklet so that students are prevented to look at simple forms and complex figures at the same time. However, they have permission to look at the simple forms as much as they want. This instrument was translated into Turkish and validated by Çakan (2003).

The reliability coefficient of the GEFT scores was reported as 0.82 for males and females (calculated by Spearman-Brown prophecy formula). The scores of the GEFT and other cognitive style tests (ABC Scale, EFT) were correlated and resulted in high coefficients as a construct related validity evidence.

### 2.4.6 Field-dependent and Field-independent Learners

Educators and psychologists paid more attention to field-dependent and field-independent cognitive styles than they did to other styles. People cannot be divided into two distinct categories as field-dependent and field-independent, rather each individual is at somewhere between the two extreme. Lastly, it is important not to consider these ends as negative and positive poles; however, each extreme has important implications for both learners and educators in designing the most appropriate form of instructions. Witkin (1974, as cited in Riding & Rayner, 1998) describes these constructs as indicated below:

"The person with a more field independent way of perceiving tends to experience his surroundings analytically, with objects experienced as discrete from their backgrounds. The person with a more field dependent way of perceiving tends to experience his surroundings in a relatively global fashion, passively conforming to the influence of the prevailing field or context" (p. 35).

Field-independent persons tend to see the objects apart from their surrounding context, for instance, they can easily distinguish a fruit from the leaves on the tree, whereas field-dependent learners are not very skillful to view things separate from their surrounding context. Therefore, field-dependent learners prefer things to remain their total contexts for a better understanding. Field-independent learners like to work alone and to interact with persons individually, whereas field-dependents usually learn better in groups or in pairs and when they are interacting in a group.

Above properties of field-independent learners made them to be considered as the desired type of students especially in traditional classrooms. Since they prefer to work individually, and perceive analytically, they tended to fit the expectations of the traditional classes. Field-dependent learners, on the other hand, were considered as less-able and field-dependency as a deficit. However, nowadays this judgment has been changed, skillful teachers and educators developed new methods and techniques, like cooperative learning, individual and small group assignments, and by matching their preferences with class expectancies to maximize field-dependent's learning.

In this regard, Rosalie Cohen (1969, as cited in Riding and Rayner, 1998) reported that learners with field dependent, cognitive styles might not do as well as their counterparts on standardized tests because such tests were oriented toward field independent and analytical conceptual styles. Cohen observed that schooling is organized in a manner that some children come face-to-face with cultural conflict because their conceptual style is not compatible with the academic model of the system.

Also, when an object or idea is removed from its usual context, the field independent learner, being more analytically prone, would enjoy the challenge; the field dependent learner, on the other hand, would experience greater difficulty with the types of problems that separate an element from its common field. It has also been shown that when the field is not firmly organized, the field dependent person is more likely to interpret the material as it is, and their field independent peers will more than likely impose a structure. In Table 2.2 below, fundamental characteristics of field-dependent and field-independent are summarized in a comparative manner.

Table 2.2 Characteristics of Field-Dependent and Field-Independent Learners (Garger & Guild, 1987)

| Field-Dependent Learner | Field-Independent Learner |
|---|---|
| • Perceives globally. | • Perceives analytically. |
| • Experiences in a global fashion, adheres to structures as given. | • Experiences in an articulate fashion, imposes structures. |
| • Makes broad general distinctions among concepts, sees relationships. | • Makes specific concept distinctions, little overlap. |
| • Socially oriented. | • Impersonal orientation. |
| • Learns material with social content best. | • Learns social material only as an intentional task. |
| • Attends best to material relevant to own experience. | • Interested in new concepts for their own sake. |
| • Requires externally defined goals and reinforcement. | • Has self-defined goals and reinforcements. |
| • Needs organization provided. | • Can self-structure situations. |
| • More affected by criticism. | • Less affected by criticism. |
| • Uses spectator approach for concept attainment. | • Uses hypothesis testing approach to attain concepts. |

## 2.5 Summary of the Related Literature

One can summarize the results of these studies as follows:

1. Simple electric circuits are neither simple for students in the early grades of school nor for those at the higher levels as well (Duit & von Rhöneck, 1998).

2. The way that individual differences modify treatment effects should be taken into consideration (Cronbach, 1957). Aptitude-Treatment-Interactions (ATI) studies investigate how individual differences modify treatment effects (Cronbach, 1957). This interaction is shown by nonparallel regression slopes of aptitude on achievement for different instructional treatments (Cronbach & Snow, 1977).

3. “There is no one best educational treatment or environment suited to some general, average individual, but different individuals thrive in different environments suited to their own characteristics and needs (Koran & Koran, 1984, p 795).”

4. Field-independent learners achieved best with deductive instruction, and field-dependent learners performed best in instruction based on examples (Davis, 1991; Messick, 1994).

5. Research findings have shown that the higher level of prior achievement, the less the instructional support required in order to accomplish the given task (Abramson & Kagen, 1975; Salomon, 1974; Tobias, 1973; Tobias & Frederico, 1984; Tobias & Ingber, 1976).

6. Cronbach and Snow (1977) asserted about the methodology of the ATI studies that the treatment should last more than at least ten class periods in order to be informative. Additionally, it was suggested that at least a hundred subjects should be randomly assigned in one of the two treatment groups, in order to obtain and detect interaction effects.

7. Much more emphasis should be given to posing questions, investigating them, reaching conclusions and explanations in line with a theory, or to proposing a model for explaining a scientific phenomenon and testing hypotheses which were stated considering that model (Grandy & Duschl, 2005). Students should learn how to explain, interpret, criticize and reach further research questions from their inquiries (Windschitl, Thompson, & Braaten, 2008).

8. Tai and Sadler (2009) pointed out that higher achievers responded better to less-structured learning environments, while lower achievers responded better to more-structured environments.

9. Shymansky, Kyle, and Alport (1983) reported effect sizes favoring inquiry-oriented curriculum materials in cognitive achievement, process skills, and attitude to science. Additionally, Wise and Okey (1983) reported an average effect size of 0.4 standard deviations in favor of inquiry-discovery teaching for cognitive outcomes. There were studies reporting positive results similar to the mentioned ones in the literature (Bredderman, 1982; Lott, 1983; Weinstein, Boulanger, & Walberg, 1982, as cited in Anderson, 2002). Haury (1993, as cited in Anderson, 2002) also drew similar conclusions for the effect of inquiry teaching on scientific literacy, science processes, vocabulary knowledge, conceptual understanding, critical thinking and attitudes toward science. Sincere and conclusive results were being reported about the positive impacts of inquiry teaching on various student outcomes (Heywood & Heywood, 1992; Huveyda, 1994, as cited in Anderson, 2002).

10. An individual's cognitive style does not infer anything about that individual's level of intelligence; it is just an indication of the utilized ways, to which the individual is inclined, of acquiring new knowledge (Morgan, 1997).

11. Field dependency and field independency are the two ends of a continuum; individuals are not necessarily either field-dependent or field-independent, they fall in somewhere on the continuum, and this point might be closer

to one of the ends, to either field-dependency or field-independency (Morgan, 1997; Riding & Rayner, 1998).

# CHAPTER 3

# METHODS

In this chapter, population and sampling, development of measuring tools, teaching/learning materials, procedure and methods that are used to analyze data are explained.

## 3.1 Population and Sample

The target population of the study covers all eleventh grade high school students in Aydın. The accessible population is determined as all eleventh grade High School students in the central district of Aydın. This is the population for which the results of the study are generalized.

There are five Anatolian high schools, five public high schools, seven vocational, industrial and technical high schools, one social-sciences high school, and one science high school in the accessible population. Vocational, technical, and industrial high schools follow a different curriculum from the rest of high schools; social-science high school's curriculum favors history, geography, literature, psychology, philosophy, and sociology rather than physics, chemistry, biology, and mathematics, so they are not represented in the sample. Among the eleven high schools, there were four Anatolian High Schools, four public high schools, and one science high school, a total of nine schools that had eleventh grade students in the time of the current study. In these schools there were totally sixty classes and 1659 students in the eleventh grade. Nine hundred and one students were female, whereas there were 758 male students attending to eleventh grade. The sample of this study consisted of 16 classes, six schools, and 460 students, and this matched more than ten percent of the whole population. In fact, in 67 percent of the schools and in 27 percent of the classes of the population, by the 27 percent of all the students in the population, this study was conducted. By the way, this ratio was the ratio of students who selected science as the main branch in the high school, to the entire eleventh graders; it would be greater if the ratio of the number of participant students to the entire eleventh graders who selected science in the high school, however the number of students those selected science could not be obtained. Anatolian and science high schools required students to get a high score from the nation-wide high school entrance examination. Students got this exam at the end of the eight-grade in a two and a half hour session. Fraenkel and Wallen (1996) state that a convenience sample is a group of individual that is conveniently available for study. In this study, sample chosen from the accessible population is a sample of convenience. Nine classes from three Anatolian high schools, five (three from one, two from the other) classes from two public high schools, and two classes from science high school were chosen conveniently as the sample of the study. Since selecting students and assigning them to the treatment groups randomly was impossible due to administrative constraints, these classes were taken as intact and assigned to treatment and control groups randomly. The detailed information about the sample was given in Table 3.1.

Table 3.1 Sample Characteristics

| School Name and Type | Class | Treatment Groups: Inquiry-based Instruction | Treatment Groups: Lecture Instruction | Gender and # of students: Male | Female | Total | Teacher | Existence of a lab |
|---|---|---|---|---|---|---|---|---|
| School A (Anatolian High School) | A1 | X | | 14 | 11 | 25 | K (Female) | Yes |
| | A2 | | X | 15 | 11 | 26 | K (Female) | Yes |
| School B (Public High School) | B1 | X | | 16 | 16 | 32 | L (Male) | No |
| | B2 | | X | 13 | 19 | 32 | L (Male) | No |
| | B3 | X | | 20 | 10 | 30 | M (Male) | No |
| School C (Public High School) | C1 | X | | 11 | 24 | 35 | N (Male) | No |
| | C2 | | X | 17 | 11 | 28 | N (Male) | No |
| School D (Anatolian High School) | D1 | X | | 17 | 8 | 25 | O (Male) | Yes |
| | D2 | | X | 11 | 17 | 28 | P (Female) | Yes |
| | D3 | X | | 13 | 14 | 27 | P (Female) | Yes |
| | D4 | X | | 18 | 8 | 26 | Q (Male) | Yes |
| School E (Science High School) | E1 | | X | 14 | 10 | 24 | R (Male) | Yes |
| | E2 | X | | 14 | 10 | 24 | S (Male) | Yes |
| School F (Anatolian High School) | F1 | X | | 18 | 15 | 33 | T (Male) | No |
| | F2 | | X | 12 | 21 | 33 | T (Male) | No |
| | F3 | X | | 15 | 17 | 32 | T (Male) | No |
| Total | 16 | 10 | 6 | 238 | 222 | 460 | 10 | |

A total of sixteen classes ten of them were inquiry-based instructed and six of them were lectured from six high schools formed a 460 student sample. Two hundred thirty eight students of the sample were male and 222 students of the sample were female. While this sample size was determined, the missing test scores of the students were not considered; therefore in statistical analysis a lower sample size was used. This procedure was discussed in detail in Chapter 4.

Students in the sample were born mostly at the year 1992. The gender distribution of the students is said to be evenly distributed. Their prior physics course grades were collected with a question at the beginning of the physics achievement test and physics attitude scale. The group means of students' prior physics achievement scores out of five are given in Table 3.2. According to Table 3.2, in the public high schools, there was an apparent difference in the group means for the prior physics achievement between the classes. In School B, one of the classes had a mean of "3.97", while the others had means "1.63" and "1.03." Teachers of B1 and B2 in School B and C1 and C2 in School C were the same. When their teachers were asked "What could be the reason of this difference?", they stated that classes were formed according to their prior achievement levels. Hence students who were in the class for more successful ones were more motivated to study and had self-confidence and faith in that they could achieve and learn physics. Also, according to the teachers of the classes, there were competitive atmospheres in the classes for more successful students. Meanwhile, in the less successful classes, students felt that they were put in a class because they could not learn and they were considered as a problem so that they had been isolated from the more successful students. As a matter of fact, they lost their motivation and faith to achieve. This mood of less successful students and the improved motivation of the successful ones caused the difference to get larger. The experimental and control classes were determined randomly.

Table 3.2 Group Means of Students' Prior Physics Achievement Scores out of Five

| School Name and Type | Class | Treatment Groups | |
|---|---|---|---|
| | | Inquiry Instruction | Lecture Instruction |
| School A (Anatolian High School) | A1 | 4.00 | ----- |
| | A2 | ----- | 3.69 |
| School B (Public High School) | B1 | 1.63 | ----- |
| | B2 | ----- | 3.97 |
| | B3 | 1.03 | ----- |
| School C (Public High School) | C1 | 3.73 | ----- |
| | C2 | ----- | 1.68 |
| School D (Anatolian High School) | D1 | 3.20 | ----- |
| | D2 | ----- | 4.18 |
| | D3 | 2.89 | ------ |
| | D4 | 3.58 | ------ |
| School E (Science High School) | E1 | ----- | 4.17 |
| | E2 | 4.67 | ----- |
| School F (Anatolian High School) | F1 | 4.00 | ----- |
| | F2 | ----- | 3.70 |
| | F3 | 4.19 | ----- |
| Average | | 3.29 | 3.57 |
| Weighted Average | | 4.19 | 3.70 |

Anatolian and science high schools are not differing in terms of their students' socioeconomic status, since most of the students took private course or registered to private course centers, their family should be in at least upper middle socioeconomic level. In public high schools however, this situation is a little bit heterogeneous. In this type of schools there are students both from the upper middle SES families as well as from the lower levels. If students could not enter Anatolian and science high schools, they are attending public high schools in Turkey.

## 3.2 Variables

Students' physics achievement pretest scores (PREACH), physics attitude pretest scores (PREATT), previous physics course grades (PPCG), cognitive style (CoS; Field-independent versus field-dependent), school, age, gender and methods of instruction (MOI; inquiry-based teaching and lecturing) are the independent variables (IVs) of this study. Seven IVs; the PREACH, PREATT, PPCG, school, gender, CoS and age are the potential covariates. Students' physics achievement posttest scores (PSTACH) and physics attitude posttest scores (PSTATT) are the dependent variables (DVs). Some characteristics of the variables are shown in Table 3.3.

Table 3.3 Variables of the Study

| Name of the variable | Dependent/Independent | Continuous/Categorical | Scale |
|---|---|---|---|
| MOI | Independent | Categorical | Nominal |
| Gender | Independent | Categorical | Nominal |
| School | Independent | Categorical | Nominal |
| PPCG | Independent | Continuous | Interval |
| PREACH | Independent | Continuous | Interval |
| PREATT | Independent | Continuous | Interval |
| CoS | Independent | Continuous | Interval |
| Age | Independent | Continuous | Interval |
| PSTACH | Dependent | Continuous | Interval |
| PSTATT | Dependent | Continuous | Interval |

## 3.3 Instruments

For this study, four measuring tools are used. These are Physics Achievement Test (PACT), Physics Attitude Scale (PATS) about electric circuits unit; Group Embedded Figures Test (GEFT) which is a scale for determining cognitive style of learners, and an observation checklist for the treatment verification.

### 3.3.1 Physics Achievement Test

The instrument PACT is developed by the researcher to assess students' achievement about electric circuits unit. The content of electric circuits unit covers; circuit elements, measurement of voltage difference, resistance (Ohm Law, Factors affecting resistance and resistivity), current in electric circuits (Current in series and parallel-connected circuits, current in main and parallel branches), work done by the electric current-Joule's Law (Electromotor Force, and efficiency of an electric motor), connecting batteries (in series and in parallel). The PACT covers the physics contents taught in the eleventh grade curriculum in electric circuits unit. It consists of 30 questions having twenty four multiple-choice, three true false and three matching type questions. Most of the questions are multiple-choice questions since it is easy and quick to administer and it enables the researcher to evaluate objectively. Possible PACT scores range from 0 to 30 with higher scores indicating higher achievement in electric circuits unit.

Before developing this test, objective list of the electric circuits unit was prepared. There were twenty objectives covering all of the "electric circuits" content. While writing the objectives, it was considered that all objectives were not too general or too specific, that all of them could be measured by definite questions; in fact, they did not have ambiguous statements and verbs as "know," "comprehend," and etc. The list was revised by the supervisor of the test three times. These three versions of the objective list were given in Appendix A. All these twenty objectives were planned to be measured with thirty questions. For deciding on the questions, wide ranges of sources (physics books, University Entrance Exam questions, related literature and instruments developed by other researchers) were searched. All possible questions were examined one by one and the questions that coincided with the related objectives were chosen. Then, a table of test specification was prepared in order to ensure that objectives and the related items covered the all electric circuits concepts and that they were in approximately the same proportion of time it was indicated in the yearly plans. This table indicated that these were achieved more or less. In essence, this table was an evidence of content validity. In this table, the objectives and the questions were categorized according to the cognitive domain of Bloom's Taxonomy. Finally, the questions were reexamined by taking into consideration of the table of test specification. The table of test specification is given in Appendix B. Table 3.4 indicates the sources from where the questions were taken. Some of the questions taken from previous studies were adapted to make them measure only one objective each time; these are represented by researcher developed items in the table. For this purpose, they were divided into two or three items; each was a step for reaching solution of the original question.

Table 3.4 Sources of Items in the PACT

| Source of Items | Item Numbers |
|---|---|
| Engelhardt & Beichner (2004) | 3, 4, 5, 6, 7, 9, 11, 12, 13, 16 |
| Taşlıdere (2002) | 10, 14, 25, 26, 27, 28, 29, 30 |
| Cohen, Eylon, & Ganiel (1983) | 17 |
| OSS | 18, 23, 24 |
| OYS | 19, 20, 21, 22 |
| Researcher developed | 1, 2, 8, 15 |

To establish the face validity, the PACT about electric circuit concept was checked by experts and teachers from the physics and physics education departments according to the content and format of the instrument. Two experts (PhD candidate research assistant, and an assistant professor) from the Secondary Science and Math Education Department and three at least eight-year experienced physics teachers reviewed the PACT. All these people were explained about the main purpose of test and then they checked the measuring tool according to given criteria asking opinions for appropriateness of items to the grade level, appropriateness of the format and representativeness of content by the selected items. They were given a list of questions about the above criteria and were asked to complete this feedback form attached to the question list. Suggestions were taken into consideration for the revision of instrument. One of the teachers reviewed the test and stated that in the sixteenth question two distracters were same as “İkisinin de parlaklığı artar.” One of the distracters was revised and changed as “İkisinin de parlaklığı azalır.” They all agree that the objectives covered the electric circuits content, that the language difficulty level, the size and format of the figures and script were appropriate for the eleventh grade students, and that a lesson hour was enough for the administration. Finally most of the reviewers were indicated that the level of objectives and the questions measuring them were appropriate. The feedback form is given in Appendix C. Additionally, three versions of PACT were presented in Appendix D. In the first version of PACT, there were thirty items, however, some of these items required that students should solve several steps in order to reach the right answer. Also, all of the items were multiple choice type. In some items, for example, in Item 15, students had to know how to connect a light bulb to the circuit to solve the question, but treatment did not aim to teach students this fact. Therefore such items were excluded form the test in the second and third versions. In the second version, the items that require several steps were rewritten as two or three separate items. This caused the number of items in the test to increase, therefore some of the items were excluded form the test and the number of the items in the test was thirty again. But, while excluding, it was considered that all of the objectives should be measures by at least one item, and all of the content of electric circuits subject was covered by the test. Also, matching type and true-false type items were added to the test. Since some of the symbols could not be seen in the second version of PACT, third version of it was written. This was the final version administered before and after the implementation of treatment.

Also, this test was administered to twenty high school students from various grades to find out the unclear points, the statements that would be probably misunderstood, and the optimal administration time. Students solved the test aloud, after finishing they commented on the language, necessary time to solve all the problems, and perceived difficulty of the test. They found the language clear and understandable and the time enough for solving all the questions, however, some of them said that the test was a little bit harder than they were used to because questions were mostly conceptual rather than computational.

The PACT was applied to the students twice as a pretest before the treatment (n=422) and as a posttest after the treatment (n=307) to both groups. Cronbach α reliability coefficient was calculated for pretest and post test results and was found to be 0.80 and 0.89, respectively. Item analysis was conducted by the ITEMAN program. According to this analysis, item difficulty and item discrimination indices were acceptable. Some statistics of the item analysis of the post-PACT were given in Table 3.5.

Table 3.5 Post-test statistics for the PACT

| | |
|---|---|
| Number of items | 30 |
| Number of examinees | 307 |
| Mean | 16.629 |
| Standard deviation | 7.051 |
| Skewness | 0.01 |
| Kurtosis | -1.09 |
| Cronbach alpha | 0.896 |
| Mean item difficulty | 0.554 |
| Mean item discrimination | 0.447 |

Additionally, item analysis conducted for the pretest and posttest results of the experimental and control groups. The item difficulty values of items in pre and posttest and their differences were presented in a table for experimental and control groups separately in Appendix E and Appendix F. According to these tables, all items were acceptable and they all contributed to overall reliability of the test results.

However, some items which needed further discussion were presented below. There were two tables and two figures related to each item discussed. The tables presented the related item difficulty (P), item discrimination indices (Rpbis and Rbis), Alpha (w/o) index indicated what reliability coefficient would be if the related item were excluded from the entire test. Also pretest and posttest results of each item were examined according to students' achievement (low, medium, and high group). Item difficulty indices were calculated for each group. Additionally, there were two figures representing the P values for each alternative of the item for each achievement group. In fact, a positive slope was expected for the right alternative, while the slopes of the other alternatives were expected to be negative.

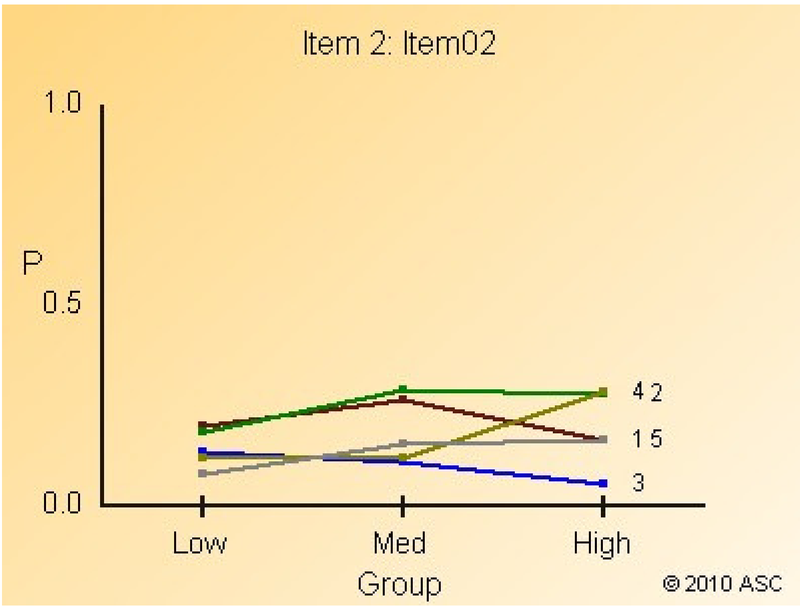


Figure 3.1 Item difficulty versus achievement groups graph for Item 2 in the pretest

Table 3.6 Item difficulty parameters for Item 2 in the pretest

| ID | Key | Scored | Num Options | Domain | N | P | Rpbis | Rbis | Alpha w/o |
|---|---|---|---|---|---|---|---|---|---|
| Item02 | 5 | Yes | 5 | 1 | 273 | 0.139 | 0.020 | 0.031 | 0.787 |
| **Option** | **N** | **Prop.** | **Rpbis** | **Rbis** | **Mean** | **Low P** | **Med P** | **High P** | **Color** |
| 1 | 57 | 0.209 | -0.039 | -0.055 | 11.877 | 0.200 | 0.267 | 0.167 | Maroon |
| 2 | 70 | 0.256 | 0.116 | 0.157 | 13.186 | 0.187 | 0.289 | 0.278 | Green |
| 3 | 26 | 0.095 | -0.130 | -0.226 | 10.308 | 0.133 | 0.111 | 0.056 | Blue |
| 4 | 51 | 0.187 | 0.246 | 0.357 | 14.706 | 0.120 | 0.122 | 0.287 | Olive |
| 5 | 38 | 0.139 | 0.020 | 0.031 | 13.474 | 0.080 | 0.156 | 0.167 | Gray |
| Omit | 31 | 0.114 | -0.188 | -0.311 | 8.032 | 0.280 | 0.056 | 0.046 | |
| Not Reach | 0 | | | | | | | | |

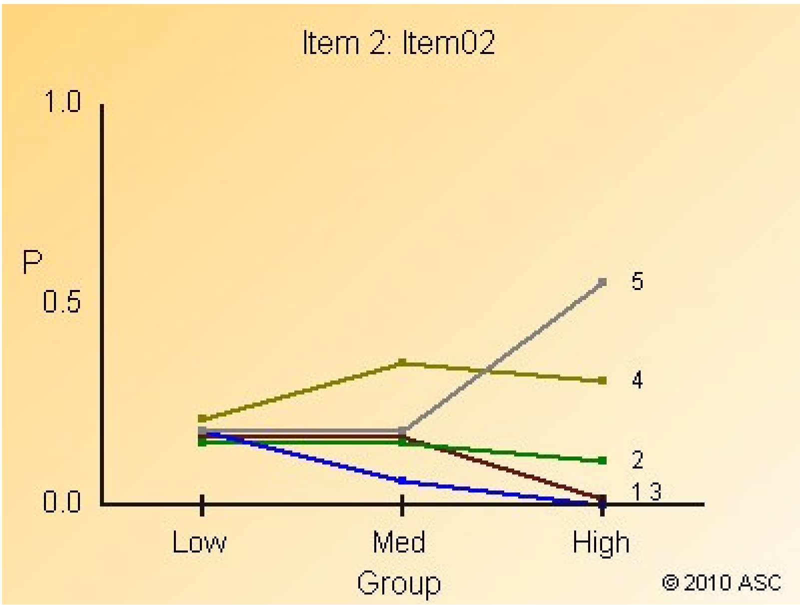


Figure 3.2 Item difficulty versus achievement groups graph for Item 2 in the posttest

Table 3.7 Item difficulty parameters for Item 2 in the posttest

| **ID** | **Key** | **Scored** | **Num Options** | **Domain** | **N** | **P** | **Rpbis** | **Rbis** | **Alpha w/o** |
|---|---|---|---|---|---|---|---|---|---|
| Item02 | 5 | Yes | 5 | 1 | 195 | 0.308 | 0.336 | 0.441 | 0.908 |
| **Option** | **N** | **Prop.** | **Rpbis** | **Rbis** | **Mean** | **Low P** | **Med P** | **High P** | **Color** |
| 1 | 23 | 0.118 | -0.172 | -0.281 | 13.348 | 0.169 | 0.169 | 0.015 | Maroon |
| 2 | 27 | 0.138 | -0.112 | -0.176 | 14.704 | 0.154 | 0.154 | 0.108 | Green |
| 3 | 16 | 0.082 | -0.271 | -0.490 | 10.250 | 0.185 | 0.062 | 0.000 | Blue |
| 4 | 57 | 0.292 | 0.083 | 0.110 | 17.614 | 0.215 | 0.354 | 0.308 | Olive |
| 5 | 60 | 0.308 | 0.336 | 0.441 | 21.283 | 0.185 | 0.185 | 0.554 | Gray |
| Omit | 12 | 0.062 | -0.068 | -0.135 | 13.917 | 0.092 | 0.077 | 0.015 | |
| Not Reach | 0 | | | | | | | | |

Item 2 revealed interesting results, since this item could not discriminate students both in the pretest and posttest for the low and medium groups as Figure 3.1 and Figure 3.2 showed. At the same time, however, this item worked well for the high achievers group. As Table 3.6 indicated, in the pretest, students were not discriminated and the item difficulty level was 0.139 and this value was less than the chance factor of five alternative items, 0.20. In the posttest, as can be seen from Table 3.7 for low and medium achievers groups, students mostly marked the Alternative D, hence, this item cannot discriminate between students in those groups. In the high achiever group, most of the students marked the right alternative, resultantly, the discriminative property of the item increased for high achiever group. One of the reason for this might be the statement “Batteries connected in parallel endure more than the batteries connected in series.” repeated most of the time in teaching the subject. This also showed that students in the high achiever group grasped the principle that "Life of a battery is inversely proportional to the amount of current passing through it." instead of the previously stated more superficial one.

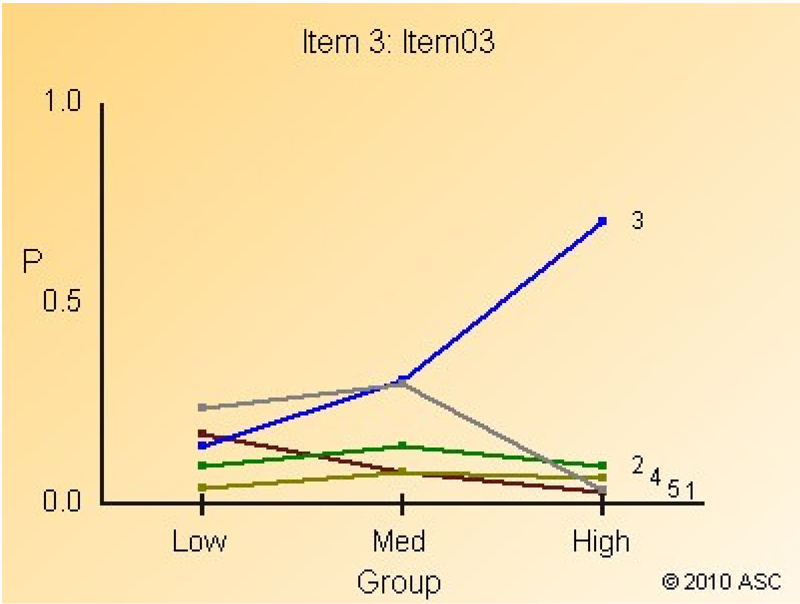


Figure 3.3 Item difficulty versus achievement groups graph for Item 3 in the pretest

Table 3.8 Item difficulty parameters for Item 3 in the pretest

| ID | Key | Scored | Num Options | Domain | N | P | Rpbis | Rbis | Alpha w/o |
|---|---|---|---|---|---|---|---|---|---|
| Item03 | 3 | Yes | 5 | 1 | 273 | 0.421 | 0.445 | 0.562 | 0.769 |
| **Option** | **N** | **Prop.** | **Rpbis** | **Rbis** | **Mean** | **Low P** | **Med P** | **High P** | **Color** |
| 1 | 23 | 0.084 | -0.170 | -0.305 | 9.391 | 0.173 | 0.078 | 0.028 | Maroon |
| 2 | 30 | 0.110 | -0.007 | -0.011 | 11.867 | 0.093 | 0.144 | 0.093 | Green |
| 3 | 115 | 0.421 | 0.445 | 0.562 | 15.348 | 0.147 | 0.311 | 0.704 | Blue |
| 4 | 17 | 0.062 | 0.032 | 0.063 | 12.529 | 0.040 | 0.078 | 0.065 | Olive |
| 5 | 49 | 0.179 | -0.208 | -0.304 | 9.918 | 0.240 | 0.300 | 0.037 | Gray |
| Omit | 39 | 0.143 | -0.179 | -0.277 | 8.795 | 0.307 | 0.089 | 0.074 | |
| Not Reach | 0 | | | | | | | | |

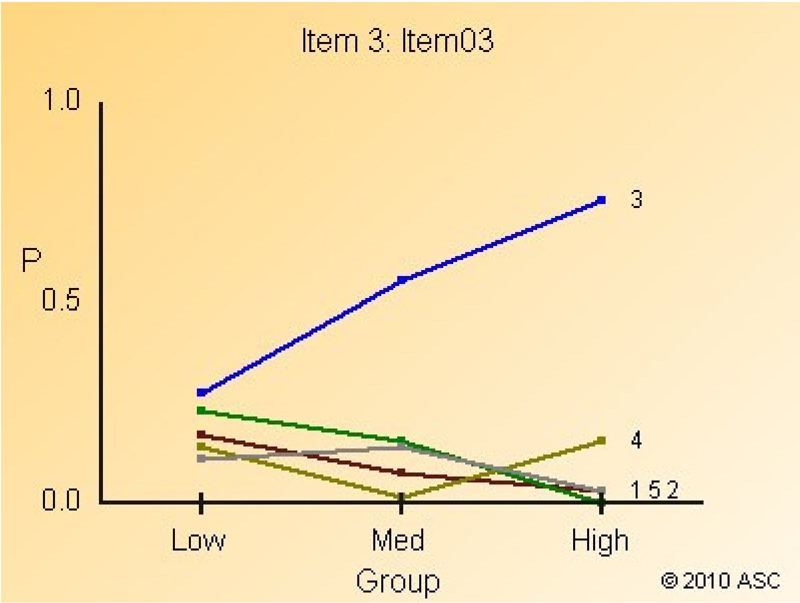


Figure 3.4 Item difficulty versus achievement groups graph for Item 3 in the posttest

Table 3.9 Item difficulty parameters for Item 3 in the posttest

| ID | Key | Scored | Num Options | Domain | N | P | Rpbis | Rbis | Alpha w/o |
|---|---|---|---|---|---|---|---|---|---|
| Item03 | 3 | Yes | 5 | 1 | 195 | 0.528 | 0.368 | 0.461 | 0.907 |
| **Option** | **N** | **Prop.** | **Rpbis** | **Rbis** | **Mean** | **Low P** | **Med P** | **High P** | **Color** |
| 1 | 18 | 0.092 | -0.176 | -0.309 | 12.556 | 0.169 | 0.077 | 0.031 | Maroon |
| 2 | 25 | 0.128 | -0.270 | -0.431 | 11.480 | 0.231 | 0.154 | 0.000 | Green |
| 3 | 103 | 0.528 | 0.368 | 0.461 | 19.942 | 0.277 | 0.554 | 0.754 | Blue |
| 4 | 20 | 0.103 | 0.030 | 0.050 | 17.100 | 0.138 | 0.015 | 0.154 | Olive |
| 5 | 18 | 0.092 | -0.136 | -0.239 | 13.444 | 0.108 | 0.138 | 0.031 | Gray |
| Omit | 11 | 0.056 | -0.036 | -0.072 | 15.000 | 0.077 | 0.062 | 0.031 | |
| Not Reach | 0 | | | | | | | | |

Item 3 was an example of the well worked items in the test. Although it could not discriminate among student in the pretest well, in the posttest, students were discriminated well. When Figure 3.3 and Figure 3.4 were examined, it was apparent that the positive slope of the right alternative becomes steeper from pretest to posters. There was a positive slope for the right alternative, as expected. As can be seen from Table 3.8, in the pretest, the right answer of the question could not discriminate students in low and medium groups, however students in high achievement group chose the right Alternative B, mostly. In the posttest, Table 3.9 showed that students were discriminated well by this question. The slope of P-achievement group graph for Alternative C was positive while those for other alternatives were not. In fact, the treatment applied in the experimental group was effective; students could judge that the amount of energy supplied per unit time (power) is proportional to the amount of current. In activities, students experienced this situation, and saw that lamps were brighter in the third situation.

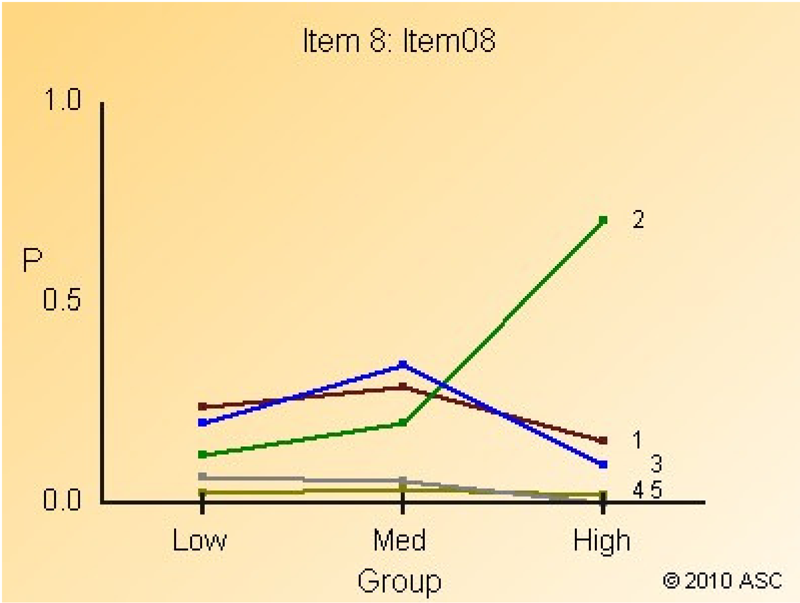


Figure 3.5 Item difficulty versus achievement groups graph for Item 8 in the pretest

Table 3.10 Item difficulty parameters for Item 8 in the pretest

| **ID** | **Key** | **Scored** | **Num Options** | **Domain** | **N** | **P** | **Rpbis** | **Rbis** | **Alpha w/o** |
|---|---|---|---|---|---|---|---|---|---|
| Item08 | 2 | Yes | 5 | 1 | 273 | 0.377 | 0.476 | 0.607 | 0.768 |
| **Option** | **N** | **Prop.** | **Rpbis** | **Rbis** | **Mean** | **Low P** | **Med P** | **High P** | **Color** |
| 1 | 61 | 0.223 | -0.083 | -0.115 | 11.295 | 0.240 | 0.289 | 0.157 | Maroon |
| 2 | 103 | 0.377 | 0.476 | 0.607 | 15.796 | 0.120 | 0.200 | 0.704 | Green |
| 3 | 56 | 0.205 | -0.087 | -0.124 | 11.214 | 0.200 | 0.344 | 0.093 | Blue |
| 4 | 7 | 0.026 | -0.035 | -0.094 | 11.000 | 0.027 | 0.033 | 0.019 | Olive |
| 5 | 10 | 0.037 | -0.107 | -0.249 | 9.500 | 0.067 | 0.056 | 0.000 | Gray |
| Omit | 36 | 0.132 | -0.229 | -0.363 | 7.306 | 0.347 | 0.078 | 0.028 | |
| Not Reach | 0 | | | | | | | | |

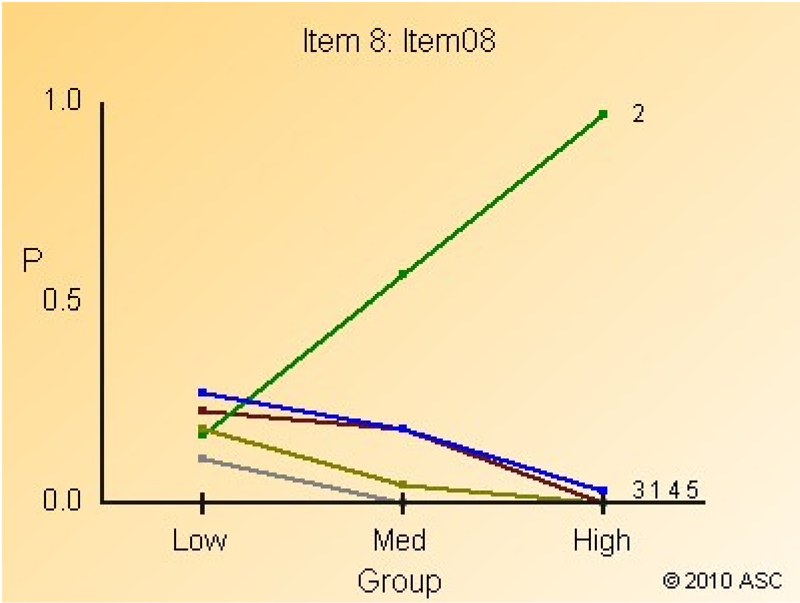


Figure 3.6 Item difficulty versus achievement groups graph for Item 8 in the posttest

Table 3.11 Item difficulty parameters for Item 8 in the posttest

| ID | Key | Scored | Num Options | Domain | N | P | Rpbis | Rbis | Alpha w/o |
|---|---|---|---|---|---|---|---|---|---|
| Item08 | 2 | Yes | 5 | 1 | 195 | 0.569 | 0.644 | 0.811 | 0.902 |
| **Option** | **N** | **Prop** | **Rpbis** | **Rbis** | **Mean** | **Low P** | **Med P** | **High P** | **Color** |
| 1 | 27 | 0.138 | -0.243 | -0.379 | 12.222 | 0.231 | 0.185 | 0.000 | Maroon |
| 2 | 111 | 0.569 | 0.644 | 0.811 | 21.333 | 0.169 | 0.569 | 0.969 | Green |
| 3 | 32 | 0.164 | -0.294 | -0.441 | 11.812 | 0.277 | 0.185 | 0.031 | Blue |
| 4 | 15 | 0.077 | -0.272 | -0.503 | 9.867 | 0.185 | 0.046 | 0.000 | Olive |
| 5 | 7 | 0.036 | -0.242 | -0.570 | 7.714 | 0.108 | 0.000 | 0.000 | Gray |
| Omit | 3 | 0.015 | -0.045 | -0.142 | 12.667 | 0.031 | 0.015 | 0.000 | |
| Not Reach | 0 | | | | | | | | |

In the pretest, Item 8 could not discriminate the students in the low and medium group, as Figure 3.5 indicated. When Table 3.10 was investigated, it can be stated that students in the low and medium group tended to favor the Alternative C and A mostly, although relatively more students marked the right answer in medium group when compared to those in low group. High group students marked the right alternative mostly. In posttest, Figure 3.6 depicted that there was a smooth positively sloped graph for the Alternative B, the right answer. As Table 3.11 presented, again, in the low group, students were spread among all alternatives, but mostly A and C, while in the medium and high group, the question could discriminate students quite well. In essence, Item 8, one of the circuits showed a short circuited arm, so students should notice that short circuit to solve the question. In the treatment group, students examine the effect of an empty wire connected parallel to a lamp, so medium and high group students' success was expected. The reason for low group students' failure might be their failure in recognizing the wire without resistor in the diagram.

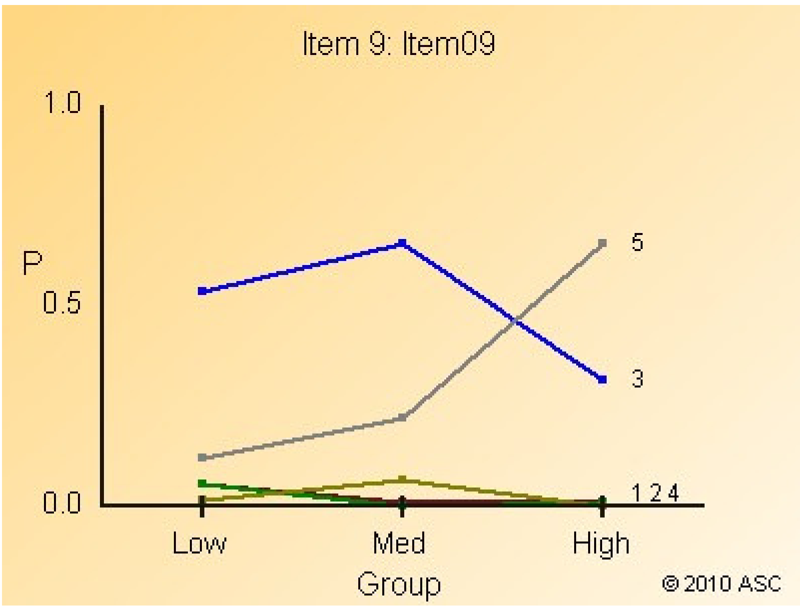


Figure 3.7 Item difficulty versus achievement groups graph for Item 9 in the pretest

Table 3.12 Item difficulty parameters for Item 9 in the pretest

| ID | Key | Scored | Num Options | Domain | N | P | Rpbis | Rbis | Alpha w/o |
|---|---|---|---|---|---|---|---|---|---|
| Item09 | 5 | Yes | 5 | 1 | 273 | 0.366 | 0.478 | 0.612 | 0.767 |
| **Option** | **N** | **Prop.** | **Rpbis** | **Rbis** | **Mean** | **Low P** | **Med P** | **High P** | **Color** |
| 1 | 6 | 0.022 | -0.049 | -0.138 | 10.500 | 0.053 | 0.011 | 0.009 | Maroon |
| 2 | 5 | 0.018 | -0.138 | -0.411 | 7.400 | 0.053 | 0.000 | 0.009 | Green |
| 3 | 133 | 0.487 | -0.182 | -0.228 | 11.158 | 0.533 | 0.656 | 0.315 | Blue |
| 4 | 7 | 0.026 | -0.056 | -0.148 | 10.429 | 0.013 | 0.067 | 0.000 | Olive |
| 5 | 100 | 0.366 | 0.478 | 0.612 | 15.890 | 0.120 | 0.222 | 0.657 | Gray |
| Omit | 22 | 0.081 | -0.201 | -0.366 | 6.045 | 0.227 | 0.044 | 0.009 | |
| Not Reach | 0 | | | | | | | | |

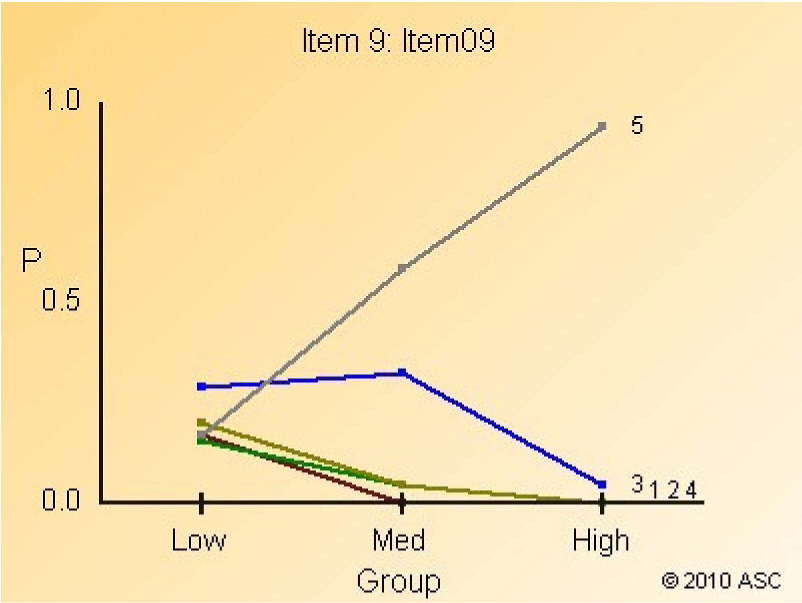


Figure 3.8 Item difficulty versus achievement groups graph for Item 9 in the posttest

Table 3.13 Item difficulty parameters for Item 9 in the posttest

| **ID** | **Key** | **Scored** | **Num Options** | **Domain** | **N** | **P** | **Rpbis** | **Rbis** | **Alpha w/o** |
|---|---|---|---|---|---|---|---|---|---|
| Item09 | 5 | Yes | 5 | 1 | 195 | 0.564 | 0.605 | 0.762 | 0.903 |
| **Option** | **N** | **Prop.** | **Rpbis** | **Rbis** | **Mean** | **Low P** | **Med P** | **High P** | **Color** |
| 1 | 11 | 0.056 | -0.286 | -0.582 | 8.273 | 0.169 | 0.000 | 0.000 | Maroon |
| 2 | 13 | 0.067 | -0.270 | -0.521 | 9.385 | 0.154 | 0.046 | 0.000 | Green |
| 3 | 43 | 0.221 | -0.227 | -0.317 | 13.465 | 0.292 | 0.323 | 0.046 | Blue |
| 4 | 16 | 0.082 | -0.271 | -0.490 | 10.125 | 0.200 | 0.046 | 0.000 | Olive |
| 5 | 110 | 0.564 | 0.605 | 0.762 | 21.155 | 0.169 | 0.585 | 0.938 | Gray |
| Omit | 2 | 0.010 | 0.011 | 0.040 | 17.500 | 0.015 | 0.000 | 0.015 | |
| Not Reach | 0 | | | | | | | | |

In Item 9, there was a short circuit, again, to solve the problem students should notice that empty wire. Interestingly, the results were parallel to the results of Item 8. In the pretest, students in the low and medium group could not notice the short circuit and they could not solve the problem, as supported by Figure 3.7 and Table 3.12. After the treatment, however, medium group students could notice the short circuit but low group students still could not solve the problem, as can be seen from Figure 3.8 and Table 3.13. In the treatment, more emphasis should be given to present the circuits in different forms. For example, in the activity which involved short circuit, students might be asked to draw its symbolic representation. By this way, all students would become familiar and be able to transform one representation of a circuit into other forms of representations.

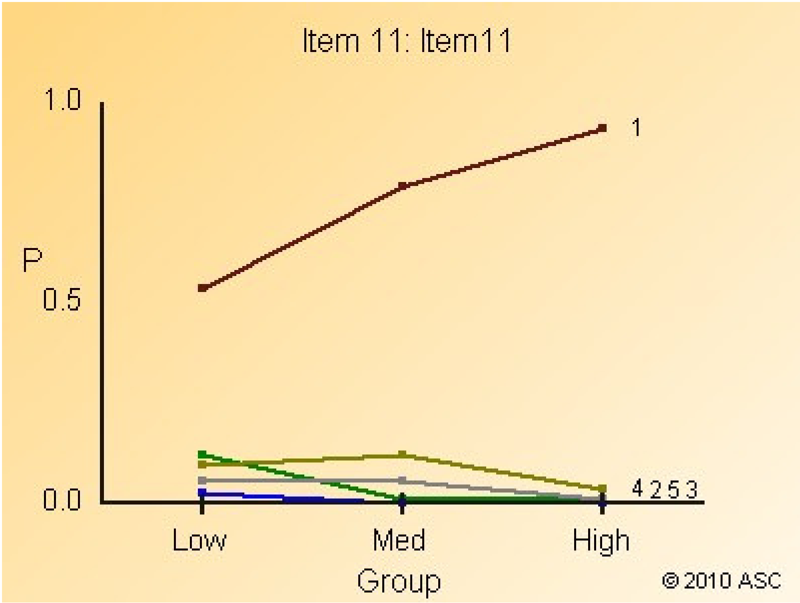


Figure 3.9 Item difficulty versus achievement groups graph for Item 11 in the pretest

Table 3.14 Item difficulty parameters for Item 11 in the pretest

| **ID** | **Key** | **Scored** | **Num Options** | **Domain** | **N** | **P** | **Rpbis** | **Rbis** | **Alpha w/o** |
|---|---|---|---|---|---|---|---|---|---|
| Item11 | 1 | Yes | 5 | 1 | 273 | 0.777 | 0.344 | 0.480 | 0.775 |
| **Option** | **N** | **Prop.** | **Rpbis** | **Rbis** | **Mean** | **Low P** | **Med P** | **High P** | **Color** |
| 1 | 212 | 0.777 | 0.344 | 0.480 | 13.462 | 0.533 | 0.789 | 0.935 | Maroon |
| 2 | 11 | 0.040 | -0.214 | -0.485 | 6.727 | 0.120 | 0.011 | 0.009 | Green |
| 3 | 2 | 0.007 | -0.103 | -0.433 | 6.000 | 0.027 | 0.000 | 0.000 | Blue |
| 4 | 22 | 0.081 | -0.064 | -0.117 | 10.591 | 0.093 | 0.122 | 0.037 | Olive |
| 5 | 10 | 0.037 | -0.071 | -0.166 | 9.900 | 0.053 | 0.056 | 0.009 | Gray |
| Omit | 16 | 0.059 | -0.149 | -0.299 | 6.687 | 0.173 | 0.022 | 0.009 | |
| Not Reach | 0 | | | | | | | | |

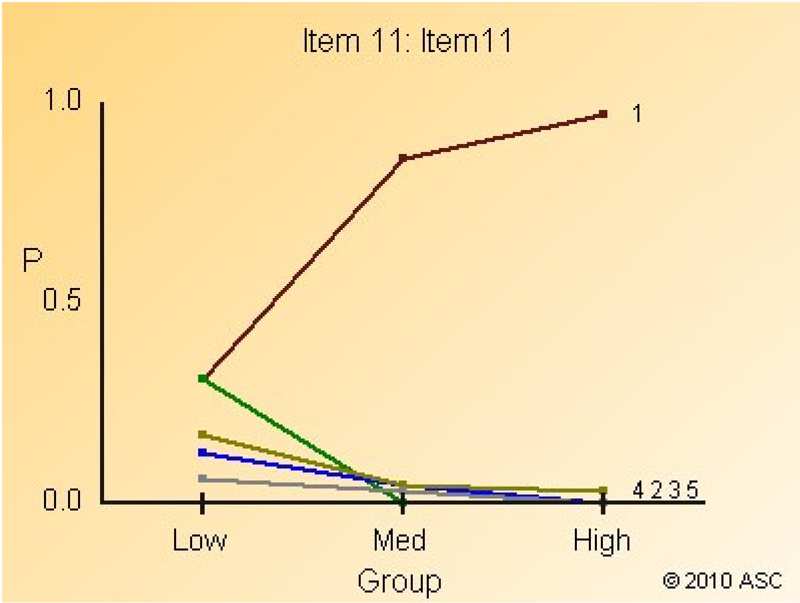


Figure 3.10 Item difficulty versus achievement groups graph for Item 11 in the posttest

Table 3.15 Item difficulty parameters for Item 11 in the posttest

| ID | Key | Scored | Num Options | Domain | N | P | Rpbis | Rbis | Alpha w/o |
|---|---|---|---|---|---|---|---|---|---|
| Item11 | 1 | Yes | 5 | 1 | 195 | 0.713 | 0.607 | 0.806 | 0.903 |
| **Option** | **N** | **Prop.** | **Rpbis** | **Rbis** | **Mean** | **Low P** | **Med P** | **High P** | **Color** |
| 1 | 139 | 0.713 | 0.607 | 0.806 | 19.993 | 0.308 | 0.862 | 0.969 | Maroon |
| 2 | 20 | 0.103 | -0.451 | -0.765 | 6.950 | 0.308 | 0.000 | 0.000 | Green |
| 3 | 11 | 0.056 | -0.213 | -0.434 | 10.182 | 0.123 | 0.046 | 0.000 | Blue |
| 4 | 16 | 0.082 | -0.202 | -0.366 | 11.562 | 0.169 | 0.046 | 0.031 | Olive |
| 5 | 6 | 0.031 | -0.156 | -0.387 | 10.167 | 0.062 | 0.031 | 0.000 | Gray |
| Omit | 3 | 0.015 | -0.036 | -0.114 | 13.333 | 0.031 | 0.015 | 0.000 | |
| Not Reach | 0 | | | | | | | | |

Item 11 is one of the two questions that have a larger P value in the pretest than it has in the posttest; the P value difference was -0.064, as can be calculated from Tables 3.14 and 3.15. As Figure 3.9 and Figure 3.10 indicated, when the P values compared in medium and high level groups from the pretest to the posttest, it was seen that the P values for the right alternative increased. However, in the low level, P values for all distracters increased while the P value for the right answer and omits decreased. One of the reasons for the increase in P values of distracters might be that students, who did not answer the question in the pretest, might possibly, choose the distracters rather than the right answer. But, why did the P value for Alternative A, decreased from the pretest to the posttest? It is apparent also from Item 7, that low group students had difficulty in transferring from one type of representation to other types.

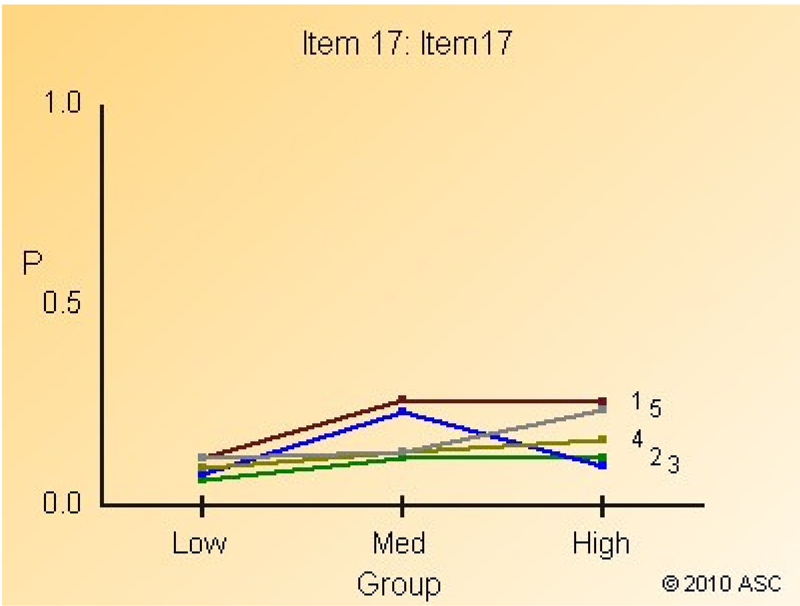


Figure 3.11 Item difficulty versus achievement groups graph for Item 17 in the pretest

Table 3.16 Item difficulty parameters for Item 17 in the pretest

| ID | Key | Scored | Num Options | Domain | N | P | Rpbis | Rbis | Alpha w/o |
|---|---|---|---|---|---|---|---|---|---|
| Item17 | 4 | Yes | 5 | 1 | 273 | 0.136 | 0.038 | 0.060 | 0.787 |
| **Option** | **N** | **Prop.** | **Rpbis** | **Rbis** | **Mean** | **Low P** | **Med P** | **High P** | **Color** |
| 1 | 61 | 0.223 | 0.109 | 0.151 | 13.213 | 0.120 | 0.267 | 0.259 | Maroon |
| 2 | 29 | 0.106 | 0.092 | 0.154 | 13.517 | 0.067 | 0.122 | 0.120 | Green |
| 3 | 38 | 0.139 | 0.002 | 0.003 | 12.263 | 0.080 | 0.233 | 0.102 | Blue |
| 4 | 37 | 0.136 | 0.038 | 0.060 | 13.703 | 0.093 | 0.133 | 0.167 | Olive |
| 5 | 47 | 0.172 | 0.211 | 0.313 | 14.468 | 0.120 | 0.133 | 0.241 | Gray |
| Omit | 61 | 0.223 | -0.251 | -0.349 | 8.656 | 0.520 | 0.111 | 0.111 | |
| Not Reach | 0 | | | | | | | | |

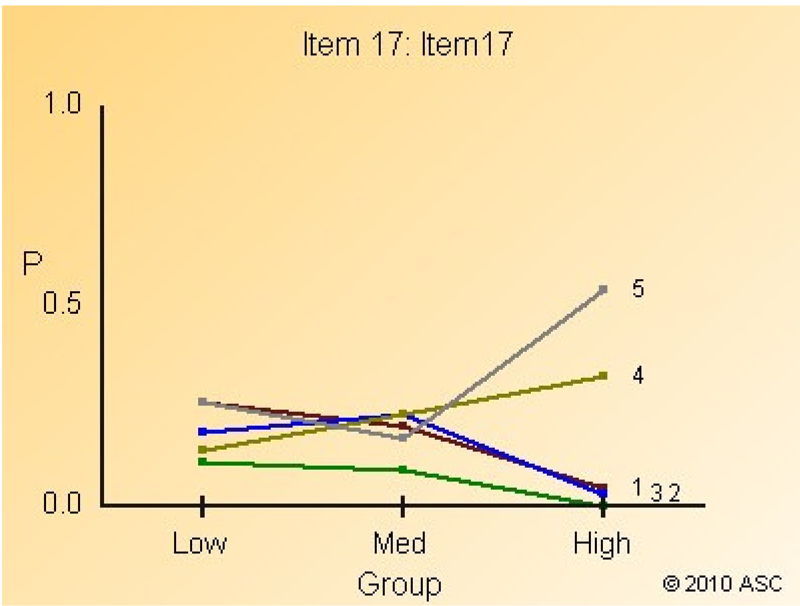


Figure 3.12 Item difficulty versus achievement groups graph for Item 17 in the posttest

Table 3.17 Item difficulty parameters for Item 17 in the posttest

| **ID** | **Key** | **Scored** | **Num Options** | **Domain** | **N** | **P** | **Rpbis** | **Rbis** | **Alpha w/o** |
|---|---|---|---|---|---|---|---|---|---|
| Item17 | 4 | Yes | 5 | 1 | 195 | 0.231 | 0.173 | 0.239 | 0.910 |
| **Option** | **N** | **Prop.** | **Rpbis** | **Rbis** | **Mean** | **Low P** | **Med P** | **High P** | **Color** |
| 1 | 33 | 0.169 | -0.225 | -0.335 | 13.182 | 0.262 | 0.200 | 0.046 | Maroon |
| 2 | 13 | 0.067 | -0.194 | -0.375 | 11.538 | 0.108 | 0.092 | 0.000 | Green |
| 3 | 29 | 0.149 | -0.193 | -0.296 | 13.448 | 0.185 | 0.231 | 0.031 | Blue |
| 4 | 45 | 0.231 | 0.173 | 0.239 | 20.044 | 0.138 | 0.231 | 0.323 | Olive |
| 5 | 63 | 0.323 | 0.261 | 0.340 | 19.492 | 0.262 | 0.169 | 0.538 | Gray |
| Omit | 12 | 0.062 | 0.020 | 0.040 | 17.583 | 0.046 | 0.077 | 0.062 | |
| Not Reach | 0 | | | | | | | | |

Item 17 is the only question that has a larger Alpha w/o value; if this item was excluded from the entire test, test scores would be more reliable. Although Table 3.17 showed that the increase in the reliability coefficient would be very small (0.908 to 0.910), it is worth to discuss the situation. This item asked students whether the stated facts in the alternatives would occur if a second battery was connected in parallel to the present one in a circuit. Figure 3.11, Figure 3.12, and Table 3.16 showed that students in the low and medium group could not be discriminated both in the pretest and posttest, however, in the posttest high achiever students tended to choose either Alternative D or E, and unfortunately, most of those choose the Distracter E. Students used to consider how much was the current in the main branch, and how much was it on the resistors. Although high achievers were able to solve that the current circling around the main wires and the resistors would not change, they could not thought that the current would be divided when passing through the batteries. In the treatment, it would be better to include an activity for measuring the amount of current passing through each battery.

### 3.3.2 Physics Attitude Scale

The instrument PATS was used to determine the attitudes of eleventh grade students in both groups. This attitude scale was previously used by Küçüker (2004) reported in her master thesis. She had also adapted this instrument from the attitude scale used by Taşlıdere (2002) by reversing 5 items to their negative ones and changing the last two items into their new forms. The previous items were “Simple electric circuits topics are more interesting than other topics.” and “I want to be a member of physics society.” Both attitude scales were in simple electric circuits unit, so there is no need to adapt the scale for the content. The items were designed to be rated on a 5-point Likert type response format ranging from absolutely disagree to absolutely agree. Strongly disagree was graded as 1 points and strongly agree was graded as 5 point on a Likert type. The scale includes 24 items that measure the attitudes of eleventh grade students. Küçüker (2004) reported that this instrument had 5 sub-dimensions as enjoyment, self-efficacy, importance of physics, interest related behavior, and achievement motivation and she had made five of the questions negative (Items 4, 8, 13, 17, 24). She had reported a reliability of $\alpha$=0.83, however, she did not report factor analysis of the modified attitude scale; she only wrote the sub-dimensions which were reported in Taşlıdere’s study. Also, Taşlıdere (2002) reported a reliability coefficient of 0.94 (Cronbach $\alpha$) for the results of this attitude test in his study. The items numbers belong to each factor according to Taşlıdere’s study were indicated in Table 3.18.

Table 3.18 Item numbers associated with the factors of the attitude scale in Taşlıdere's study

| **Factors** | **Item Numbers** |
|---|---|
| Enjoyment | 1, 2, 16, 17, 23 |
| Self-efficacy | 9, 10, 11, 18, 21 |
| Importance of physics | 3, 4, 5, 13, 14 |
| Achievement motivation | 6, 7, 8, 12 |
| Interest related behavior | 15, 19, 20, 22, 24 |

For the content validity, the views of the physics teachers and experts in universities that are studying in that area were taken. In order to assess whether the attitude scale had the same sub-dimensions, a factor analysis was carried out on results of both pre and post attitude scales. All the items were coded and entered in SPSS data file. While entering the data, positively stated items were coded as 1 for "Kesinlikle katılmıyorum." and 5 for "Kesinlikle katılıyorum."; negatively stated items were coded in an opposite manner, 1 for "Kesinlikle katılıyorum." and 5 for "Kesinlikle katılmıyorum." In the pretest, the KMO measure is 0.88 that indicates that the sample is enough to conduct a factor analysis. The observed significance level is 0.00 for the Barlett's test that indicates that there is a strong relationship among variables and thus a factor analysis for the data can be conducted. The items loaded to the factors are presented in Table 3.19. In this study, these factors are almost similar to those presented in Taşlıdere's (2002) study however; enjoyment factor seemed to scatter on the other factors. Also, negative items were loaded on an individual factor. Items loaded on the self-efficacy factor were same as the items in Taşlıdere's study. Nearly the same pattern of factor loadings was found in Serin's doctoral thesis study in 2009. In his doctoral thesis, Serin used the adapted version of this attitude scale to pressure unit. The negative items were loaded on a single individual factor in the analysis of attitude scale both in the pilot study and in the results of pre-attitude scale; items in the enjoyment factor were loaded on the other factors. In the current study, three of the five negative items were loaded on a separate factor whereas the other two negatively stated items were loaded on the other factors to which they were related.

Table 3.19 Factors from the Pre-PATS

| **Factors** | **Item Numbers** |
|---|---|
| Interest related behavior / **Enjoyment** | **1, 2**, 15, **16**, 19, 20, 22 |
| Self-efficacy | 9, 10, 11, 18, 21 |
| Importance of physics / **Enjoyment** | 3, 5, 14, **23** |
| Achievement motivation / **Enjoyment** | 6, 7, 8, 12, **17** |
| Negative items | 4, 13, 24 |

The KMO measure was 0.91 for the post-PATS. The Bartlett's test indicated the significance level of 0.00. Five factors were found as a result of factor analysis of post-attitude scale scores. The eigenvalues of the factors are presented in Table 3.20. These five factors explain nearly 63 % of the total variance as seen in the table.

Table 3.20 Eigenvalues and Explained Variance for the Factors

| Component | Initial Eigenvalues | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 9.085 | 37.853 | 37.853 | 5.395 | 22.481 | 22.481 |
| 2 | 2.206 | 9.190 | 47.043 | 3.438 | 14.326 | 36.807 |
| 3 | 1.446 | 6.027 | 53.070 | 3.330 | 13.875 | 50.682 |
| 4 | 1.271 | 5.295 | 58.365 | 1.591 | 6.629 | 57.311 |
| 5 | 1.031 | 4.294 | 62.659 | 1.284 | 5.348 | 62.659 |
| 6 | .884 | 3.685 | 66.344 | | | |
| 7 | .822 | 3.426 | 69.771 | | | |
| 8 | .792 | 3.301 | 73.072 | | | |
| 9 | .717 | 2.988 | 76.060 | | | |
| 10 | .638 | 2.659 | 78.718 | | | |
| 11 | .606 | 2.527 | 81.245 | | | |
| 12 | .557 | 2.321 | 83.565 | | | |
| 13 | .521 | 2.170 | 85.735 | | | |
| 14 | .479 | 1.994 | 87.729 | | | |
| 15 | .449 | 1.869 | 89.598 | | | |
| 16 | .417 | 1.736 | 91.334 | | | |
| 17 | .383 | 1.594 | 92.928 | | | |
| 18 | .336 | 1.400 | 94.329 | | | |
| 19 | .303 | 1.262 | 95.591 | | | |
| 20 | .267 | 1.114 | 96.705 | | | |
| 21 | .252 | 1.050 | 97.755 | | | |
| 22 | .240 | 1.000 | 98.754 | | | |
| 23 | .117 | .725 | 99.480 | | | |
| 24 | .125 | .520 | 100.000 | | | |

The factor loadings of the items are presented in Table 3.21. In the first item there were 11 items. Four items were loaded on the second and third factors. Three items were included in the fourth factor. Finally, fifth factor consists of two items.

Table 3.21 Loadings of Items to the Factors

| Items | Components | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Q7 | .769 | | .180 | .123 | |
| Q6 | .769 | .104 | .202 | .192 | |
| Q12 | .759 | .147 | .231 | | |
| Q10 | .720 | .171 | .163 | | .266 |
| Q11 | .689 | .351 | .160 | | .142 |
| Q18 | .658 | .444 | | | |
| Q2 | .655 | .151 | .515 | | |
| Q1 | .623 | .205 | .462 | | .143 |
| Q21 | .562 | .483 | .160 | .181 | |
| Q8 | .546 | -.107 | | .514 | |
| Q16 | .455 | .404 | .424 | .134 | |
| Q20 | .132 | .827 | .226 | | |
| Q19 | .148 | .818 | | | |
| Q22 | .161 | .736 | .323 | .132 | |
| Q15 | .180 | .601 | .423 | | |
| Q14 | .157 | .166 | .807 | | |
| Q3 | .205 | .258 | .788 | | |
| Q5 | .335 | .230 | .632 | .102 | |
| Q23 | .270 | .316 | .521 | .147 | |
| Q24 | | .255 | .167 | .675 | .213 |
| Q17 | .289 | | .198 | .638 | .220 |
| Q9 | .353 | | .253 | -.493 | .202 |
| Q13 | | | | | .747 |
| Q4 | | | -.197 | .160 | .655 |

Factors extracted from the analysis of the post-attitude scale scores were named in line with Taşlıdere's study. They were indicated in Table 3.22. The factor interest related behavior was nearly same as it was in Taşlıdere's study, except Item 24. This item was changed by Küçüker and the new item is more related to enjoyment factor. In the current study, the factors self-efficacy and achievement motivation coincided. Since the items of each factor have very close meanings, it is tolerable that students' answers yielded a single factor instead of two. If students have self-efficacy, they will be more self confident and think that they are able to succeed in electric circuits. Also in the same factor, there are three items (1, 2, and 16) previously loaded on the enjoyment factor in Taşlıdere's study. This situation was not a surprise, hence, the students, who are motivated, are expected to enjoy and to have positive feelings toward the electric circuits topic. The third factor was importance of physics, same three items (3, 5, and 14) were loaded in this factor, and however Item 23 was loaded in enjoyment factor in Taşlıdere's study. As previously mentioned, Küçüker changed this item and it is more related to importance of physics factor in the current study. Items 4 and 13 were loaded on another factor in present study; although they are related to how students give importance to physics, they are much more indicators of students' views that their career choices and plans will relate to their learning of electric circuits topic. Apart from being negatively stated items in the scale, they can be labeled as future use of electric circuits. Three items were loaded on the enjoyment factor, Item 17 was loaded on the same factor in Taşlıdere's study, and Item 24 was changed by Küçüker and now it is more related to enjoyment factor. As can be seen from Table 3.9, Item 9 was negatively loaded in this factor. Although students think that they are able to learn this topic, they can simply do not like to study it. In the Post-PATS, two of the five negative items were loaded on a separate factor whereas the other three negatively stated items were loaded on the other factors to which they were related.

Table 3.22 Factors from the Post-PATS

| Factors | Item Numbers |
|---|---|
| Interest related behavior | **15, 19, 20, 22** |
| Self-efficacy / *Achievement Motivation* | 1, 2, ***6, 7, 8,*** **10, 11**, ***12,*** 16, **18, 21** |
| Importance of physics | **3, 5, 14**, 23 |
| Enjoyment | 9, **17**, 24 |
| Negative items | 4, 13 |

Also the reliability of the scale was found to be 0.89 for both the pretest and posttest results. The items are scored with respect to their favorable meanings, "1" indicating the lowest favorable choice in the Likert scale while "5" indicates the highest favorable one. Possible PATS scores range from 24 to 120, with higher scores indicating positive attitudes towards electric circuits unit and lower scores indicating negative attitudes towards electric circuits unit.

The PATS, given in Appendix G, also was applied to the students twice as a pretest before the treatment (n=452) and as a post test after the treatment (n=320) to both inquiry-based and lecture groups.

### 3.3.3 Group Embedded Figures Test

Students' cognitive styles were measured by a eighteen item Group Embedded Figures Test (GEFT). This test was developed by Witkin et al (1971). Witkin and et al had developed an Embedded Figures Test (EFT) which was administered individually and so inefficient to use with large groups. Therefore they developed the group administered version of this test as GEFT. The GEFT includes three sections; there are 7 figures in the first section, 9 items in the second and third sections. There are 6 simple figures named as simple form A, B, C, D, E, F, H, and G. These simple forms are embedded in 26 complex figures, and students are asked to find the simple forms in the complex figures and draw them on these complex ones. Students have 2 minutes for completing the first section, and 5 minutes each for completing the second and third sections. The GEFT is a speed test indeed and these time limits are especially important for administration. First section is for exercising only, to prevent students' errors and to provide them a warm up session. Second and third sections are scored only. The items are accepted as true if and only if students draw the exact simple form without extra or missing lines. Each true item is scored 1 and each wrong or missing item is scored 0. So the range of the possible scores is between 0 and 18. Also, there are important and useful instructions in the first page of the GEFT and before administration, examiner should read these instructions and be sure that students understand them. The GEFT should be in a booklet form and the simple forms should be printed at the back cover of this booklet so that students are prevented to look at simple forms and complex figures at the same time. However, they have permission to look at the simple forms as much as they want. This instrument was translated into Turkish and validated by Cakan (2003).

Mind Garden Incorporation sent to each researcher an information letter about the GEFT. In this letter they provided some evidences of reliability of GEFT results. The reliability coefficient of the GEFT scores was reported as 0.82 for males and females (calculated by Spearman-Brown prophecy formula). The scores of the GEFT and other cognitive style tests (ABC Scale, EFT) were correlated and resulted in high coefficients as a construct related validity evidence.

The internal reliability of the GEFT results was calculated and was found as 0.86 in the current study. The GEFT was administered in 16 classrooms in line with the administration rules before the treatment. The GEFT booklet is not given in the appendix due to copyright constraints, however, the sample questions provided by Mind Garden Incorporation is given in Appendix H.

### 3.3.4 Classroom Observation Checklist

A classroom observation checklist was developed in order to use for treatment verification. It consisted of items according to the Inquiry-based Teaching Methods and Lecturing Methods criteria to observe whether there existed a difference in terms of treatments between the two groups or not and whether the methods used in the groups were what the researcher intended or not. There were twenty items in the checklist. And each item was evaluated by selecting one of the alternatives, yes, partially, no, and not applicable and by noting the frequencies of the situation. This classroom observation checklist is presented in Appendix I. For the reliability concern, two persons from the Secondary Science and Mathematics Education department at METU observed same classes for eight lessons and their observations were analyzed in order to obtain inter-rater reliability. The reliability coefficients were found to be between the range 0.92 to 1.00. Therefore, it could be concluded that the observations made by one of the observers was also reliable. Thirty nine lessons out of one hundred and sixty eight lessons were observed, eight of the thirty six lessons were observed by two observers, the rest of them were observed by the researcher only. By this way, each class of both experimental and control groups was observed three times in random time intervals. This corresponded to 23% of the lessons. A score was calculated for each group to determine to what degree the treatment was given to each group. The results of this analysis are presented in Chapter 4.

The same observation checklist was also used to define teachers preferred teaching styles one month before the study. The researcher observed a regular physics course of each teacher and scored their lessons by the observation checklist. After that, teachers were grouped as those who are instructing physics with inquiry-based or lecture methods. All of the teachers were found to be teaching with deductive methods as a result of these observations. So, the regular lessons of the teachers were accepted as lecture lessons. Additionally, their lesson plans, the questions solved in the classes were collected as proofs for lecture instruction. The regular lessons that teachers were used to were accepted as the lectured classes, however, this lessons were again observed during implementation as well as the inquiry-based taught classes in order to have treatment verification.

### 3.4 Teaching/Learning Materials

Various materials were used in this study; objective list, table of test specification, lesson plans, objective-lesson plan table, and inquiry-based teaching criteria list. While preparing lesson plans, the objective list of electric circuits unit and inquiry-based teaching criteria list were taken into consideration. These materials were developed by the researcher.

Lesson plans applied in the inquiry-based teaching classes were mostly based on the CASTLE project and then revised by two experts (a PhD candidate research assistant, and a assistant professor from the Secondary Science and Math Education Department of METU) in physics education, three at least eight-year experienced physics teachers, and the teachers of the treatment groups. Four lesson plans were prepared for four week treatment period. There were three 45-minute physics lessons in a week, and these lessons plans were applied in the first two lessons of inquiry groups. By this way, inquiry groups would be presented firstly with application of the principles and then they were presented with the definitions of related concepts, formulas and quantitative problems in which they were going to use these previous information and their previous experiences.

The CASTLE Project was developed by Dr. Melvin S. Steinberg in 1995 and revised through 10 editions up to year 2008. In this project he aimed to make students visualize electricity while they were learning. The CASTLE was the abbreviation for Capacitor Aided System for Teaching and Learning Electricity. In extent of this project, a guide book was written, Electricity Visualized, containing instructional materials, homework and quizzes for teachers. It tried to be an alternative for the textbooks by providing an introductory module not requiring prior knowledge of electricity for high school students. Also its target audience was physics teachers who wanted to engage students' interest through hands-on investigation, overcome misconceptions that inhibit learning and reasoning, and foster development of effective explanatory models. It included a series of experiments about electric circuits with light bulbs, batteries, and specially designed capacitors, since this topic provides a productive domain for hands-on inquiry and inquiry teaching.

The CASTLE included eleven lesson plans covering all electric circuits concepts, however the aim of this study was developing inquiry lesson plans in line with the eleventh grade physics curriculum offered by Ministry of Education. Therefore only four of these lesson plans were chosen and necessary revisions were made. They were translated into Turkish by the researcher and then these Turkish versions were given a teacher of English to translate back in English. The original and the translated English lesson plans were compared. There were not any serious differences which would cause misunderstandings. The lesson plans were also revised by the experienced physics educators and implementer teachers whether they could be completed in a lesson hour, whether they were appropriate for the students and in line with the curriculum, and whether there were necessary materials in the schools. The objective-lesson plan table was also presented to the reviewers with the lesson plans. Teachers approved the plans to be completed in a lesson, and they told how many materials were missing and should be supplied. Some of the teachers were suspicious for they did not have laboratory or adequate amount of materials. Therefore, in the schools with no laboratories, desks were arranged in clusters and necessary materials were provided by the researcher. Physics educators also approved that the lesson plans were appropriate for students and for teaching electric circuits topic in line with the curriculum. The last versions of three of these lesson plans are given in Appendix J.

Along with these lesson plans an instructional guide for implementers (in this case, teachers) was prepared. In this guide, predict-observe-explain approach of the lesson plans, and students' possible reactions to this approach, important points that should be taken into consideration while implementing lesson plans were explained briefly. This instructional guide is also given in Appendix K

In order to see whether those lesson plans were properly developed, objective-lesson plan table was prepared firstly. It indicates which lesson plan matches with which objective and is given in Appendix L. Next, all lesson plans were prepared according to inquiry-based teaching criteria. These criteria were presented in Table 3.23.

Table 3.23 Lesson Plan Preparing Criteria

| | |
|---|---|
| Start with application | Determine the application that makes the learning relevant. |
| Ensure active involvement | Make students involve actively and work together in groups. |
| Provide scaffolding | Give initial structure and assist students throughout learning. |
| Reflect on learning together | Discuss in larger group to share learning. |

## 3.5 Research Design

In Turkey, to assign each subject to experimental and control groups randomly in regular classes is almost impossible due to administrative regulations. For this reason, intact groups were used. These intact groups were assigned to inquiry-based (experimental) and lecture (control) groups randomly. Also, students in experimental and control groups were matched statistically on certain variables. This situation makes the design of the current study a quasi-experimental one.

Table 3.24 shows the research design of the study. Both control and experimental groups were given pretests at the beginning of the study, before the treatments began. Then, students were instructed as inquiry-based or lectured, according to their groups. After treatments were completed, the students were given posttests. Covariate analysis was used to match students.

Table 3.24 Research Design of the Study

| | **O (Pretest)** | **M (Matching)** | **X (Treatment)** | **O (Posttest)** |
|---|---|---|---|---|
| **Inquiry Group** | PREACH<br>PREATT<br>GEFT | Statistical matching | Inquiry-based Teaching | PSTACH<br>PSTATT |
| **Lecture Group** | PREACH<br>PREATT<br>GEFT | Statistical matching | Lecture Teaching | PSTACH<br>PSTATT |

3.6 Procedure

At the beginning of the study, using the keywords "Aptitude Treatment Interactions", "inquiry teaching", "lecturing", "traditional methods", "deductive teaching", "learner characteristics", "cognitive style", learning style", "physics education", "electricity", and "electric circuits" a detailed review of the literature search was carried out. Educational Resources Information Center (ERIC), Academic Search Complete, JSTOR, Taylor & Francis, Wiley InterScience, International Dissertation Abstracts (DAI), Social Science Citation Index (SSCI), Ebscohost, and Internet (Google and Google Scholar) were searched systematically. Previous studies made in Turkey were also searched from the Turkish Higher Education Council National Dissertation Center, Journal of National Education, Hacettepe University Journal of Education, Eğitim ve Bilim, and from journals of various universities' education faculties. Photocopies of accessible documents were taken from METU library, library of Bilkent University and TUBİTAK Ulakbim.

After literature review was completed and population and sample size were decided, treatments were shaped. Since teachers are reluctant to participate in experiments in which they are only implementers, they were included into the decision making period. Teaching styles of them were investigated by a checklist to determine whether they were teaching with inquiry-based or lecturing methods mostly. After establishing their preferred styles, necessary modifications were discussed and decided in a workshop which was conducted two weeks before the implementation in one of the schools and lasted for one weekend. In this workshop, the basic principles of inquiry-based teaching were explained to teachers, implementation guide was presented and discussion sessions were set. Since this method was new to implementer teacher, they had many questions about method, activities; they were a bit suspicious about students' reactions, and so on. Also, the researcher wanted to reach a consensus about what the common terms like inquiry, activities, mean to every teacher, and about the important points that should be obeyed and attended in the implementation process. Implementation guide and lesson plans were read together, hands-on activities were performed as if all they were in a class, the amount of time and materials required were decided. So that, the last form of the lessons (lesson plans, teacher and student materials) for both of the treatment groups were determined. Then lesson plans were given their final shapes. And they were showed to experienced physics educators for content and face validity.

In the implementation period, classes were observed in order to make sure that treatments were implemented as intended. Treatments lasted approximately five weeks.

Fraenkel and Wallen (1996) stated that there are three important ethical principles that should be addressed in every research. These are protecting participants from harm, ensuring confidentiality of research data and deception. In this study protecting participants from harm was not a problem since there was no physical or psychological harm and danger that might arise due to research procedures. Ensuring confidentiality was also important in this study. Once the data is collected, the researcher made sure that no one else had access to the data and the names of the subjects were removed from all data collection forms. All subjects were assured that any data collected from them were held in confidence. The names of the individual subjects were never used in any publications. Consent forms were signed by the subjects' families where the purpose of the research was announced to the participants in detail. The consent form is given in Appendix M. Everything was clearly explained to the subjects of the study. Therefore, deception also was not the concern of this study.

When the sample was selected, necessary permission was taken from the ministry of education in order to implement the treatment and the tests. The permission document is presented in Appendix N. After permission taken, the study was carried out in 2008-2009 academic year on eleventh grade students from the six high schools in the central district of Aydın. Pretests were administered to both control and experimental groups by the researcher herself by the last week of March 2009. Since all six high schools were not following the curriculum in same speed, the pretests, treatments, and posttests were not administered at the same time in the all schools. The PACT and PATS were applied to the students twice as a pretest and after the treatment period as a post test to both groups. Students in the control group were lectured, whereas students in the experimental groups were instructed based on inquiry. Treatments were given by the teachers of the students included in the sample and continued up to five weeks except test administration. But, in one of the school, treatment could not be implemented because they could not finish the previous topics in the curriculum in the previously set time. Therefore this school was excluded from the study, although students were pretested. Also, in one school, in one of the experimental groups, the post tests could not be implemented because students were all absent during the last two weeks. Although they took the treatment, this group was excluded from the study also.

Electric circuits unit is the last topic of the second semester, and Ministry of National Education orders teachers to complete their assessment procedure two weeks before the schools are closed. Therefore, students did not continue to attend school for the last two weeks, after their examinations ended. Although the treatments were completed successfully before the last two weeks, because of students' absence, some data were lost at the posttest. In fact, in one of the classes of an Anatolian high school, students did not attend any of the physics course in the last two week and unfortunately the achievement test could not be administered as posttest in that classroom. Additionally, in one of the public high schools of the sample, "electric circuits" topic could not be completely instructed, consequently, treatment was not completed and achievement test was not administered to this group as posttest. This situation explains the excess amount of data lost from the pretest to the posttest.

## 3.7 Implementation of Treatments

In this section, treatments given to inquiry-based instructed and lectured groups are explained in two parts.

### 3.7.1 Treatment given to Inquiry-based Instructed Group

Inquiry-based instruction was given to 9 classes from five different high schools and it was planned for a four week period. There were three physics lessons in a week. In the first two lessons students were given an activity sheet in which they would perform hands-on inquiry activities about electric circuits. In the last lesson, related concepts and formulas were instructed. Students would have the background learning experiences to which they would relate these concepts. Also, in the last lesson, a class discussion and quantitative problem solving session were performed. The aim of class discussion was to make students reflect about their learning, to make the relation between inquiry activities and related concepts explicit. While doing hands-on activities, the terms like current, resistance, voltage, and energy were not used until they were discovered by students. After students experienced these concepts and needed a common term to define them, these terms were defined. This was a very important point in the implementation of the treatment. Students worked in groups of five usually, but these amount increased or decreased one students time to time.

Before the treatment began, teachers and the researcher met twice to make the implementation procedure clear to everyone. They negotiated about the important points to consider, possible students responses to the activities and how to handle them, duration of the activities, availability of the necessary materials and equipments. Also they performed these activities in their own and discussed about the possible handicaps and solutions.

In the activity sheets, there were some circuit diagrams, and questions. Students set up these circuits as shown in the figures and then were asked to answer the questions by writing down these answers to the blanks between the questions. Each group should complete an activity sheet, and these sheets were collected at the end of the activity. While students were doing activities, they were required to participate in group discussions; each student was forced to share his or her group's responsibility. To ensure this participation, and to guide when needed, teachers walked around the class and asked students questions about the activity randomly. This forces each student to be interested in the inquiry. In the first week, students were a bit reluctant to participate in the activities and express their ideas about the questions; they were asking for the formal lecture format and formulas, but by the second week they got used to inquiry approach. Additionally, since they relate their experiences with the concepts, they stated that the lesson content was making more sense to them. In the end of the activities, all groups were presented their answers to the questions in the activity sheets; they discussed the similar and different observations and the inferences made from those observations. This helped them to find and construct a common ground for further learning. The activity sheets for the three of the four weeks are given in Appendix J.

### 3.7.2 Treatment given to the Lectured Group

After the population and sample of the study were decided, the researcher had observed the teachers regular lessons to figure out their teaching styles. All of the teachers were found to be deductive instructors. They firstly presented content, fundamental principles, necessary formulas, and then solved sample quantitative problems on board; wanted their students to note them down; and finally asked students more quantitative problems similar to the ones he or she had solved. This way of instruction was nearly same to the lecture method that the researcher had intended. Therefore, there was not any manipulation in the control group, the lessons were just observed in order to maintain what they instructed and how they did. The observations were expected to verify that the treatment given to control group was lecture method. The analysis of the observation checklist is presented in Chapter 4.

## 3.8 Analysis of Data

After data collection, all the related variables data were entered in a SPSS data file. Students' numbers, schools, classes, genders, treatment groups (group memberships), pre and post PACT and PATS scores, GEFT scores, ages, PPCGs were presented in this data file. Then missing data analysis was conducted. Missing values of all variables were inspected and treated in an appropriate manner. This missing data analysis procedure was explained in more detail in Chapter 4. To describe the data, the mean, standard deviation, skewness, kurtosis, range, minimum, maximum values and the histograms were presented for the inquiry-based teaching and lecturing groups. Following descriptive statistics, inferential statistics were calculated. In order to test the null hypotheses, all statistical computations were done by using statistical package program (SPSS). In this study, there were two DVs (post achievement and post attitude scores of students). The effect of the interactions between the methods of instruction and students' cognitive styles and other independent variables on students' achievement and attitude toward electric circuits topic were investigated. Therefore, statistical technique, named Multivariate Analysis of Covariance (MANCOVA) was used. The PREACH, PREATT, school, PPCG, gender, age, and CoS were covariates. Lastly, posttest scores of the students were the dependent variables. This process was explained in more detail in Chapter 4.

3.9 Power Analysis

To achieve the desired power for the study at the end of the study, sample size determination procedure was conducted at the beginning of the study. In order to determine the necessary sample size, the probability of rejecting true null hypothesis (probability of making Type I error) named as alpha ($\alpha$), the probability of failing to reject a false null hypothesis (probability of making Type II error) named as beta ($\beta$), and the aimed effect size of the results should be preset before the study. In the current study, $\alpha$ was set as 0.05, $\beta$ was set to value of 0.20, therefore the preset power of the study (1-$\beta$), the probability of rejecting a false null hypothesis was set to 0.80. This value for power of the study was suggested by Cohen and Cohen (1983, p.162). The effect size of the study was set as medium effect size of 0.15 which is measured by $f^2$ (Cohen & Cohen, 1983, p.161) in the light of the previous researches.

Then, L value was determined as 18.34 as it was indicated in the L values table presented in Cohen and Cohen (2003, p. 651). Since there were seven independent variables and two dependent variables in the study, $k_b$ was taken as 7+7=14. To conclude L value was 18.34 for $\alpha$=0.05, power=0.80, and $k_b$=14.

The required sample size was calculated by the formula given in Cohen and Cohen (2003, p.93). The values of L (18.34), effect size (0.15), and number of covariates $k_b$ (14) were substituted in the formula and required sample size was found to be 138 for the current study.

In this study, sample size was 298 for inferential statistics. For this sample size of 298, L value was calculated and it was found as 42.45 for medium effect size of 0.15, fourteen independent variables by using the same formula above mentioned (Cohen & Cohen, 2003, p.93). According the L values table for $\alpha=0.05$, this calculated L value was beyond the power=0.99.

## 3.10 Unit of Analysis

In this study, unit of analysis is the each individual student; however, experimental unit is the each class in which the treatments were implemented. Thus, experimental unit of study and the unit of analysis did not match. Since the experimental unit is one intact classroom, students' interactions between themselves were inevitable. Therefore, independent observations of the treatment could not be reached. But in the testing steps, data collectors were warned that they should be careful about preventing interactions between students and all tests were administered to students in one school simultaneously. Independence of observation could be said to be attained at least in the testing process.

## 3.11 Assumptions and Limitations

In this study, the following cases are assumed to be met:

- Students completed the tests and activities seriously, consciously, independently, and truthfully.
- Independence of observations was satisfied.
- Characteristics of nine teachers who implemented the treatments were not affected the results of the study.

This study is limited by and to the following situations:

- This study is limited to the eleventh grade high school students in central district of a middle size city.
- This study is limited to the "electric circuits" unit.

- The pilot studies for the treatment and measuring instruments could not be performed due to lack of time. Replicates of this study will provide more informative results.

# CHAPTER 4

# RESULTS

The results are divided into five sections. The first section presents how the missing data were handled before the analysis. The second section presents the descriptive statistics associated with the data collected from the administration of the physics achievement and physics attitude pre-and post-tests and the GEFT. The third section of this chapter presents the inferential statistical data yielded from testing the three null hypotheses outlined in Chapter 1. Additionally, the third section explains the results of the aptitude treatment interactions practically. The fourth section explains the results of classroom observations. Finally, the last section summarizes the findings of the study.

## 4.1 Missing Data Analysis

Since the electric circuits unit was the last chapter of the second semester of the academic year, some students were absent in the post-testing procedure. Additionally, in one of the public schools, treatment did not start; because teacher could not catch up with the curriculum. In this high school, students took the pretests, but they did not take the treatments and post-tests. Also, in one of the Anatolian High Schools, in an experimental class, all of the students were absent when the posttests were administered. The missing values of the variables are presented in Table 4.1.

Table 4.1 Missing Data Analysis before Treatments

| Variables | Present (N) | Missing (N) | Missing (%) |
|---|---|---|---|
| PREACH | 419 | 41 | 8.9 |
| PREATT | 431 | 29 | 6.3 |
| CoS | 431 | 29 | 6.3 |
| PSTACH | 307 | 153 | 33.3 |
| PSTATT | 319 | 141 | 30.7 |
| Gender | 460 | 0 | 0 |
| Age | 451 | 9 | 2 |
| PPCG | 449 | 11 | 2.4 |
| School | 460 | 0 | 0 |

Those students who did not have all two posttest scores were excluded listwise from the data. After posttests, the number of students who had all the two posttests is 298. The missing values of each variable are presented in Table 4.2. Since the missing values did not exceed 10% of the total values, they were replaced by the mean of the distribution.

Table 4.2 Missing Data Analysis after Excluding Absentees

| Variables | Present (N) | Missing (N) | Missing (%) |
|---|---|---|---|
| PREACH | 288 | 10 | 3.4 |
| PREATT | 298 | 0 | 0 |
| CoS | 290 | 8 | 2.7 |
| PSTACH | 298 | 0 | 0 |
| PSTATT | 298 | 0 | 0 |
| Gender | 298 | 0 | 0 |
| Age | 298 | 0 | 0 |
| PPCG | 298 | 0 | 0 |
| School | 298 | 0 | 0 |

## 4.2 Descriptive Statistics

Male and female students were distributed approximately even. There were 157 male and 141 female students corresponding to 52.7 % and 47.3% of the whole sample respectively. Students' distribution according to their PPCG levels is presented in Table 4.3.

Table 4.3 Distribution of Students across PPCG Levels

| Science Course Grade | f | % |
|---|---|---|
| 0 | 10 | 3.4 |
| 1 | 25 | 8.4 |
| 2 | 30 | 10.1 |
| 3 | 55 | 18.5 |
| 4 | 98 | 32.9 |
| 5 | 80 | 26.8 |
| Total | 298 | 100 |

After the missing data were handled, some of the descriptive statistics were computed for the variables GENDER, CoS, SCHOOL, PPCG, Age, PREACH, PREATT, PSTACH, and PSTATT. Some of these statistics are given in Table 4.4.

Table 4.4 Descriptive Statistics for Independent Variables, PSTACH, and PSTATT

| | N | Mean | SD | Effect Size | Skewness | Kurtosis | Min | Max |
|---|---|---|---|---|---|---|---|---|
| **GENDER** | | | | | | | | |
| Inquiry | 189 | 1.45 | 0.50 | 0.12 | 0.20 | -1.98 | 1 | 2 |
| Lecture | 109 | 1.51 | 0.50 | | -0.06 | -2.04 | 1 | 2 |
| Total | 298 | 1.47 | 0.50 | | 0.11 | -2.00 | 1 | 2 |
| **CoS (GEFT Scores)** | | | | | | | | |
| Inquiry | 189 | 9.76 | 4.18 | 0.33 | 0.07 | -1.02 | 1 | 18 |
| Lecture | 109 | 11.22 | 4.38 | | -0.33 | -0.67 | 1 | 18 |
| Total | 298 | 10.30 | 4.31 | | -0.06 | -0.96 | 1 | 18 |
| **PPCG** | | | | | | | | |
| Inquiry | 189 | 3.24 | 1.52 | 0.76 | -0.56 | -0.76 | 0 | 5 |
| Lecture | 109 | 3.95 | 0.93 | | -0.80 | 0.26 | 1 | 5 |
| Total | 298 | 3.50 | 1.38 | | -0.83 | -0.14 | 0 | 5 |
| **AGE** | | | | | | | | |
| Inquiry | 189 | 1991.90 | 0.42 | 0.13 | 1.08 | 3.87 | 1990 | 1993 |
| Lecture | 109 | 1991.95 | 0.38 | | 1.60 | 8.84 | 1990 | 1993 |
| Total | 298 | 1991.92 | 0.41 | | -1.244 | 5.17 | 1990 | 1993 |
| **PREACH** | | | | | | | | |
| Inquiry | 189 | 13.36 | 4.79 | 0.23 | 0.10 | -0.18 | 2 | 26 |
| Lecture | 109 | 14.50 | 5.06 | | 0.19 | -0.68 | 4 | 26 |
| Total | 298 | 13.77 | 5.00 | | 0.15 | -0.45 | 2 | 26 |
| **PREATT** | | | | | | | | |
| Inquiry | 189 | 76.67 | 14.94 | 0.11 | -0.46 | 0.98 | 24 | 113 |
| Lecture | 109 | 78.32 | 14.76 | | -0.20 | -0.14 | 33 | 111 |
| Total | 298 | 77.27 | 14.87 | | -0.36 | 0.59 | 24 | 113 |
| **PSTACH** | | | | | | | | |
| Inquiry | 189 | 16.91 | 7.23 | 0.14 | 0.02 | -1.12 | 2 | 30 |
| Lecture | 109 | 15.99 | 6.62 | | -0.08 | -1.23 | 4 | 29 |
| Total | 298 | 16.57 | 7.02 | | 0.00 | -1.12 | 2 | 30 |
| **PSTATT** | | | | | | | | |
| Inquiry | 189 | 76.70 | 15.66 | 0.10 | 0.239 | 1.39 | 33 | 142 |
| Lecture | 109 | 75.17 | 15.89 | | -0.228 | 0.974 | 24 | 112 |
| Total | 298 | 76.14 | 15.73 | | 0.063 | 1.232 | 24 | 142 |

The School variable included six schools and these six schools were coded as; 1 for AYDIN, 2 for EMUAL, 3 for ADMAL, 4 for SDAL, 5 for FEN and 6 for EFELER. Also, male students were coded as 1 while the females were coded as 2. Although in the overall sample the number of female students was greater than the number of male students, there were more female students in lecture group than there were in inquiry group. Students could get a minimum score of 0 and maximum score of 18 from GEFT. The higher the score that a student got from GEFT; the more field independent he or she was. The mean of the GEFT scores of the lecture group was 11.22 and it was higher than the mean of the inquiry group which was 9.76. Students' year of births were taken as they are for the variable of Age. There was not any remarkable difference between the students' ages according to Table 4. 4. The range of variable of PPCG was 0 to 5. When the experimental and control groups were investigated, students in the lecture group had a higher mean of PPCG (3.95 out of 5.00) then the students had in the control group (3.24 out of 5.00). This difference in the means of PPCG variable revealed to middle effect size. Students could get a minimum score of 0 and a maximum score of 30 from the PREACH and PSTACH. Experimental and control groups' means were very close to each other on the PREACH and on the PSTACH. However, control group had slightly higher mean on the PREACH whereas experimental group's mean was slightly higher on the PSTACH. Nearly the same situation was valid for the PREATT and PSTATT mean scores of the experimental and control groups. The minimum and maximum scores that a student could get from PREATT and PSTATT are 24 and 120 respectively. Since the skewness and Kurtosis values are between the acceptable ranges, all distributions could be accepted as normally distributed.

The students were grouped as field dependent, field intermediate, and field dependent according to their GEFT scores. The students who had GEFT scores ½ standard deviation lower from the mean were classified as field dependents and coded as 1; the students who had ½ standard deviation higher than the mean were classified as field independent and coded as 3, and finally, those who had GEFT scores between the ± ½ standard deviation of the mean were named as field intermediate or field mix students and coded as 2. The frequencies and the variation of the field dependent, field mixed, and field independent students are given in Figure 4.1 and Table 4.5. According to Figure 4.1, the students' GEFT scores were said to be distributed normally. The total number of students who had 0, 1, and 2 form GEFT was 8; that of students who had 3 and 4 from GEFT was 24, and etc. After the categorization of GEFT scores as described above, the number of field dependent students was 110, the number of field mixed students was 86 and that of the field independent students was 102, as indicated in Table 4.5.

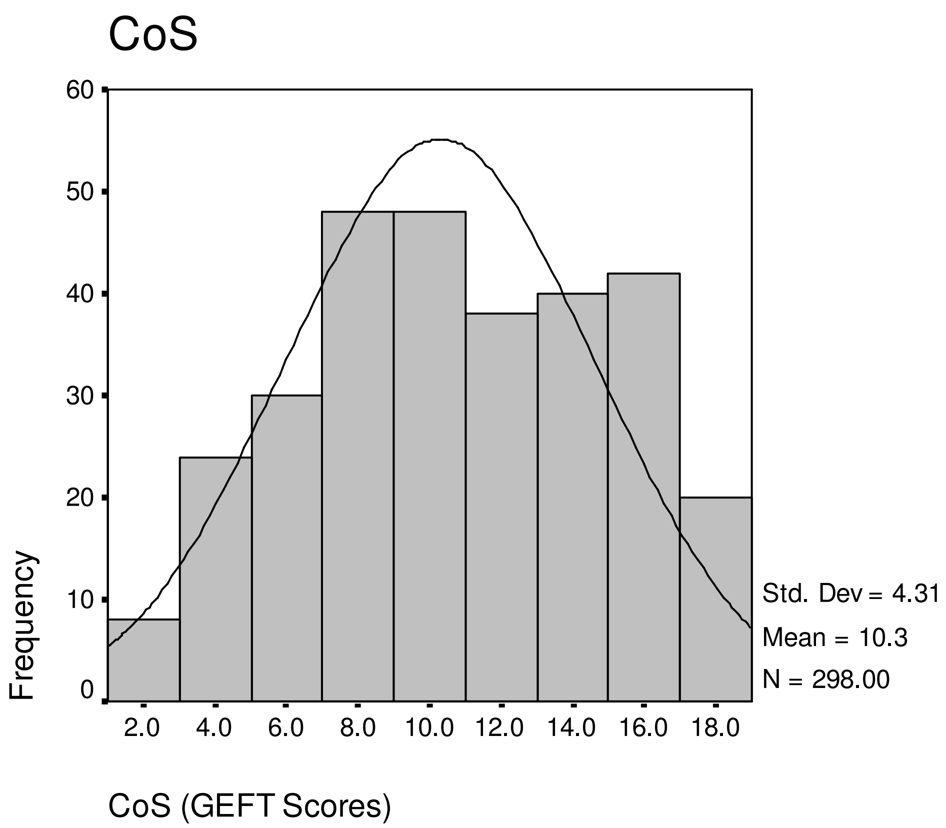


Figure 4.1 Histogram of the variable "CoS"

Table 4.5 Frequencies of Field-Dep, Field-Mix, and Field-Ind Students

| | Frequency | Percent | Valid Percent |
|---|---|---|---|
| 1 (Field-Dep) | 110 | 36.9 | 36.9 |
| 2 (Field-Mix) | 86 | 28.9 | 28.9 |
| 3 (Field-Ind) | 102 | 34.2 | 34.2 |
| Total | 298 | 100.0 | 100.0 |

The gain scores with respect to group membership are given in Table 4.6. The most increase in the achievement is observed in the experimental group. The mean of the attitude scores decreased in control group, but in the experimental group, change in the mean attitude scores is nearly zero.

Table 4.6 Gain Scores in Achievement and Attitude with respect to Group Membership

| Test | Group | Average Gain Score (Posttest-Pretest) |
|---|---|---|
| Achievement | Inquiry | 2.55 |
| | Lecture | 1.49 |
| Attitude | Inquiry | 0.03 |
| | Lecture | -2.15 |

## 4.3. Inferential Statistics

### 4.3.1 Determination of Covariates

In order to decide which variables can be used as covariates, correlations between all variables used in the study were calculated. The results are given in Table 4.7.

Table 4.7 Correlations between Potential Covariates and Dependent Variables

| | POSTACH | POSTATT | PREACH | PREATT | SCHOOL | GENDER | PCGA | CoS |
|---|---|---|---|---|---|---|---|---|
| POSTATT | 0.15* | | | | | | | |
| PREACH | 0.48* | 0.09 | | | | | | |
| PREATT | 0.19* | 0.59* | 0.24* | | | | | |
| SCHOOL | 0.70* | -0.04 | 0.36* | -0.00 | | | | |
| GENDER | -0.07 | -0.22* | -0.17* | -0.33* | -0.02 | | | |
| PPCG | 0.52* | 0.17* | 0.34* | 0.25* | 0.51* | 0.05 | | |
| CoS | 0.28* | 0.04 | 0.26* | 0.17* | 0.26* | -0.07 | 0.29* | |
| Age | 0.13* | 0.09 | 0.08 | 0.02 | 0.20* | 0.05 | 0.23* | 0.07 |

* Correlation is significant at the 0.05 level.

According to Table 4.7, all the independent variables have a significant correlation with at least one of the dependent variables, PSTACH and PSTATT. Also, these independent variables do not have correlation among themselves exceeding 0.80. Therefore all the variables mentioned above can be used as covariates.

4.3.2 Assumptions of MANCOVA

There are five assumptions of MANCOVA; independence of observations, normality, multicollinearity, equality of variances, and homogeneity of regression.

Independence of observations assumption requires students to perform the test individually, without interacting with other students. In this study, unit of analysis is the each individual student; however, experimental unit is the each class in which the treatments were implemented. Thus, experimental unit of study and the unit of analysis did not match. Since the experimental unit is one intact classroom, students' interactions between themselves were inevitable. Therefore, independent observations of the treatment could not be reached. But in the testing steps, data collectors were warned that they should be careful about preventing interactions between students and all tests were administered to students in one school simultaneously. Independence of observation could be said to be attained at least in the testing process. Both in the pretesting and posttesting procedures, the researcher was present in all schools and the teachers were warned about this issue. Also, there were not any sign of violence to this assumption in the test results. So, this assumption is said to be met.

Normality assumption can be checked through skewness and kurtosis values. These values are given in Table 4.4 in descriptive section. None of the variables' skewness and kurtosis values exceeds ±2 which are the limit values for normal distribution (George & Mallery, 2003, pp. 98-99). Additionally, multivariate normality can be validated by using Box's Test. The result of this test is given in Table 4.8. Since p value is smaller than 0.05, multivariate normality is violated. This violation may cause from the non equal and small sample sizes in each cell. Since the Pillai's Trace index is more robust than Wilks' Lambda to violation of homogeneity of covariance matrices assumption, it is used for interpreting the MANCOVA results.

Table 4.8 Results for Multivariate Normality Test

| | |
|---|---|
| Box's M | 74.340 |
| F | 1.460 |
| df1 | 33 |
| df2 | 1277.755 |
| Sig. | 0.046 |

If there are high correlations among a set of independent variables then there might be multicollinearity (Cohen & Cohen, 1983, p115). Correlations among covariates do not exceed the values 0.80, as seen in Table 4.7. Therefore, assumption of multicollinearity is satisfied.

Equality of variances assumption is checked through the Levene's test of equality of error variances. The result of the Levene's test of equality of error variances is indicated in Table 4.9. Since all the p values are greater than 0.05, this assumption is satisfied.

Table 4.9 Results for Test of Equality of Error Variances

| | F | df1 | df2 | Sig. |
|---|---|---|---|---|
| PSTACH | 1.145 | 226 | 71 | 0.255 |
| PSTATT | 0.968 | 226 | 71 | 0.580 |

In order to check the last assumption, homogeneity of regression, Multiple Regression Correlation (MRC) analysis was conducted. This analysis was conducted for both dependent variables, PSTACH and PSTATT. For the PSTACH dependent variable, all seven independent variables, PREACH, PREATT, school, gender, PPCG, CoS, and age were included in Set A as covariates. Set B was the group membership variable. The interaction terms of Set A variables with group membership variable constituted Set C. Interaction terms were formed by multiplying Set A variables with Set B variable. The result of MRC analysis is shown in Table 4.10. According to Table 4.10, there was a significant interaction between covariates and group membership for the PSTACH ($R^2$=0.021, F Change=2.625, $df_1$=6, $df_2$=283, p=0.017). Therefore the homogeneity of regression assumption was not met for the PSTACH. MANCOVA could not be conducted; additional MRC analysis should be done to meet the homogeneity of regression assumption. In this MRC analysis, significant covariates and their interaction terms were included in the group membership block.

Table 4.10 MRC analysis indicating the homogeneity of regression assumption for the PSTACH

| | Change Statistics for the PSTACH | | | | |
|---|---|---|---|---|---|
| Model | $R^2$ Change | F Change | df1 | df2 | Sig. F Change |
| Set A (Covariates) | 0.571 | 55.162 | 7 | 290 | 0.000 |
| Set B (Group membership) | 0.022 | 15.422 | 1 | 289 | 0.000 |
| Set C (Set A X Set B) | 0.021 | 2.625 | 6 | 283 | 0.017 |

The same set of covariates, PREACH, PREATT, school, gender, PPCG, CoS, and age, was used as Set A for the PSTATT variable. Set B was the group membership while Set C was the interaction terms of covariates and the group membership variable. The result of this analysis is indicated in Table 4.11. According to this table, homogeneity of regression assumption was satisfied for the PSTATT, since there was not a significant interaction between the covariates and the group membership.

Table 4.11 MRC analysis indicating the homogeneity of regression assumption for the PSTATT

| | Change Statistics for the PSTATT | | | | |
|---|---|---|---|---|---|
| Model | $R^2$ Change | F Change | df1 | df2 | Sig. F Change |
| Set A (Covariates) | 0.319 | 19.369 | 7 | 290 | 0.000 |
| Set B (Group membership) | 0.005 | 2.327 | 1 | 289 | 0.128 |
| Set C (Set A X Set B) | 0.012 | 0.826 | 6 | 283 | 0.551 |

Additional MRC analysis for both the PSTACH and PSTATT was conducted to satisfy the condition that Set C is not significant. Therefore significant independent variables and interaction terms of the above analysis were put into Set B, group membership variables, gender remained in Set A as the covariate, and the variable age was discarded form the analysis. To avoid the significant interaction terms of covariates and group membership variables, gender was left in the covariate block, Block 1 or Set A; PREACH, PREATT, School, PPCG, and CoS were sent to Group membership block, hence Block 2 or Set B covered MOI, PREACH, PREATT, School, PPCG, CoS, MOI*PREACH, MOI*PPCG, PREATT*MOI*PPCG*CoS, MOI*PPCG*CoS, PREACH*School, and PREACH*PREATT variables; Set C covered all the interaction terms gained by multiplying all variables included in Set A and Set B (Gender*MOI, Gender*PREACH, Gender*PREATT, Gender*School, Gender*PPCG, Gender*CoS, Gender*MOI*PREACH, Gender*MOI*PPCG, Gender*PREATT*MOI*PPCG*CoS, Gender*MOI*PPCG*CoS, Gender*PREACH*School, and Gender*PREACH*PREATT). All Sets were indicated in Table 4.12.

Table 4.12 Variables in Set A, Set B, and Set C

| Variable Set | Entry Order | Variable Name |
|---|---|---|
| A (Covariates | 1st | X1=Gender |
| B (Group Membership) | 2nd | X2=MOI |
| | | X3=CoS |
| | | X4=PREACH |
| | | X5=PREATT |
| | | X6=School |
| | | X7=PPCG |
| | | X8=MOI*PREACH |
| | | X9=MOI*PPCG |
| | | X10=PREACH*School |
| | | X11=PREATT*MOI*PPCG*CoS |
| | | X12=MOI*PPCG*CoS |
| | | X13= PREACH*PREATT |
| C = A*B (Covariate*Group Interactions) | 3rd | X14= Gender*MOI |
| | | X15= Gender*CoS |
| | | X16= Gender*PREACH |
| | | X17= Gender*PREATT |
| | | X18= Gender*School |
| | | X19= Gender*PPCG |
| | | X20= Gender*MOI*PREACH |
| | | X21= Gender*MOI*PPCG |
| | | X22= Gender*PREACH*School |
| | | X23=Gender*PREATT*MOI*PPCG*CoS |
| | | X24=Gender*MOI*PPCG*CoS |
| | | X25=Gender*PREACH*PREATT |

Table 4.13 and Table 4.14 represented the MRC results for the PSTACH ($R^2$=0.028, F Change=1.779, $df_1$=12, $df_2$=272, p=0.052)and the PSTATT($R^2$=0.010, F Change=0.362, $df_1$=12, $df_2$=272, p=0.975) with interaction terms in group membership. In this MRC analyses, since the interaction terms were not significant, MANCOVA could be conducted.

Table 4.13 MRC results for the PSTACH with interaction terms in group membership

| | Change Statistics for the PSTACH | | | | |
|---|---|---|---|---|---|
| Model | $R^2$ Change | F Change | df1 | df2 | Sig. F Change |
| Set A (Gender) | 0.005 | 1.578 | 1 | 296 | 0.210 |
| Set B (Group membership) | 0.609 | 37.362 | 12 | 284 | 0.000 |
| Set C (Set A X Set B) | 0.028 | 1.779 | 12 | 272 | 0.052 |

Table 4.14 MRC results for the PSTATT with interaction terms in group membership

| | Change Statistics for the PSTATT | | | | |
|---|---|---|---|---|---|
| Model | $R^2$ Change | F Change | df1 | df2 | Sig. F Change |
| Set A (Gender) | 0.047 | 14.585 | 1 | 296 | 0.000 |
| Set B (Group membership) | 0.304 | 11.070 | 12 | 284 | 0.000 |
| Set C (Set A X Set B) | 0.010 | 0.362 | 12 | 272 | 0.975 |

### 4.3.3 MANCOVA Model

MANCOVA Model was used to test the hypotheses of this study. The dependent variables of this study were the PSTACH and PSTATT scores of the students. The covariate, gender, was used to statistically equalize the students' characteristics. Group membership with respect to two groups (inquiry or lecture groups) was named here as "MOI" and used as fixed factor of this study with the other group membership variables, PREACH, PREATT, School, PPCG, CoS, MOI*PREACH, MOI*PPCG, PREATT*MOI*PPCG*CoS, MOI*PPCG*CoS, PREACH*School, and PREACH*PREATT. Table 4.15 presents the results of this MANCOVA Model.

Table 4.15 Multivariate test results

| Effect | Pillai's Trace | F | Hyp. df | Error df | Sig. | Eta Squared | Observed Power |
|---|---|---|---|---|---|---|---|
| GENDER | 0.02 | 1.74 | 2.0 | 197.0 | 0.178 | 0.017 | 0.362 |
| MOI | 0.05 | 4.70 | 2.0 | 197.0 | 0.010 | 0.046 | 0.783 |
| CoS | 0.02 | 0.74 | 4.0 | 396.0 | 0.565 | 0.007 | 0.238 |
| PREACH | 0.02 | 0.81 | 4.0 | 396.0 | 0.519 | 0.008 | 0.259 |
| PREATT | 0.24 | 13.43 | 4.0 | 396.0 | 0.000 | 0.119 | 1.000 |
| SCHOOL | 0.41 | 12.86 | 8.0 | 396.0 | 0.000 | 0.206 | 1.000 |
| PPCG | 0.16 | 3.52 | 10.0 | 396.0 | 0.000 | 0.082 | 0.994 |
| MOI*PREACH | 0.04 | 2.11 | 4.0 | 396.0 | 0.079 | 0.021 | 0.625 |
| MOI*GPA | 0.04 | 1.06 | 8.0 | 396.0 | 0.387 | 0.021 | 0.497 |
| PREACH*SCHOOL | 0.10 | 1.36 | 16.0 | 396.0 | 0.157 | 0.052 | 0.844 |
| MOI*CoS*PPCG | 0.17 | 1.04 | 36.0 | 396.0 | 0.410 | 0.086 | 0.928 |
| MOI*CoS*PREATT*PPCG | 0.38 | 1.02 | 92.0 | 396.0 | 0.444 | 0.191 | 0.998 |
| PREACH*PREATT | 0.03 | 0.75 | 8.0 | 396.0 | 0.643 | 0.015 | 0.352 |

As Table 4.15 indicates, the observed power of this study was 0.78 and the effect size was calculated as 0.046. This is lower than the calculated power of the study, which was 0.80. The reason for the difference between calculated and observed power values is the difference between the effect size values of each. Effect size was set to medium effect size ($\eta^2$=0.06) at the beginning of the study, however at the end of the study it was found to be small effect size ($\eta^2$=0.046).

There were three null hypotheses in this study; they were listed below.

Null Hypothesis 1

There is no significant effects of methods of instruction, (MOI; lecture versus inquiry) and its interaction with students' cognitive styles (CoS; field-independent, field-mixed, field-dependent) and other independent variables (physics achievement pretest scores, PREACH; physics attitude pretest scores, PREATT; previous physics course grades, PPCG; school, age, and gender) on the population means of the collective dependent variables of eleventh grade students' achievement posttest scores (PSTACH) and attitude towards electric circuits unit posttest scores (PSTATT).

According to results of MANCOVA, this hypothesis was partly rejected. Methods of instruction had a significant effect (Pillai's Trace=0.05; df (2,197); F=4.70; p=0.01) on the collective dependent variables PSTACH and PSTATT. According to Table 4.15, MOI, PREATT, School, and PPCG had significant effects on the collective dependent variables PSTACH and PSTATT when the students' gender was controlled. However, none of the interactions had significant effects on collective dependent variables. Since the number of students in each interaction cell was very small to reach statistical significance, effect size values would be more informative than p values for the interaction terms. Therefore, it can be concluded that there is a significant mean difference of achievement in and attitude toward electric circuits subject between the eleventh grade students who were exposed to lecture and inquiry instruction.

As Table 4.15 indicates, the observed power of this study was 0.78 for the main effect and the effect size was calculated as 0.046. This is lower than the calculated power of the study, which was 0.99. The reason for the difference between calculated and observed power values is the difference between the effect size values of each. Effect size was set to medium effect size ($\eta^2$=0.06) at the beginning of the study, however at the end of the study it was found to be small effect size ($\eta^2$=0.046).

Null Hypothesis 2

There is no significant effects of methods of instruction (lecture versus inquiry) and its interaction with students' cognitive styles (field-independent versus field dependent) and other independent variables on the population means of eleventh grade high school students' physics achievement posttest scores.

ANCOVAs were conducted after MANCOVA, as a follow up analysis, in order to determine the effect of methods of instruction on single dependent variables. According to results of ANCOVA, second null hypothesis of the study was partly rejected. Methods of instruction had a significant effect (F=9.455 (1); p=0.002) on the dependent variable PSTACH, however, the interactions among several independent variables did not have a significant effect. Therefore, it can be concluded that there is a significant mean difference of achievement in electric circuits subject between the eleventh grade students who were exposed to lecture and inquiry instruction.

As Table 4.16 indicates, the observed power of this study was 0.86 and the effect size was calculated as 0.046. This is lower than the calculated power of the study, which was 0.99. The reason for the difference between calculated and observed power values is the difference between the effect size values of each. Effect size was set to medium effect size ($\eta^2$=0.06) at the beginning of the study, however at the end of the study it was found to be small effect size ($\eta^2$=0.046).

Null Hypothesis 3

There is no significant effects of methods of instruction (lecture versus inquiry) and its interaction with students' cognitive styles (field-independent versus field dependent) and other independent variables on the population means of eleventh grade high school students' physics attitude posttest scores.

According to results of ANCOVA, third null hypothesis of the study was failed to be rejected. Methods of instruction did not have a significant effect

(F=0.071 (1); p=0.791) on the dependent variable PSTATT, in addition, the interactions among several independent variables did not have a significant effect. Therefore, it can be concluded that there is no significant mean difference of attitude toward electric circuits subject between the eleventh grade students who were exposed to lecture and inquiry instruction.

As Table 4.16 indicates, the observed power of this study was 0.058. This is lower than the calculated power of the study, which was 0.99. The reason for the high difference between calculated and observed power values is the difference between the effect size values of each. Effect size was set to medium effect size (ES=0.06) at the beginning of the study, however at the end of the study it was found to be small effect size (ES=0.000).

Table 4.16 Result of ANCOVA for PSTACH and PSTATT

| Source | Dependent Variable | df | F | Sig. | Eta Squared | Observed Power |
|---|---|---|---|---|---|---|
| Corrected Model | PSTACH | 99 | 6.805 | 0.000 | 0.773 | 1.000 |
| | PSTATT | 99 | 2.513 | 0.000 | 0.557 | 1.000 |
| Intercept | PSTACH | 1 | 312.226 | 0.000 | 0.612 | 1.000 |
| | PSTATT | 1 | 620.165 | 0.000 | 0.758 | 1.000 |
| GENDER | PSTACH | 1 | 2.074 | 0.151 | 0.010 | 0.300 |
| | PSTATT | 1 | 1.748 | 0.188 | 0.009 | 0.260 |
| MOI | PSTACH | 1 | 9.455 | 0.002 | 0.046 | 0.864 |
| | PSTATT | 1 | 0.071 | 0.791 | 0.000 | 0.058 |
| PREACH | PSTACH | 2 | 0.918 | 0.401 | 0.009 | 0.207 |
| | PSTATT | 2 | 0.826 | 0.439 | 0.008 | 0.190 |
| PREATT | PSTACH | 2 | 2.619 | 0.075 | 0.026 | 0.517 |
| | PSTATT | 2 | 29.301 | 0.000 | 0.228 | 1.000 |
| SCHOOL | PSTACH | 4 | 31.372 | 0.000 | 0.388 | 1.000 |
| | PSTATT | 4 | 1.358 | 0.250 | 0.027 | 0.419 |
| PPCG | PSTACH | 5 | 5.956 | 0.000 | 0.131 | 0.994 |
| | PSTATT | 5 | 2.278 | 0.048 | 0.054 | 0.729 |
| MOI*PREACH | PSTACH | 2 | 2.378 | 0.095 | 0.023 | 0.477 |
| | PSTATT | 2 | 1.575 | 0.210 | 0.016 | 0.331 |
| MOI*GPA | PSTACH | 4 | 1.272 | 0.282 | 0.025 | 0.394 |
| | PSTATT | 4 | 1.083 | 0.366 | 0.021 | 0.338 |
| PREACH*SCHOOL | PSTACH | 8 | 1.908 | 0.061 | 0.072 | 0.789 |
| | PSTATT | 8 | 0.841 | 0.567 | 0.33 | 0.386 |
| MOI*CoS*PPCG | PSTACH | 18 | 0.639 | 0.866 | 0.055 | 0.455 |
| | PSTATT | 18 | 1.461 | 0.108 | 0.117 | 0.890 |
| MOI*CoS*PREATT*PPCG | PSTACH | 46 | 1.054 | 0.391 | 0.197 | 0.951 |
| | PSTATT | 46 | 0.961 | 0.549 | 0.183 | 0.924 |
| PREACH*PREATT | PSTACH | 4 | 0.076 | 0.989 | 0.002 | 0.065 |
| | PSTATT | 4 | 1.467 | 0.214 | 0.029 | 0.450 |
| Error | PSTACH | 198 | | | | |
| | PSTATT | 198 | | | | |
| Total | PSTACH | 298 | | | | |
| | PSTATT | 298 | | | | |
| Corrected Total | PSTACH | 297 | | | | |
| | PSTATT | 297 | | | | |

By extracting the effects of the covariate on the dependent variables estimated means of this model was calculated. These estimated means for dependent variables grouped with regard to the experimental and control groups were given in Table 4.17. Table 4.18 presented the comparison of treatment groups with each other.

According to Table 4.18 there was a significant mean difference of 2.084 ($p<0.05$) between the means of inquiry and lecture group in favor of the inquiry group on PSTACH. Additionally, there was a mean difference of 0.99 ($p>0.05$) between the means of inquiry and lecture group in favor of the inquiry group on the PSTATT, but this difference was not statistically significant.

Table 4.17 Estimated Marginal Means of the MOI

| Dependent Variable | MOI | Mean | Std. Error | 95% Confidence Interval | |
|---|---|---|---|---|---|
| | | | | Lower Bound | Upper Bound |
| PSTACH | EXP | 18.168 | 0.578 | 17.029 | 19.307 |
| | CONT | 16.085 | 0.669 | 14.765 | 17.404 |
| PSTATT | EXP | 76.409 | 1.808 | 72.844 | 79.975 |
| | CONT | 75.419 | 2.095 | 71.289 | 79.550 |

Table 4.18 Pairwise Comparisons of the MOI wrt the PSTACH and PSTATT

| Dependent Variable | MOI (I) | MOI (J) | Mean Difference (I-J) | Std. Error | Sig. | Confidence Interval for Difference | |
|---|---|---|---|---|---|---|---|
| | | | | | | Lower Bound | Upper Bound |
| PSTACH | INQUIRY | LECTURE | 2.084 | 0.688 | 0.003 | 0.727 | 3.440 |
| PSTATT | INQUIRY | LECTURE | 0.990 | 2.154 | 0.646 | -3.258 | 5.238 |

As Table 4.15 indicated, the observed power of this study was 1.00 and the effect size was calculated as 0.206 for one of the group membership variables, school. The observed power of the study was greater than the preset value, and the calculated effect size of the study was greater than the preset value. As indicated in Table 4.16, ANCOVA for PSTATT did not revealed a significant mean difference, $F(4)=1.358$, $p>0.05$. However, the ANCOVA revealed that there was a significant mean difference, $F(4)= 31.372$, $p<0.05$, on the dependent variable of PSTACH between groups attending to different schools when the covariate gender was controlled. Table 4.19 and Table 4.20 presented the comparison of schools with each other on the dependent variable of the PSTACH..

Table 4.19 Estimated Marginal Means of School wrt the PSTACH

| School | Mean | Std. Error | 95% Confidence Interval | |
|---|---|---|---|---|
| | | | Lower Bound | Upper Bound |
| AYDIN | 13.349 | 1.292 | 10.801 | 15.896 |
| EMUAL | 11.023 | 0.764 | 9.517 | 12.529 |
| ADMAL | 20.623 | 1.672 | 17.326 | 23.919 |
| SDAL | 18.857 | 0.669 | 17.538 | 20.176 |
| FEN | 22.769 | 0.888 | 21.018 | 24.521 |

Table 4.20 presented the pairwise comparisons of school within each other. According to this table, there were significant mean differences between AYDIN and ADMAL, AYDIN and SDAL, AYDIN and FEN, EMUAL and ADMAL, EMUAL and SDAL, EMUAL and FEN, and SDAL and FEN. However the mean differences between AYDIN and EMUAL, ADMAL and SDAL, and ADMAL and FEN were not significant. The mean differences between AYDIN and all other schools except EMUAL favored the other schools. Although not significant, there was a difference between the means of AYDIN and EMUAL in favor of AYDIN. The mean

differences between EMUAL and all other schools favored the other schools. The mean differences between ADMAL and all other schools except FEN favored this school. However these mean differences of ADMAL and FEN and ADMAL and SDAL were not statistically significant. There was a significant difference between the means of SDAL and FEN in favor of FEN.

Table 4.20 Pairwise Comparisons of the Schools with respect to the PSTACH

| School (I) | School (J) | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval for Difference | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| AYDIN | EMUAL | 2.325 | 1.515 | 1.000 | -1.974 | 6.625 |
| | ADMAL | -7.274 | 2.159 | 0.009 | -13.404 | -1.145 |
| | SDAL | -5.509 | 1.514 | 0.003 | -9.806 | -1.211 |
| | FEN | -9.421 | 1.577 | 0.000 | -13.897 | -4.945 |
| EMUAL | ADMAL | -9.600 | 1.829 | 0.000 | -14.791 | -4.408 |
| | SDAL | -7.834 | 0.942 | 0.000 | -10.508 | -5.160 |
| | FEN | -11.746 | 1.148 | 0.000 | -15.005 | -8.487 |
| ADMAL | SDAL | 1.766 | 1.725 | 1.000 | -3.132 | 6.663 |
| | FEN | -2.147 | 1.860 | 1.000 | -7.426 | -3.133 |
| SDAL | FEN | -3.912 | 1.028 | 0.002 | -6.831 | -0.994 |

As Table 4.15 indicated, the observed power of this study was 1.00 and the effect size was calculated as 0.119 for one of the group membership interaction variables, PREATT. The observed power of the study was greater than the preset value, and the calculated effect size of the study was greater than the preset value. The analysis revealed that there was a significant mean difference, $F(4)= 13.427$, $p<0.05$, on the collective dependent variables of PSTACH and PSTATT between groups having different previous attitudes toward electric circuits subject when the covariate gender was controlled. As indicated in Table 4.16, the ANCOVA revealed that there was a significant mean difference, $F(2)= 29.301$, $p<0.05$, on the dependent variable of PSTATT between groups having different levels of attitudes towards electric circuits subject when the covariate gender was controlled. However, ANCOVA for PSTACH did not revealed a significant mean difference, $F(4)=2.619$, $p>0.05$. Table 4.21 and Table 4.22 presented the comparison of students with each other on the dependent variable; PSTATT.

As Table 4.22 showed that the posttest scores of students who had low level of aptitude toward electric circuits prior to the study was low again in the PSTATT when compared to other intermediate and high levels. Also high preaptitude students had higher means than the intermediate preaptitude students. The mean of low-preaptitude students on PSTATT was smaller than the mean of the intermediate-preaptitude students while it was smaller than the mean of the high-preaptitude students. The high-preaptitude students had greater mean on PSTATT than the imtermediate-preaptitude students.

Table 4.21 Estimated Marginal Means of PREATT wrt the PSTATT

| Dependent Variable | PREATT | Mean | Std. Error | 95% Confidence Interval | |
|---|---|---|---|---|---|
| | | | | Lower Bound | Upper Bound |
| PSTATT | 1 | 65.757 | 2.271 | 61.279 | 70.234 |
| | 2 | 75.936 | 1.973 | 72.046 | 79.826 |
| | 3 | 87.118 | 2.263 | 82.656 | 91.580 |

Table 4.22 Pairwise Comparisons of the PREATT wrt the PSTATT

| Dependent Variable | PREATT (I) | PREATT (J) | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval for Difference | |
|---|---|---|---|---|---|---|---|
| | | | | | | Lower Bound | Upper Bound |
| PSTATT | 1 | 2 | -10.179 | 2.484 | 0.00 | -16.177 | -4.182 |
| | | 3 | -21.362 | 2.719 | 0.00 | -27.926 | -14.797 |
| | 2 | 3 | -11.182 | 2.371 | 0.00 | -16.908 | -5.457 |

As Table 4.15 indicated, the observed power of this study was 0.994 and the effect size was calculated as 0.082 for one of the group membership interaction variables, PPCG. The observed power of the study was greater than the preset value, and the calculated effect size of the study reached to the preset value. The analysis revealed that there was a significant mean difference, $F(10)= 3.517$, $p<0.05$, on the collective dependent variables of PSTACH and PSTATT between groups having different previous physics course grades when the covariate gender was controlled. As indicated in Table 4.16, the ANCOVA revealed that there was a significant mean difference, $F(5)= 5.956$, $p<0.05$, on the dependent variable of PSTACH between groups having different previous physics course grades when the covariate gender was controlled. Additionally, ANCOVA for PSTATT revealed a significant mean difference, $F(5)=2.278$, $p<0.05$, too. Table 4.23 and Table 4.24 presented the comparison of students with each other on the dependent variable; PSTATT.

Table 4.24 presented the pairwise comparisons of levels of PPCG within each other for two dependent variables, PSTACH and PSTATT respectively. According to this table, on PSTACH, there was a significant mean difference between the group of students having 2, 3 and 4 as the previous physics course grade and the students having 5 as previous physics course grade. All other mean differences between levels of PPCG were not significant. The mean differences between “2”, “3”, and “4” groups and “5” group favored the latter; in essence, the mean of “5” group was 4,942 greater than the mean of “2” group, 3,247 greater than the “3” group, and 2,657 greater than the “4” group. However, the mean of the students on PSTATT did not differ among their previous physics course grades.

Table 4.23 Estimated Marginal Means of the PPCG wrt the PSTACH and PSTATT

| Dependent Variable | PPCG | Mean | Std. Error | 95% Confidence Interval | |
|---|---|---|---|---|---|
| | | | | Lower Bound | Upper Bound |
| PSTACH | 0 | 15.021 | 1.804 | 11.464 | 18.577 |
| | 1 | 16.116 | 1.300 | 13.551 | 18.680 |
| | 2 | 15.238 | 1.131 | 13.006 | 17.469 |
| | 3 | 16.933 | 0.795 | 15.364 | 18.501 |
| | 4 | 17.523 | 0.657 | 16.228 | 18.817 |
| | 5 | 20.180 | 0.694 | 18.810 | 21.549 |
| PSTATT | 0 | 71.072 | 5.647 | 59.936 | 82.209 |
| | 1 | 73.446 | 4.071 | 65.417 | 81.474 |
| | 2 | 72.376 | 3.543 | 65.390 | 79.362 |
| | 3 | 75.530 | 2.490 | 70.619 | 80.441 |
| | 4 | 75.543 | 2.056 | 71.489 | 79.597 |
| | 5 | 82.059 | 2.174 | 77.772 | 86.346 |

Table 4.24 Pairwise Comparisons of the PPCG wrt to the PSTACH and PSTATT

| Dependent Variable | GPA (I) | GPA (J) | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval for Difference | |
|---|---|---|---|---|---|---|---|
| | | | | | | Lower Bound | Upper Bound |
| PSTACH | 0 | 1 | -1.095 | 1.959 | 1.000 | -6.916 | 4.726 |
| | | 2 | -0.217 | 1.978 | 1.000 | -6.095 | 5.661 |
| | | 3 | -1.912 | 1.899 | 1.000 | -7.554 | 3.730 |
| | | 4 | -2.502 | 1.830 | 1.000 | -7.939 | 2.935 |
| | | 5 | -5.159 | 1.876 | 0.098 | -10.734 | 0.416 |
| | 1 | 2 | 0.878 | 1.605 | 1.000 | -3.892 | 5.648 |
| | | 3 | -0.817 | 1.423 | 1.000 | -5.047 | 3.412 |
| | | 4 | -1.407 | 1.357 | 1.000 | -5.440 | 2.626 |
| | | 5 | -4.064 | 1.416 | 0.068 | -8.272 | 0.144 |
| | 2 | 3 | -1.695 | 1.286 | 1.000 | -5.515 | 2.125 |
| | | 4 | -2.285 | 1.159 | 0.750 | -5.728 | 1.158 |
| | | 5 | -4.942 | 1.234 | 0.001 | -8.610 | -1.274 |
| | 3 | 4 | -0.590 | 0.875 | 1.000 | -3.189 | 2.010 |
| | | 5 | -3.247 | 0.924 | 0.008 | -5.991 | -0.502 |
| | 4 | 5 | -2.657 | 0.780 | 0.012 | -4.974 | -0.340 |
| PSTATT | 0 | 1 | -2.373 | 6.134 | 1.000 | -20.599 | 15.853 |
| | | 2 | -1.304 | 6.194 | 1.000 | -19.707 | 17.100 |
| | | 3 | -4.458 | 5.946 | 1.000 | -22.123 | 13.208 |
| | | 4 | -4.470 | 5.729 | 1.000 | -21.492 | 12.552 |
| | | 5 | -10.987 | 5.875 | 0.944 | -28.442 | 6.469 |
| | 1 | 2 | 1.069 | 5.026 | 1.000 | -13.865 | 16.004 |
| | | 3 | -2.085 | 4.457 | 1.000 | -15.327 | 11.158 |
| | | 4 | -2.097 | 4.250 | 1.000 | -14.726 | 10.532 |
| | | 5 | -8.614 | 4.434 | 0.802 | -21.788 | 4.561 |
| | 2 | 3 | -3.154 | 4.025 | 1.000 | -15.114 | 8.807 |
| | | 4 | -3.166 | 3.628 | 1.000 | -13.946 | 7.613 |
| | | 5 | -9.683 | 3.865 | 0.196 | -21.167 | 1.801 |
| | 3 | 4 | -0.013 | 2.739 | 1.000 | -8.152 | 8.127 |
| | | 5 | -6.529 | 2.892 | 0.376 | -15.122 | 2.064 |
| | 4 | 5 | -6.517 | 2.441 | 0.124 | -13.770 | 0.737 |

The effects of interaction terms on dependent variables were not statistically significant in this study, as Table 4.15 indicated. However, this lack of statistical significance might be explained by the small sample sizes of some cells. In fact, in some of the cells, the sample was less than 10. So, the value of effect sizes in each cell would be more informative and meaningful in judging the utility and the practical significance of the interaction terms. Cohen's d was calculated and graphed for each cell in the interaction terms and then the effect sizes those reached the medium and large level were discussed. Cohen's effect size was calculated by using the formula below;

$$d = \frac{\bar{x}_1 - \bar{x}_2}{s},$$

where the standard deviation was calculated by

$$s = \sqrt{\frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2}},$$

since the sample sizes for experimental and control groups were not equal.

Table 4.25 indicated the interaction term of PREACH*MOI. According to Table 4.25, only a medium effect size was found for the interaction of PREACH*MOI for the students having high preachievement and exposed to inquiry and lecture groups. High preachiever students exposed to inquiry instruction were more successful (ES=0.57, medium effect size) than the other high preachievers who were exposed to lecture instruction on PSTACH.

Table 4.25 Pairwise comparison of the PREACH * MOI

| Dependent Variable | PREACH | N | MOI | Mean | Std. Error | Effect Size |
|---|---|---|---|---|---|---|
| PSTACH | 1 | 32 | LECTURE | 17.205 | 1.366 | 0.02 |
| | | 68 | INQUIRY | 17.374 | 1.120 | |
| | 2 | 42 | LECTURE | 15.339 | 0.834 | 0.38 |
| | | 76 | INQUIRY | 17.432 | 0.652 | |
| | 3 | 35 | LECTURE | 15.710 | 1.197 | 0.57* |
| | | 45 | INQUIRY | 19.699 | 1.094 | |
| PSTATT | 1 | 32 | LECTURE | 75.386 | 4.277 | 0.22 |
| | | 68 | INQUIRY | 81.287 | 3.506 | |
| | 2 | 42 | LECTURE | 74.770 | 2.611 | 0.12 |
| | | 76 | INQUIRY | 72.756 | 2.043 | |
| | 3 | 35 | LECTURE | 76.103 | 3.749 | 0.04 |
| | | 45 | INQUIRY | 75.185 | 3.425 | |

* Medium Effect Size

Figure 4.2 indicated the interaction term of PREACH*MOI. According to Table 4.25, only a medium effect size was found for the interaction of PREACH*MOI for the students having high preachievement and exposed to inquiry and lecture groups. High preachiever students exposed to inquiry instruction were more successful (ES=0.57, medium effect size) than the other high preachievers who were exposed to lecture instruction on PSTACH.

When considering pretest scores of achievement test, students who achieved highly in the pretest, benefited more from the inquiry based instruction rather than the lecture.

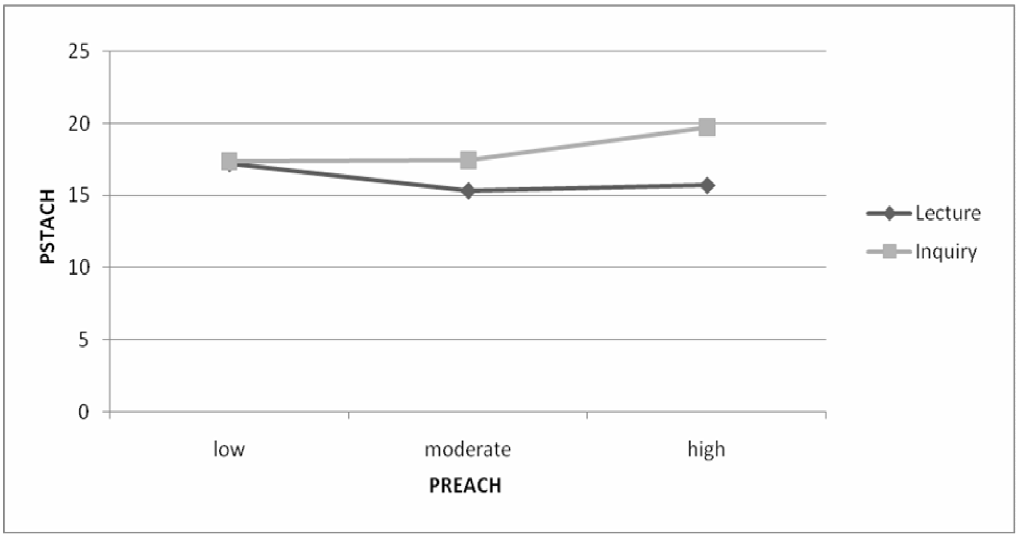


Figure 4.2 Interaction between PREACH and treatments with respect to PSTACH

Table 4.26 indicated the interaction term of PPCG*MOI. According to Table 4.26, the effect sizeof interaction between PPCG and MOI on PSTACH was medium for students who had “3” and “4” as the previous physics course grades. It was large for the students who had “2” as PPCG. The effect size of interaction between PPCG and MOI on PSTATT was medium for students who had “2” as the previous physics course grade. The other effect sizes were small. Since there were not any students who had “0” as PPCG having lecture instruction, the effect size values for these cells were not calculated.

Table 4.26 Pairwise comparison of the PPCG * MOI

| Dependent Variable | PPCG | n | MOI | Mean | Std. Error | Effect Size |
|---|---|---|---|---|---|---|
| PSTACH | 0 | 0 | LECTURE | | | |
| | | 10 | INQUIRY | 15.021 | 1.804 | |
| | 1 | 1 | LECTURE | 17.995 | 4.343 | 0.34 |
| | | 24 | INQUIRY | 15.847 | 1.390 | |
| | 2 | 9 | LECTURE | 11.360 | 1.886 | 1.15** |
| | | 21 | INQUIRY | 17.661 | 1.296 | |
| | 3 | 17 | LECTURE | 15.440 | 1.259 | 0.53* |
| | | 38 | INQUIRY | 18.259 | 0.920 | |
| | 4 | 50 | LECTURE | 15.853 | 0.816 | 0.59* |
| | | 48 | INQUIRY | 19.192 | 0.834 | |
| | 5 | 32 | LECTURE | 19.301 | 1.010 | 0.32 |
| | | 48 | INQUIRY | 21.058 | 0.822 | |
| PSTATT | 0 | 0 | LECTURE | | | |
| | | 10 | INQUIRY | 71.072 | 5.647 | |
| | 1 | 1 | LECTURE | 79.435 | 13.598 | 0.34 |
| | | 24 | INQUIRY | 72.590 | 4.352 | |
| | 2 | 9 | LECTURE | 65.384 | 5.906 | 0.66* |
| | | 21 | INQUIRY | 76.746 | 4.059 | |
| | 3 | 17 | LECTURE | 74.991 | 3.942 | 0.06 |
| | | 38 | INQUIRY | 76.010 | 2.879 | |
| | 4 | 50 | LECTURE | 74.468 | 2.555 | 0.12 |
| | | 48 | INQUIRY | 76.618 | 2.611 | |
| | 5 | 32 | LECTURE | 81.881 | 3.162 | 0.02 |
| | | 48 | INQUIRY | 82.237 | 2.575 | |

* Medium Effect Size  ** Large Effect Size

Figure 4.3 indicated the interaction term of PPCG*MOI. According to Table 4.26, the effect size of interaction between PPCG and MOI on PSTACH was medium (ES=0.53, and ES=0.59, respectively) for students who had "3" and "4" as the previous physics course grades. It was large (ES= 1.15) for the students who had "2" as PPCG.

Students who had grades "2", "3", and "4" from the previous physics courses, benefited more from the inquiry instruction then they did from the lecture instruction.

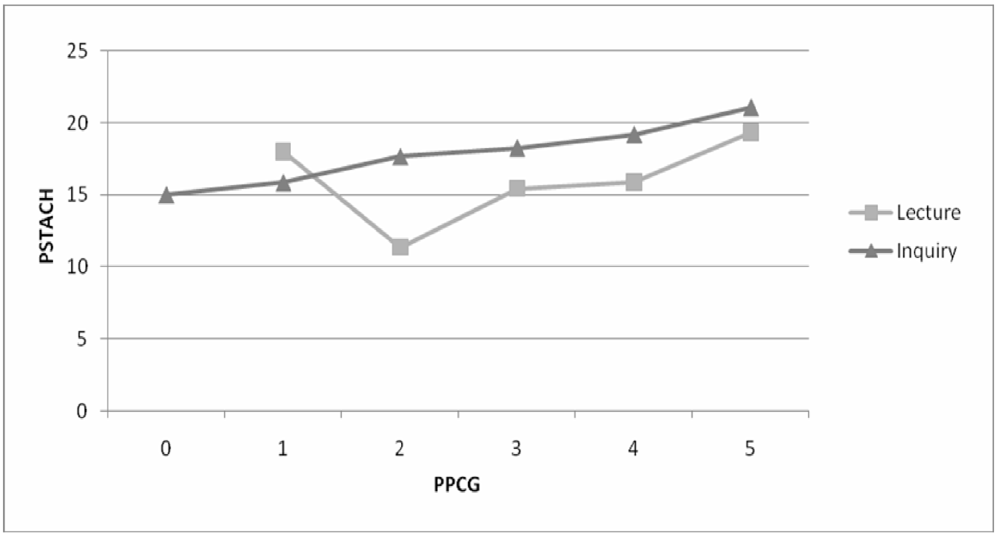


Figure 4.3 Interaction between PPCG and treatments with respect to PSTACH

According to Table 4.26 and as represented in Figure 4.4, the effect size of interaction between PPCG and MOI on PSTATT was medium (ES=0.66) for students who had "2" as the previous physics course grade. The other effect sizes were small. For students who had "2" from the previous physics courses, inquiry instruction was more beneficial on improving their attitudes toward electric circuits subject.

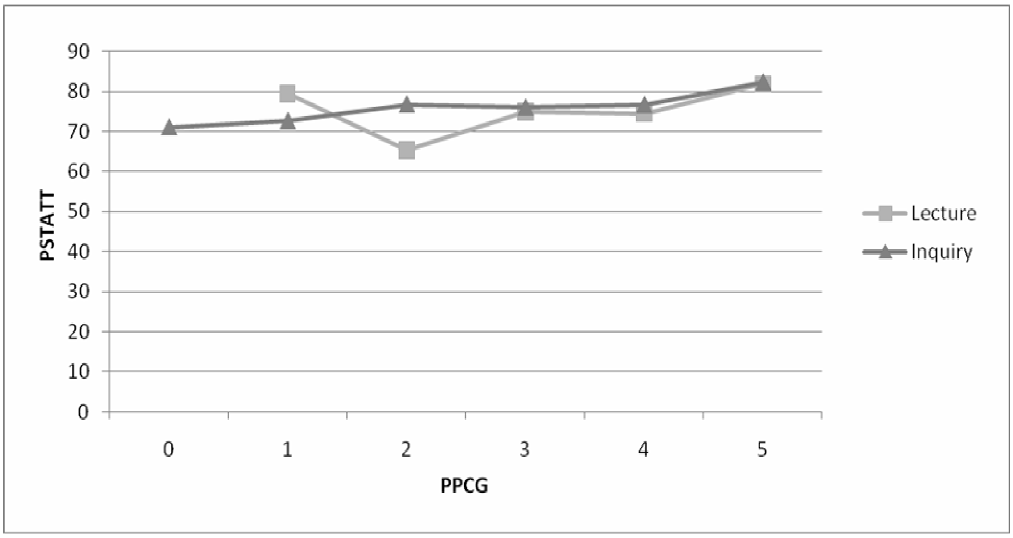


Figure 4.4 Interaction between PPCG and treatments with respect to PSTATT

Table 4.27 indicated the interaction term of CoS*PPCG*MOI. According to Table 4.27, the effect size of interaction between PPCG and MOI on PSTACH was medium for students who were field dependents and had “1”, “3”, “4”, and “5” as previous physics course grade; was large for those had “2” as PPCG. Table 4.27 also indicated that for students who were field intermediate (field mixed), there were large effect sizes for students who had “2”, “3”, and “4”; while there were medium effect for students who had “5” as PPCG. The effect size for field independent students who had “3” as previous physics course grade was medium whereas for those who had “2” as PPCG it was large. According to Table 4.27, the effect size of interaction between PPCG and MOI on PSTATT was medium for students who were field dependents and had “1” and “3”. Table 4.26 also indicated that for students who were field intermediate, there was large effect size for students who had “2” as PPCG. The effect size for field independent students who had “3” as previous physics course grade was medium whereas for those who had “2” as PPCG it was large.

Table 4.27 Pairwise comparison of the CoS * PPCG * MOI

| Dependent Variable | CoS | PPCG | n | MOI | Mean | Std. Error | Effect Size |
|---|---|---|---|---|---|---|---|
| PSTACH | FDEP | 0 | 0 | LEC | | | |
| | | | 6 | INQ | 16.175 | 2.028 | |
| | | 1 | 1 | LEC | 17.995 | 4.343 | 0.54* |
| | | | 17 | INQ | 15.219 | 1.371 | |
| | | 2 | 6 | LEC | 13.118 | 2.262 | 0.85** |
| | | | 11 | INQ | 16.860 | 1.416 | |
| | | 3 | 4 | LEC | 14.929 | 2.323 | 0.51* |
| | | | 18 | INQ | 17.493 | 1.330 | |
| | | 4 | 10 | LEC | 15.821 | 1.519 | 0.59* |
| | | | 17 | INQ | 18.490 | 1.202 | |
| | | 5 | 9 | LEC | 18.979 | 1.529 | 0.64* |
| | | | 11 | INQ | 21.756 | 1.512 | |
| | FMIX | 0 | 0 | LEC | | | |
| | | | 3 | INQ | 15.939 | 2.764 | |
| | | 1 | 0 | LEC | | | |
| | | | 3 | INQ | 18.713 | 2.692 | |
| | | 2 | 2 | LEC | 8.497 | 3.062 | |
| | | | 5 | INQ | 17.273 | 2.255 | |
| | | 3 | 6 | LEC | 15.167 | 1.827 | |
| | | | 13 | INQ | 18.635 | | |
| | | 4 | 13 | LEC | 14.644 | | |
| | | | 15 | INQ | 19.646 | | |
| | | 5 | 10 | LEC | 18.352 | | |
| | | | 16 | INQ | 21.559 | 2.44 | |
| | FIND | 0 | 0 | LEC | | | |
| | | | 1 | INQ | 10.874 | 0.86** | |
| | | 1 | 0 | LEC | | | |
| | | | 4 | INQ | 13.924 | 1.07** | |
| | | 2 | 1 | LEC | 8.951 | | 2.79** |
| | | | 5 | INQ | 18.584 | 0.66* | |
| | | 3 | 7 | LEC | 16.135 | | 0.58* |
| | | | 7 | INQ | 18.650 | 1.923 | |
| | | 4 | 27 | LEC | 17.095 | 0.989 | 0.47 |
| | | | 16 | INQ | 19.439 | 1.334 | |
| | | 5 | 13 | LEC | 20.572 | 1.686 | 0.13 |
| | | | 21 | INQ | 19.860 | 1.181 | |

Table 4.27 (continued)

| Dependent Variable | CoS | PPCG | n | MOI | Mean | Std. Error | Effect Size |
|---|---|---|---|---|---|---|---|
| PSTATT | FDEP | 0 | 0 | LEC | | | |
| | | | 6 | INQ | 69.317 | 6.350 | |
| | | 1 | 1 | LEC | 79.435 | 13.598 | 0.51* |
| | | | 17 | INQ | 71.262 | 4.294 | |
| | | 2 | 6 | LEC | 80.917 | 7.083 | 0.37 |
| | | | 11 | INQ | 75.859 | 4.433 | |
| | | 3 | 4 | LEC | 81.454 | 7.274 | 0.73* |
| | | | 18 | INQ | 69.895 | 4.163 | |
| | | 4 | 10 | LEC | 72.084 | 4.755 | 0.28 |
| | | | 17 | INQ | 76.056 | 3.765 | |
| | | 5 | 9 | LEC | 78.908 | 4.787 | 0.12 |
| | | | 11 | INQ | 80.489 | 4.735 | |
| | FMIX | 0 | 0 | LEC | | | |
| | | | 3 | INQ | 67.752 | 8.655 | |
| | | 1 | 0 | LEC | | | |
| | | | 3 | INQ | 79.934 | 8.427 | |
| | | 2 | 2 | LEC | 58.177 | 9.587 | 2.57** |
| | | | 5 | INQ | 87.153 | 7.059 | |
| | | 3 | 6 | LEC | 73.510 | 5.719 | 0.44 |
| | | | 13 | INQ | 79.012 | 3.932 | |
| | | 4 | 13 | LEC | 78.429 | 4.069 | 0.02 |
| | | | 15 | INQ | 78.765 | 4.265 | |
| | | 5 | 10 | LEC | 80.970 | 5.651 | 0.12 |
| | | | 16 | INQ | 79.174 | 3.923 | |
| | FIND | 0 | 0 | LEC | | | |
| | | | 1 | INQ | 81.226 | 13.480 | |
| | | 1 | 0 | LEC | | | |
| | | | 4 | INQ | 67.238 | 8.127 | |
| | | 2 | 1 | LEC | 25.993 | 13.696 | 3.79** |
| | | | 5 | INQ | 66.932 | 6.611 | |
| | | 3 | 7 | LEC | 69.514 | 5.908 | 0.71* |
| | | | 7 | INQ | 79.121 | 6.021 | |
| | | 4 | 27 | LEC | 72.891 | 3.097 | 0.14 |
| | | | 16 | INQ | 75.031 | 4.178 | |
| | | 5 | 13 | LEC | 85.766 | 5.278 | 0.08 |
| | | | 21 | INQ | 87.048 | 3.697 | |

* Medium Effect Size ** Large Effect Size

Figure 4.5, 4.6, and 4.7 indicated the interaction term of CoS*PPCG*MOI. According to Table 4.27, the effect size of interaction between PPCG and MOI on PSTACH was medium for students who were field dependents and had “1” (ES=0.54), “3” (ES=0.51), “4” (ES=0.59), and “5” (ES=0.64) as previous physics course grade; was large for those had “2” (ES=0.85) as PPCG.

In the light of Figure 4.5 and Table 4.27, field dependent students who had grade “2” and grades higher than “2” from previous physics courses benefited more from inquiry instruction than they did from lecture in increasing their achievement in electric circuits subject. Nonetheless, students who had “1” from previous physics course, benefited more from the lecture method.

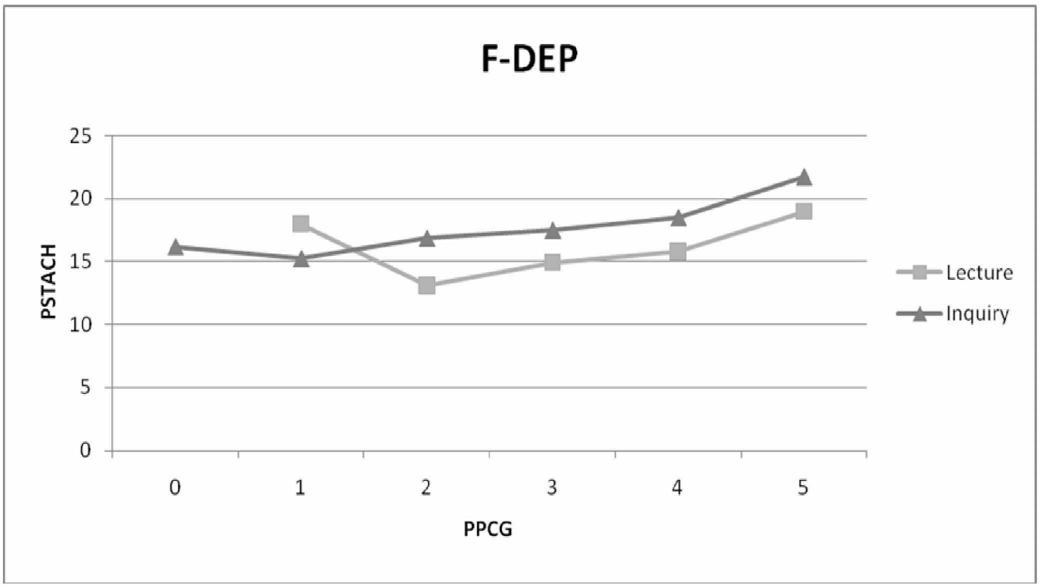


Figure 4.5 Interaction between PPCG and MOI with respect to PSTACH for Field Dependent Students

Table 4.27 also indicated that for students who were field intermediate (field mixed), there were large effect sizes for students who had “2” (ES=2.44), “3” (ES=0.86), and “4” (ES=1.07); while there were medium effect for students who had “5” (ES=0.66) as PPCG. Figure 4.6 illustrated this fact clearly.

Inquiry instruction is more beneficial than the lecture on electric circuits subject achievement for field intermediate students who got grade “2” and higher than “2” grades. For students who got “0” and “1”, comparison of the methods could not be done.

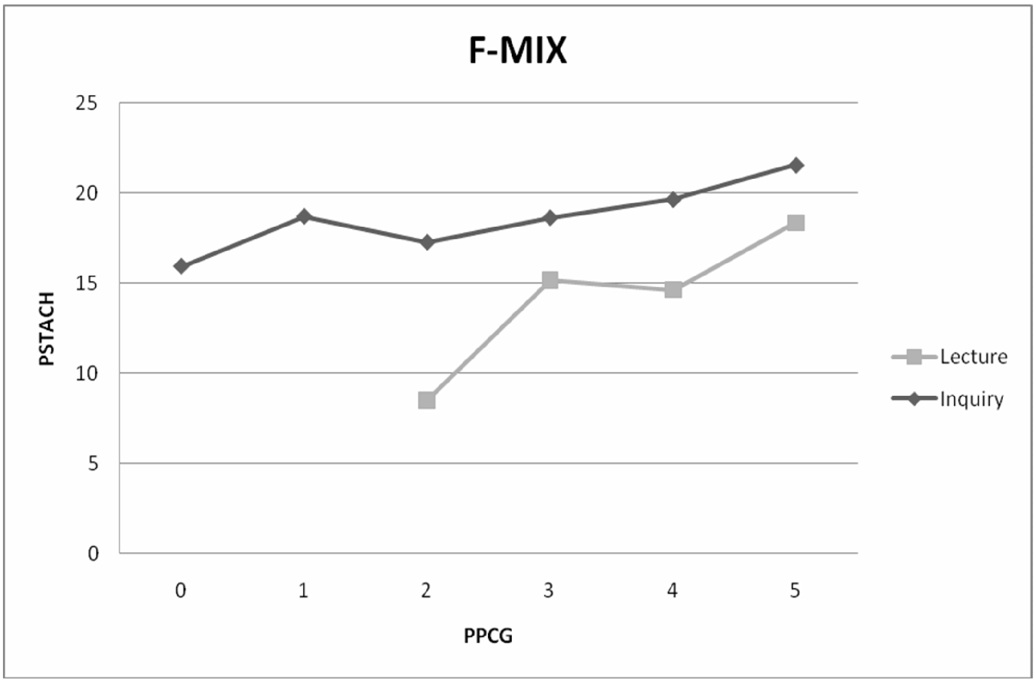


Figure 4.6 Interaction between PPCG and MOI with respect to PSTACH for Field Mixed Students

According to Table 4.27 and Figure 4.7, the effect size for field independent students who had “3” as previous physics course grade was medium (ES=0.58) whereas for those who had “2” as PPCG it was large (ES=2.79). For field independent students who had “2” and “3” as PPCG, inquiry method was better than the lecture method on improving achievement in electric circuits subject.

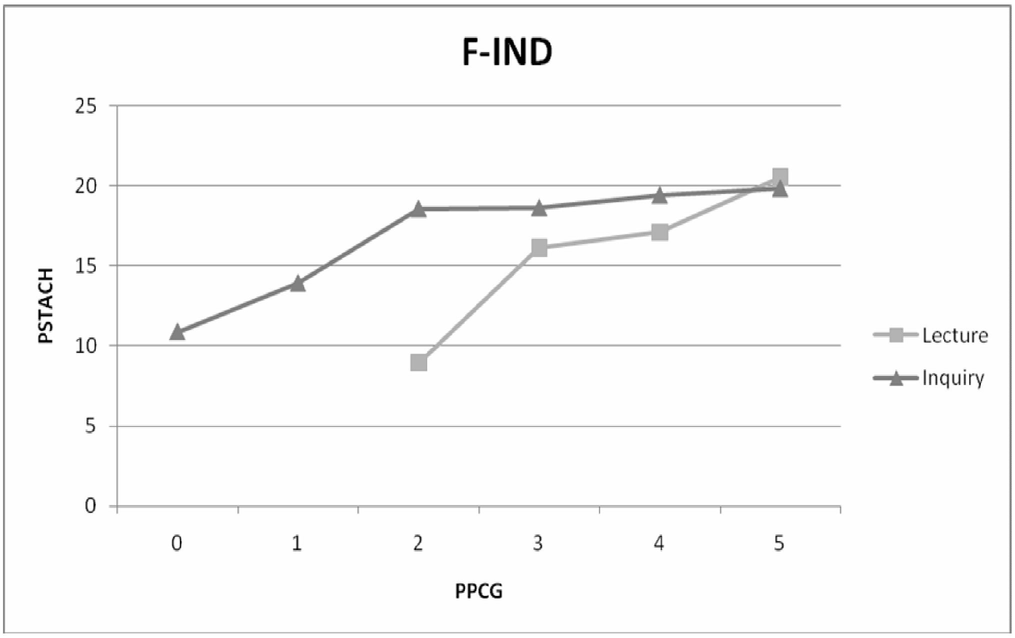


Figure 4.7 Interaction between PPCG and MOI with respect to PSTACH for Field Independent Students

According to Table 4.27 and Figure 4.8, the effect size of interaction between PPCG and MOI on PSTATT was medium for students who were field dependents and had “1” (ES=0.51) and “3” (ES=0.73).

For field dependent students who had “1” and “3” as PPCG, lecture instruction was better than the inquiry-based instruction on improving students attitudes toward electric circuits subject.

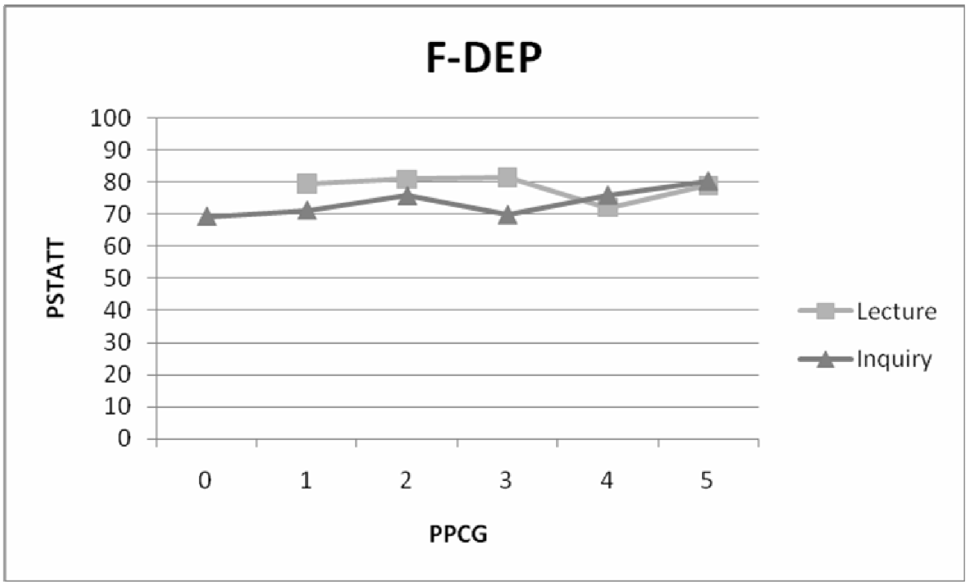


Figure 4.8 Interaction between PPCG and MOI with respect to PSTATT for Field Dependent Students

Table 4.27 and Figure 4.9 also indicated that for students who were field intermediate, there were large effect size (ES=2.57) for students who had “2” as PPCG. For field intermediate students who had “2” as PPCG, inquiry-based instruction was better than the lecture instruction on improving students’ attitudes toward electric circuits subject.

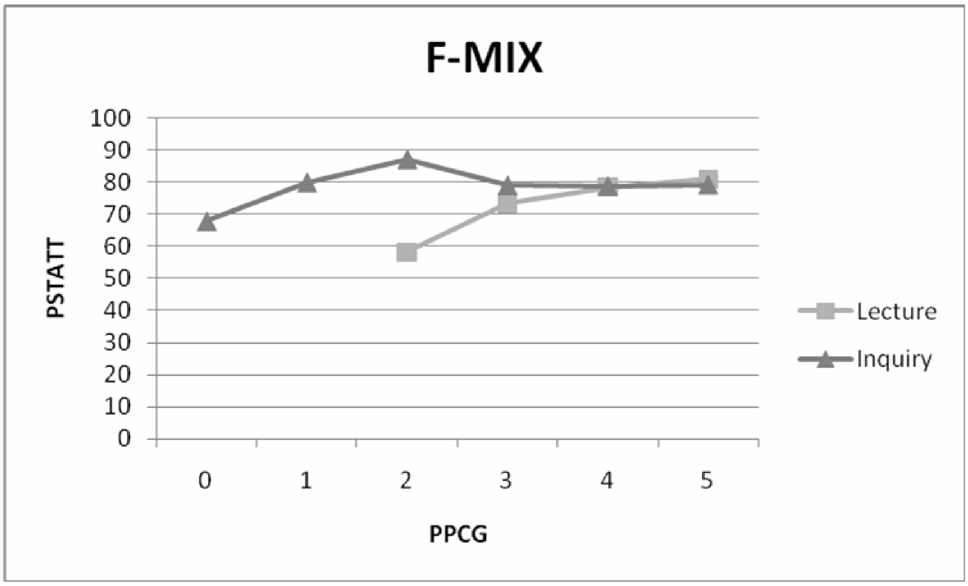


Figure 4.9 Interaction between PPCG and MOI with respect to PSTATT for Field Mixed Students

According to Table 4.27 and Figure 4.10, the effect size for field independent students who had “3” as previous physics course grade was medium (ES=0.71) whereas for those who had “2” as PPCG it was large (ES=3.79). For field independent students who had “3” and “2” as PPCG, inquiry based instruction was more effective than lecture on improving their attitude toward electric circuits subject.

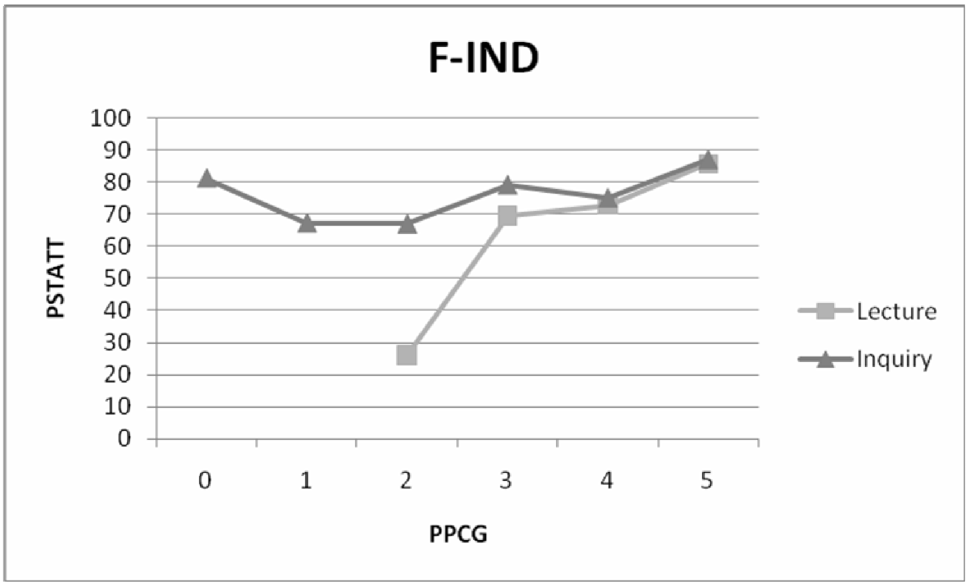


Figure 4.10 Interaction between PPCG and MOI with respect to PSTATT for Field Independent Students

The number of students in each cell of the interaction term CoS*PREATT*PPCG*MOI was very few so that the effect sizes for this interaction term were not calculated.

4.4 Aptitude-Treatment Interaction Analysis for only SDAL and FEN

While examining the results of MANCOVA, the researcher noticed that the lecture group PSTACH mean was higher than the inquiry group PSTACH mean in AYDIN. Also the mean of this lecture group was higher than some of the mean PSTACH scores of lecture groups in Anatolian High Schools. Therefore, the change in the mean scores of PREACH through PSTACH was examined and Table 4.28 was produced.

Table 4.28 Means of PREACH and PSTACH Grouped by School and MOI

| | AYDIN | | EMUAL | | ADMAL | | SDAL | | FEN | |
|---|---|---|---|---|---|---|---|---|---|---|
| PREACH | n | Mean | n | Mean | n | Mean | n | Mean | n | Mean |
| INQ | 40 | 10.54 | 46 | 12.01 | 25 | 18.80 | 59 | 13.92 | 19 | 13.65 |
| LEC | 28 | 10.10 | 14 | 13.86 | 26 | 17.35 | 20 | 13.54 | 21 | 18.17 |
| TOTAL | 68 | 10.36 | 60 | 12.44 | 51 | 18.06 | 79 | 13.82 | 40 | 16.02 |
| PSTACH | | | | | | | | | | |
| INQ | 40 | 9.65 | 46 | 11.41 | 25 | 23.28 | 59 | 20.31 | 19 | 26.58 |
| LEC | 28 | 13.68 | 14 | 9.29 | 26 | 12.69 | 20 | 20.80 | 21 | 23.05 |
| TOTAL | 68 | 11.31 | 60 | 10.92 | 51 | 17.88 | 79 | 20.43 | 40 | 24.73 |

It was apparent from Table 4.28 that in EMUAL, and ADMAL there was a remarkable decrease in the mean scores on PSTACH through PREACH of students having lecture instruction. In AYDIN, inquiry group students had higher mean on the same test in PREACH than they had in PSTACH, however the difference was in tolerable range. In lecture group of EMUAL, a considerable mean decrease occurred at the end of the study, while the means of the inquiry group were nearly same with each other. Also, in ADMAL, the mean of the lecture group dropped from PREACH test to PSTACH tests, while there was an increase in the means of inquiry group. Although approximately finding the same means of PREACH and PSTACH for lecture or inquiry group might indicate that the treatment given in that group did not work at all, the decrease of mean from PREACH to PSTACH was irrational. Students were expected to learn some information unintentionally even if they just sat on the desk and were present in the classroom. This situation yielded suspension in the data collection process of PSTACH. Students probably did not give much attention to the postachievement test. In some classes the posttests were administered after the administration of the last examination; hence students did not answer seriously. Although the teachers were warned about this possibility, and they took cautions as telling students the scores they got in the PSTACH would be their oral exam scores, students did not care this fact, unfortunately. In the other two schools SDAL and FEN, both groups increased their means on PSTACH with respect to those in PREACH. In fact, all the possible explanations suggested above were just guess; because the real reason for the situation could not be found from now on, it would be better to perform all the main effect and interaction analyses for only SDAL and FEN.

To perform this analyses for only SDAL and FEN, necessary sample size could not be reached ($n_{SDAL+FEN}$=119), so that, the main and interaction analyses were explored in terms of effect sizes.

Firstly the effect sizes for each category of group membership variables were figured out for PSTACH and PSTATT. Tables 4.29, 4.30, 4.31, 4.32, 4.33, 4.34, 4.35, 4.36, 4.37, 4.38 and 4.39 indicated the effect size values in PSTACH and PSTATT with respect to MOI, CoS, PREACH, PREATT, school (two level; SDAL and FEN), PPCG, PREACH*MOI, PPCG*MOI, CoS * PPCG * MOI, and CoS * PREATT * PPCG * MOI.

Although the mean of students in inquiry based instruction group was greater than the mean of the students in lecture group on PSTACH and PSTATT, these differences were small in effect, as Table 4.29 indicated.

Table 4.29 Mean comparisons and the effect sizes of the levels of MOI

| Dependent Variable | n | MOI | Mean | Std. Error | Effect Size |
|---|---|---|---|---|---|
| PSTACH | 109 | LEC | 21.607 | 0.636 | 0.08 |
| | 189 | INQ | 22.193 | 0.536 | |
| PSTATT | 109 | LEC | 74.090 | 2.942 | 0.11 |
| | 189 | INQ | 77.614 | 2.478 | |

Although the mean of the field intermediate students was greater than the mean of the field dependent and field independent students on PSTACH and PSTATT, and the mean of the field independent students was slightly higher than the mean of the field dependent students on PSTACH and PSTATT, these pairwise differences were small in effect, as Table 4.30 indicated.

Table 4.30 Mean comparisons and the effect sizes of the levels of CoS

| Dependent Variable | CoS | n | Mean | Std. Error | Compared Pairs | Effect Size |
|---|---|---|---|---|---|---|
| PSTACH | FDEP | 34 | 21.332 | 0.839 | FDep-FMix | 0.23 |
| | FMIX | 43 | 22.362 | 0.663 | FDep-Find | 0.18 |
| | FIND | 42 | 22.144 | 0.699 | FMix-FInd | 0.05 |
| PSTATT | FDEP | 34 | 74.042 | 3.883 | FDep-FMix | 0.25 |
| | FMIX | 43 | 79.157 | 3.065 | FDep-Find | 0.03 |
| | FIND | 42 | 74.655 | 3.236 | FMix-FInd | 0.23 |

Although the mean of the high preachiever students was greater than the mean of the intermediate and low preachiever students on PSTACH, and intermediate preachievers outperformed the low preachievers on PSTACH, there was only one medium effect size between the high and low preachievers, as Table 4.31 presented. Additionally, although the mean of the low preachiever students was greater than the mean of the intermediate and high preachiever students on PSTATT, and intermediate preachievers outperformed the high preachievers on PSTATT, these pairwise differences were small in effect, as Table 4.31 indicated.

Table 4.31 Mean comparisons and the effect sizes of the levels of PREACH

| Dependent Variable | PREACH | n | Mean | Std. Error | Compared Pairs | Effect Size |
|---|---|---|---|---|---|---|
| PSTACH | 1 | 32 | 20.190 | 0.850 | 1-2 | 0.35 |
| | 2 | 48 | 21.904 | 0.746 | 1-3 | 0.71* |
| | 3 | 39 | 23.643 | 0.832 | 2-3 | 0.34 |
| PSTATT | 1 | 32 | 78.627 | 3.935 | 1-2 | 0.05 |
| | 2 | 48 | 77.431 | 3.454 | 1-3 | 0.31 |
| | 3 | 39 | 71.719 | 3.848 | 2-3 | 0.24 |

* Medium Effect Size

Although the mean of the students who had high preattitude was greater than the mean of the students who had intermediate and low preattitude on PSTATT, and the students having intermediate preattitudes outperformed those having low preattitudes on PSTATT, there was only one high effect size between the students having high and low preattitudes, as Table 4.32 presented. Additionally, although the mean of the intermediate preattitude students was greater than the mean of the low and high preattitude students on PSTATT, and low preattitude students slightly outperformed the high preattitude students on PSTACH, these pairwise differences were small in effect, as Table 4.32 indicated.

Table 4.32 Mean comparisons and the effect sizes of the levels of PREATT

| Dependent Variable | PREATT | n | Mean | Std. Error | Compared Pairs | Effect Size |
|---|---|---|---|---|---|---|
| PSTACH | 1 | 32 | 21.900 | 0.723 | 1-2 | 0.04 |
| | 2 | 52 | 22.063 | 0.674 | 1-3 | 0.04 |
| | 3 | 35 | 21.745 | 0.803 | 2-3 | 0.07 |
| PSTATT | 1 | 32 | 67.526 | 3.344 | 1-2 | 0.40 |
| | 2 | 52 | 75.898 | 3.118 | 1-3 | 0.93** |
| | 3 | 35 | 86.158 | 3.713 | 2-3 | 0.47 |

** Large Effect Size

Although the mean of students in FEN was greater than the mean of the students in SDAL on PSTACH and PSTATT, only the difference on PSTACH was large in effect, as Table 4.33 indicated.

Table 4.33 Mean comparisons and the effect sizes of the levels of School

| Dependent Variable | SCHOOL | n | Mean | Std. Error | Effect Size |
|---|---|---|---|---|---|
| PSTACH | SDAL | 79 | 19.762 | 0.513 | 0.94** |
| | FEN | 40 | 24.063 | 0.767 | |
| PSTATT | SDAL | 79 | 73.989 | 2.372 | 0.18 |
| | FEN | 40 | 77.862 | 3.547 | |

** Large Effect Size

Table 4.34 revealed that although the mean of the students on PSTACH and PSTATT did not yield a systematic increase or decrease when examined with regard to their previous physics course grades, the students who had “5” as PPCG outperformed the others on both dependent variables. The effect sizes on the other hand were all small, except the ones calculated for 1-3 (medium effect) and 3-5 (high effect) on PSTACH, as Table 4.35 indicated.

Table 4.34 Mean comparisons of the levels of PPCG

| Dependent Variable | PPCG | n | Mean | Std. Error |
|---|---|---|---|---|
| PSTACH | 1 | 1 | 22.340 | 3.473 |
| | 2 | 4 | 21.545 | 1.828 |
| | 3 | 21 | 19.932 | 0.825 |
| | 4 | 44 | 22.040 | 0.703 |
| | 5 | 49 | 23.444 | 0.666 |
| PSTATT | 1 | 1 | 71.955 | 16.069 |
| | 2 | 4 | 70.517 | 8.456 |
| | 3 | 21 | 73.433 | 3.818 |
| | 4 | 44 | 73.471 | 3.252 |
| | 5 | 49 | 81.514 | 3.082 |

Table 4.35 Pairwise effect sizes of the levels of PPCG

| Dependent Variable | PPCG (I) | PPCG (J) | Effect Size |
|---|---|---|---|
| PSTACH | 1 | 2 | 0.32 |
| | | 3 | 0.69* |
| | | 4 | 0.07 |
| | | 5 | 0.24 |
| | 2 | 3 | 0.46 |
| | | 4 | 0.11 |
| | | 5 | 0.43 |
| | 3 | 4 | 0.49 |
| | | 5 | 0.82** |
| | 4 | 5 | 0.27 |
| PSTATT | 1 | 2 | 0.13 |
| | | 3 | 0.09 |
| | | 4 | 0.07 |
| | | 5 | 0.46 |
| | 2 | 3 | 0.18 |
| | | 4 | 0.15 |
| | | 5 | 0.39 |
| | 3 | 4 | 0.00 |
| | | 5 | 0.41 |
| | 4 | 5 | 0.38 |

* Medium Effect Size  ** Large Effect Size

As Table 3.36 indicated, when the interaction between PREACH and MOI was investigated, it was found that the interaction between high preachiever students who had inquiry and lecture instruction yielded a medium effect on PSTATT. In essence, high preachiever students having inquiry-based instruction outperformed their high preachiever peers having lecture instruction on PSTATT, and this difference was of medium effect size. The other pairwise comparisons of PREACH and MOI did not produce a medium or high effect sizes, although in all preachievement levels inquiry group had higher means than the lecture group on PSTACH, and although in low and medium preachievement levels the lecture groups had higher means on PSTATT then the inquiry groups.

Table 4.36 Pairwise comparison of PREACH * MOI

| Dependent Variable | PREACH | n | MOI | Mean | Std. Error | Effect Size |
|---|---|---|---|---|---|---|
| PSTACH | 1 | 9 | LEC | 19.718 | 1.449 | 0.22 |
| | | 23 | INQ | 20.624 | 0.930 | |
| | 2 | 15 | LEC | 21.561 | 1.197 | 0.15 |
| | | 33 | INQ | 22.220 | 0.826 | |
| | 3 | 17 | LEC | 23.542 | 1.389 | 0.04 |
| | | 22 | INQ | 23.736 | 1.063 | |
| PSTATT | 1 | 9 | LEC | 79.319 | 6.703 | 0.07 |
| | | 23 | INQ | 77.991 | 4.304 | |
| | 2 | 15 | LEC | 78.592 | 5.538 | 0.11 |
| | | 33 | INQ | 76.364 | 3.824 | |
| | 3 | 17 | LEC | 64.360 | 6.424 | 0.61* |
| | | 22 | INQ | 78.489 | 4.918 | |

* Medium Effect Size

As Table 4.36 and Figure 4.11 indicated, when the interaction between PREACH and MOI was investigated, it was found that the interaction between high preachiever students who had inquiry and lecture instruction yielded a medium effect (ES=0.61) on PSTATT. In essence, high preachiever students having inquiry-based instruction outperformed their high preachiever peers having lecture instruction on PSTATT.

For students who had high achievement previously on electric circuits, inquiry-based instruction was better than lecture instruction for improving their attitudes toward the same subject.

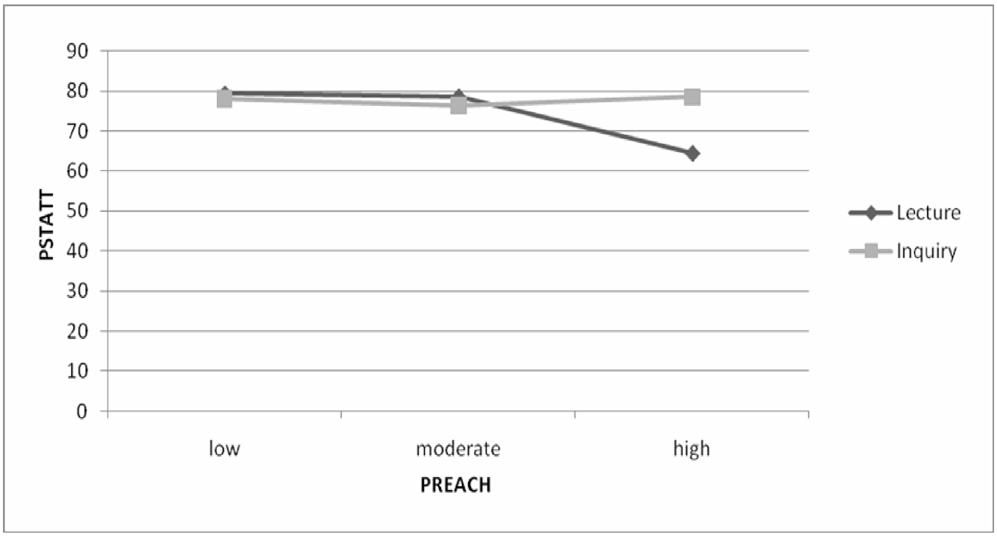


Figure 4.11 Interaction between PREACH and MOI with respect to PSTATT

There was only one student in the lecture group who had "1" as the previous physics course grade, while there was none in the inquiry group, therefore the effect size for this cell was not computed, as Table 4.37 presented. Also, in the grade "2" group, the sample sizes were so low ($n_{INQ}$= 3 ; $n_{LEC}$ = 1) that meaningful results could not be obtained. Although the sample size was small, the interaction between PPCG and MOI revealed a high effect for the students who had "2" as the previous physics course grade and exposed to lecture or inquiry based instructions. Students who were exposed to lecture outperformed those who had inquiry based instruction on PSTACH. However, this high effect size should be considered with caution because of the previously mentioned reason. For students who had "5" as PPCG, the inquiry instruction has more positive effect on PSTACH than the lecture instruction. There existed a medium effect. On the other side, this interaction term PPCG*MOI did not produced a medium or high effect on the mean of students on PSTATT, although the mean of the inquiry groups were higher than the mean of the lecture groups by the increasing PPCG levels.

Table 4.37 Pairwise comparison of the PPCG * MOI

| Dependent Variable | PPCG | n | MOI | Mean | Std. Error | Effect Size |
|---|---|---|---|---|---|---|
| PSTACH | 1 | 1 | LEC | 22.340 | 3.473 | |
| | | 0 | INQ | | | |
| | 2 | 1 | LEC | 22.870 | 3.438 | 0.97** |
| | | 3 | INQ | 20.882 | 2.048 | |
| | 3 | 8 | LEC | 19.075 | 1.278 | 0.41 |
| | | 13 | INQ | 20.468 | 1.078 | |
| | 4 | 18 | LEC | 22.191 | 1.004 | 0.08 |
| | | 26 | INQ | 21.868 | 0.882 | |
| | 5 | 13 | LEC | 22.357 | 1.149 | 0.57* |
| | | 36 | INQ | 24.531 | 0.661 | |
| PSTATT | 1 | 1 | LEC | 71.955 | 16.069 | |
| | | 0 | INQ | | | |
| | 2 | 1 | LEC | 70.352 | 15.904 | 0.03 |
| | | 3 | INQ | 70.600 | 9.475 | |
| | 3 | 8 | LEC | 72.490 | 5.914 | 0.10 |
| | | 13 | INQ | 74.023 | 4.988 | |
| | 4 | 18 | LEC | 70.730 | 4.644 | 0.30 |
| | | 26 | INQ | 76.605 | 4.083 | |
| | 5 | 13 | LEC | 79.185 | 5.318 | 0.26 |
| | | 36 | INQ | 83.842 | 3.057 | |

* Medium Effect Size ** Large Effect Size

As Table 4.37 and Figure 4.12 indicated, the interaction between PPCG and MOI revealed a high effect (ES=0.97) for the students who had “2” as the previous physics course grade and exposed to lecture or inquiry based instructions. Students who were exposed to lecture outperformed those who had inquiry based instruction on PSTACH. However, this high effect size should be considered with caution because of the previously mentioned small sample size. For students who had “5” as PPCG, the inquiry instruction had more positive effect on PSTACH than the lecture instruction. There existed a medium effect (ES=0.57).

For students who had “2” as PPCG, lecture instruction was more beneficial than the inquiry based instruction on improving students’ achievement in electric circuits subject. On the other hand, for students who had “5” as PPCG, the inquiry-based instruction was better than the lecture instruction.

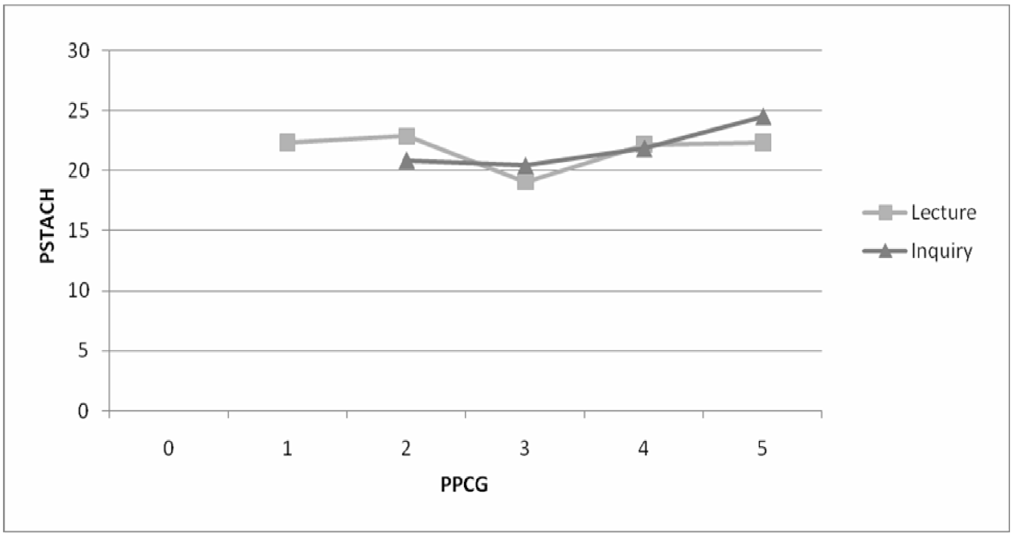


Figure 4.12 Interaction between PPCG and MOI with respect to PSTACH

Table 4.38 indicated the pairwise comparison of the interaction term CoS*PPCG*MOI. According to Table 4.38, for the dependent variable of PSTACH, field dependent students who had “2” and “3” as previous physics course grades, gained higher mean scores when they were exposed to lecture instruction. The effect of this difference was large, however, this effect size values should be handled with caution, since there were just a few students in the related cells. Field intermediate students who had “3” as PPCG were more successful in inquiry group on PSTACH, and the effect size reached to medium. Also, field intermediate students who had “5” as PPCG benefited from inquiry-based instruction; the effect size was large, this time. Also, field independent students who had “3” and “5” as PPCG benefited more from the inquiry instruction with large and medium effect sizes, respectively.

Again referring to Table 4.38, for the dependent variable of PSTATT, field dependent learners with “2” and “3” PPCGs seemed to favor lecture instruction more and the effect sizes were large in both cases. It is worth to emphasize again that the sample sizes for the cells were too small, and so this effect size values should be interpreted carefully. For the field intermediate students, the mean differences on PSTATT between two instruction groups did not reach the high or medium effect sizes, and these differences did not show a coherent pattern in favor of one of the method of instructions. Field independent students who had “3”, “4”, and “5” as PPCGs were all more successful in inquiry based instruction compared to their peers having lecture instruction. The effect size values for each “3”, “4”, and “5” groups of PPCG were large, medium and medium, respectively.

Table 4.38 Pairwise comparison of the CoS * PPCG * MOI

| Dependent Variable | CoS | PPCG | n | MOI | Mean | Std. Error | Effect Size |
|---|---|---|---|---|---|---|---|
| PSTACH | FDEP | 1 | 1 | LEC | 22.340 | 3.473 | |
| | | | 0 | INQ | | | |
| | | 2 | 1 | LEC | 22.870 | 3.438 | 4.98** |
| | | | 2 | INQ | 15.878 | 2.433 | |
| | | 3 | 1 | LEC | 21.357 | 3.399 | 1.30** |
| | | | 4 | INQ | 18.066 | 1.885 | |
| | | 4 | 4 | LEC | 22.305 | 1.903 | 0.04 |
| | | | 9 | INQ | 22.168 | 1.359 | |
| | | 5 | 4 | LEC | 23.163 | 1.729 | 0.29 |
| | | | 8 | INQ | 22.216 | 1.422 | |
| | FMIX | 1 | 0 | LEC | | | |
| | | | 0 | INQ | | | |
| | | 2 | 0 | LEC | | | |
| | | | 1 | INQ | 25.886 | 3.213 | |
| | | 3 | 4 | LEC | 19.604 | 1.742 | 0.78* |
| | | | 5 | INQ | 21.790 | 1.637 | |
| | | 4 | 4 | LEC | 22.772 | 1.751 | 0.34 |
| | | | 11 | INQ | 21.506 | 1.368 | |
| | | 5 | 3 | LEC | 20.901 | 2.342 | 1.27** |
| | | | 15 | INQ | 25.154 | 0.961 | |
| | FIND | 1 | 0 | LEC | | | |
| | | | 0 | INQ | | | |
| | | 2 | 0 | LEC | | | |
| | | | 0 | INQ | | | |
| | | 3 | 3 | LEC | 17.404 | 2.060 | 1.63** |
| | | | 4 | INQ | 22.087 | 2.138 | |
| | | 4 | 10 | LEC | 21.689 | 1.234 | 0.11 |
| | | | 6 | INQ | 22.056 | 1.359 | |
| | | 5 | 6 | LEC | 22.520 | 1.618 | 0.71* |
| | | | 13 | INQ | 25.452 | 1.348 | |

Table 4.38 (continued)

| Dependent Variable | CoS | PPCG | n | MOI | Mean | Std. Error | Effect Size |
|---|---|---|---|---|---|---|---|
| PSTATT | FDEP | 1 | 1 | LEC | 71.955 | 16.069 | |
| | | | 0 | INQ | | | |
| | | 2 | 1 | LEC | 70.352 | 15.904 | 1.91** |
| | | | 2 | INQ | 57.952 | 11.255 | |
| | | 3 | 1 | LEC | 86.979 | 15.724 | 1.63** |
| | | | 4 | INQ | 67.925 | 8.722 | |
| | | 4 | 4 | LEC | 66.264 | 8.805 | 0.47 |
| | | | 9 | INQ | 73.674 | 6.289 | |
| | | 5 | 4 | LEC | 82.469 | 8.002 | 0.32 |
| | | | 8 | INQ | 87.259 | 6.579 | |
| | FMIX | 1 | 0 | LEC | | | |
| | | | 0 | INQ | | | |
| | | 2 | 0 | LEC | | | |
| | | | 1 | INQ | 83.247 | 14.867 | |
| | | 3 | 4 | LEC | 75.797 | 8.060 | 0.33 |
| | | | 5 | INQ | 79.991 | 7.576 | |
| | | 4 | 4 | LEC | 81.060 | 8.102 | 0.15 |
| | | | 11 | INQ | 78.459 | 6.330 | |
| | | 5 | 3 | LEC | 78.383 | 10.834 | 0.05 |
| | | | 15 | INQ | 79.144 | 4.447 | |
| | FIND | 1 | 0 | LEC | | | |
| | | | 0 | INQ | | | |
| | | 2 | 0 | LEC | | | |
| | | | 0 | INQ | | | |
| | | 3 | 3 | LEC | 61.940 | 9.532 | 0.92** |
| | | | 4 | INQ | 74.217 | 9.893 | |
| | | 4 | 10 | LEC | 68.307 | 5.709 | 0.77* |
| | | | 6 | INQ | 79.839 | 6.287 | |
| | | 5 | 6 | LEC | 76.435 | 7.487 | 0.51* |
| | | | 13 | INQ | 86.263 | 6.236 | |

* Medium Effect Size  ** Large Effect Size

According to Table 4.38 and Figure 4.13, for the dependent variable PSTACH, field dependent students who had “2” (ES=4.98) and “3” (ES=1.30) as previous physics course grades, gained higher mean scores when they were exposed to lecture instruction. The effect of this difference was large, however, this effect size values should be handled with caution, since there were just a few students in the related cells.

For field dependent students, students who had “2” and “3” as previous physics course grade, benefited more from lecture instruction than they did from inquiry-based instruction in increasing electric circuits achievement.

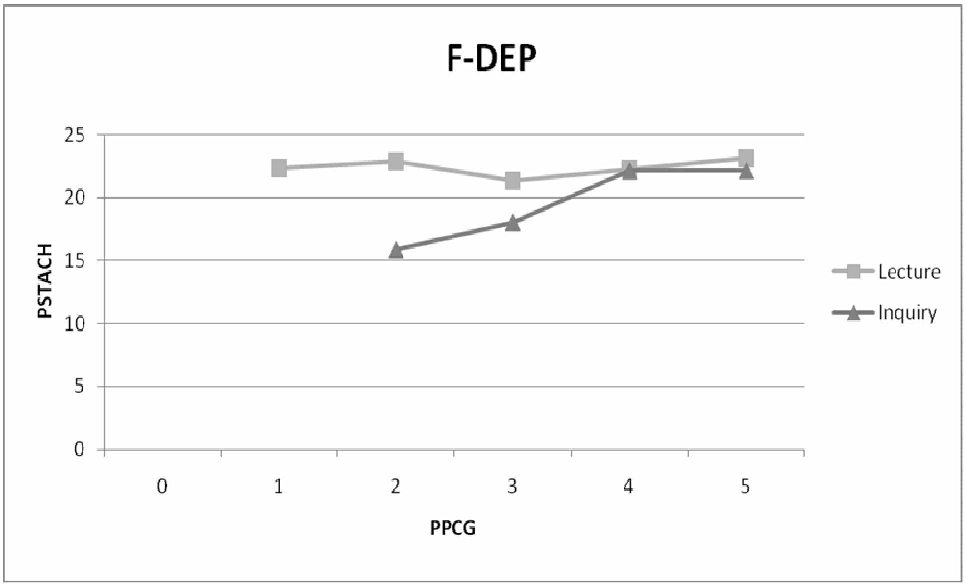


Figure 4.13 Interaction between PPCG and MOI with respect to PSTACH for Field Dependent Students

As Table 4.38 and Figure 4.14 indicated, field intermediate students who had “3” as PPCG were more successful in inquiry group on PSTACH, and the effect size reached to medium (ES=0.78). Also, field intermediate students who had “5” as PPCG benefited from inquiry-based instruction, whereas the effect size was large (ES=1.27), this time.

For field intermediate students, students who had “3” and “5” as previous physics course grade, benefited more from inquiry-based instruction than they did from lecture instruction in increasing electric circuits achievement.

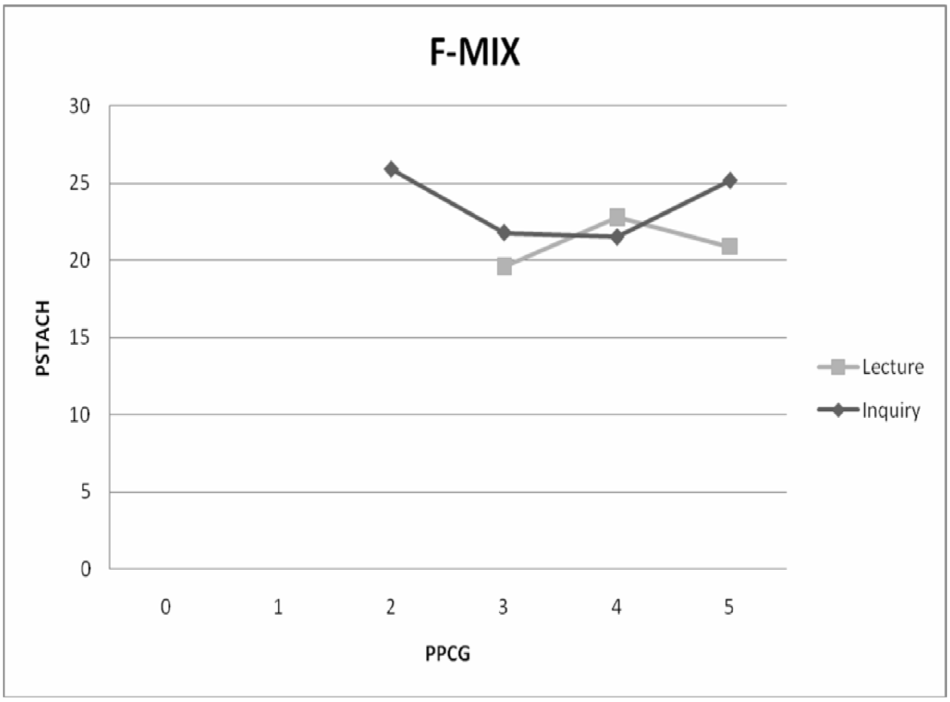


Figure 4.14 Interaction between PPCG and MOI with respect to PSTACH for Field Mixed Students

As Table 4.38 and Figure 4.15 presented, field independent students who had “3” and “5” as PPCG benefited more from the inquiry instruction with large (ES=1.63) and medium (ES= 0.71) effect sizes, respectively.

For field independent students, students who had “3” and “5” as previous physics course grade, benefited more from inquiry-based instruction than they did from lecture instruction in increasing electric circuits achievement.

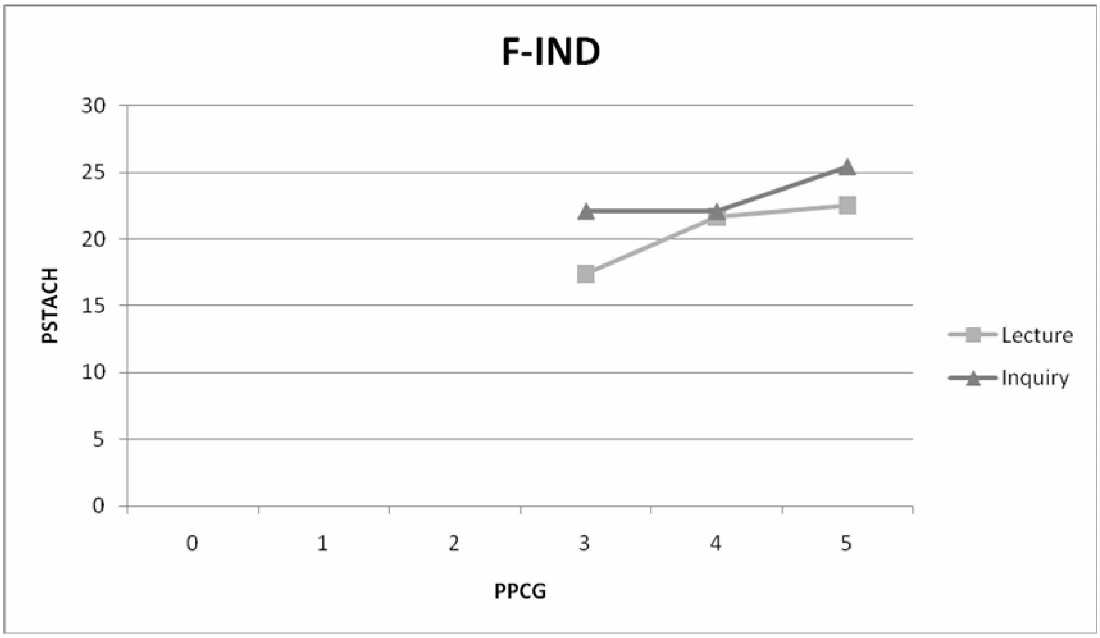


Figure 4.15 Interaction between PPCG and MOI with respect to PSTACH for Field Independent Students

Referring to Table 4.38 and Figures 4.16, for the dependent variable PSTATT, field dependent learners with “2” (ES=1.91) and “3” (ES=1.63) PPCGs seemed to favor lecture instruction more and the effect sizes were large in both cases. It is worth to emphasize again that the sample sizes for the cells were too small, and so this effect size values should be interpreted carefully.

For field dependent students, students who had “2” and “3” as previous physics course grade, the lecture instruction was better than the inquiry-based instruction on improving their attitudes toward electric circuits subject.

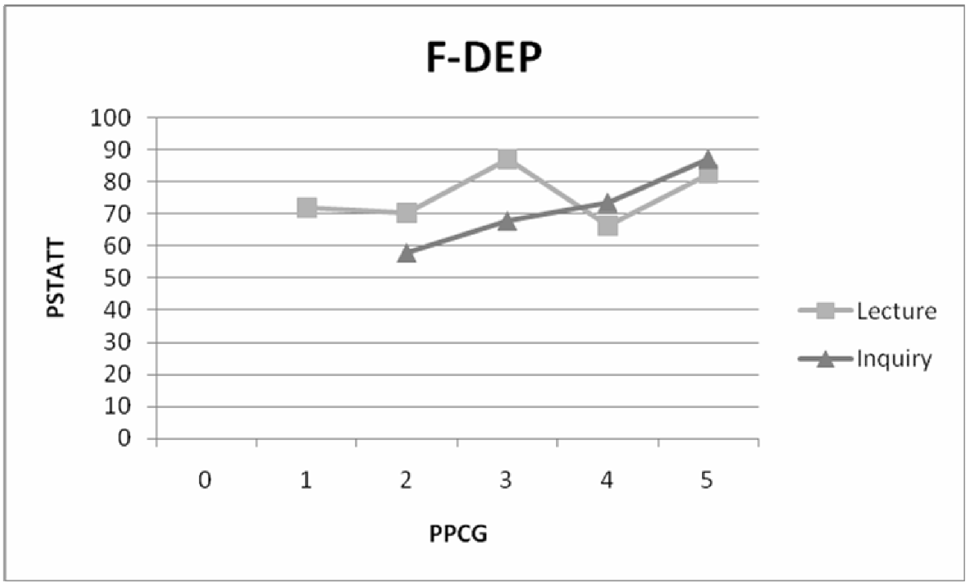


Figure 4.16 Interaction between PPCG and MOI with respect to PSTATT for Field Dependent Students

As Table 4.38 and Figure 4.17 clearly showed, field independent students who had “3”, “4”, and “5” as PPCGs were all more successful in inquiry based instruction compared to their peers having lecture instruction. The effect size values for each “3”, “4”, and “5” groups of PPCG were large (ES=0.92), medium (ES=0.77) and medium (ES=0.51), respectively.

For field independent students, inquiry-based instruction was more beneficial than the lecture instruction on improving students’ attitudes toward electric circuits subject.

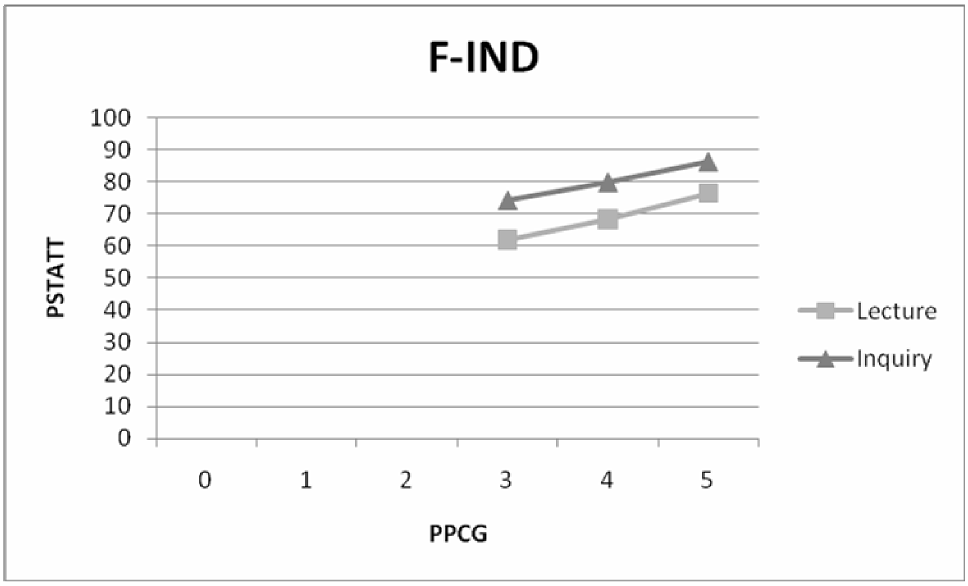


Figure 4.17 Interaction between PPCG and MOI with respect to PSTATT for Field Independent Students

For the pairwise comparison of the interaction term of CoS*PREATT*PPCG*MOI; since the sample sizes for each cell were really small (between 0 and 7), the effect sizes were not computed and discussed in this study.

4.5 Classroom observation checklist

There are 20 items in the classroom observation checklist and these items were grouped into three categories according to their relatedness to the methods of instruction, inquiry and lecture. Items 1, 3, 4, 5, 6, 7, 9, 11, 12, 13, 14, 15, 16, and 18 were related to the inquiry based instruction, whereas Items 2 and 8 were related to lecture method. The remaining Items 10, 17, 19, and 20 were the common items related to all treatments.

Each item in the observation checklist had four alternatives, namely, "Yes," "Partially," "No," and "Not Applicable." These alternatives were coded as "3" for "Yes", "2" for "Partially", "1" for "No", and "0" for "Not Applicable."

There were thirteen classes in this study and each class was observed three times during the intervention, in fact, thirty nine lessons from a total of one hundred and sixty eight lessons were observed. The observations were done in random intervals. Table 4.39 described the means and standard deviations of each item in the checklist. The bold and underlined numbers indicated that the item was related to the method of instruction which was specified at the top of the column. If both columns were bold and underlined, then it means that the item was common to both methods. All the items related to inquiry-based instruction had higher means in the inquiry groups than in the lecture groups. Also items related to lecture instruction had higher means in the lecture groups than they did in the inquiry groups. Two of the common Items 19 and 20 had higher scores in the inquiry groups; however, the means of these items were expected to be close to each other for lecture and inquiry groups. Item 20 was concerned about whether the students had enjoyed the lesson or not, since students were more active in the inquiry-based instruction, the higher mean for the inquiry was not surprising.

Table 4.39 Results of classroom observation checklist with respect to each item

| Item No | Inquiry Group (n=24) | | Lecture Group (n=15) | |
|---|---|---|---|---|
| | Mean (Out of 3) | S.D. | Mean (Out of 3) | S.D. |
| 1 | **<u>3.0</u>** | 0.0 | 1.0 | 0.0 |
| 2 | 1.0 | 0.1 | **<u>2.9</u>** | 0.3 |
| 3 | **<u>3.0</u>** | 0.0 | 1.1 | 0.1 |
| 4 | **<u>2.9</u>** | 0.2 | 1.1 | 0.2 |
| 5 | **<u>2.8</u>** | 0.4 | 1.1 | 0.2 |
| 6 | **<u>2.9</u>** | 0.3 | 1.6 | 0.3 |
| 7 | **<u>2.8</u>** | 0.4 | 1.8 | 0.2 |
| 8 | 1.1 | 0.3 | **<u>2.3</u>** | 0.3 |
| 9 | **<u>2.8</u>** | 0.4 | 1.8 | 0.2 |
| 10 | **<u>2.8</u>** | 0.4 | **<u>2.0</u>** | 0.0 |
| 11 | **<u>3.0</u>** | 0.0 | 1.0 | 0.1 |
| 12 | **<u>2.9</u>** | 0.2 | 1.0 | 0.1 |
| 13 | **<u>2.9</u>** | 0.2 | 1.0 | 0.1 |
| 14 | **<u>2.9</u>** | 0.2 | 1.0 | 0.1 |
| 15 | **<u>2.9</u>** | 0.3 | 1.0 | 0.1 |
| 16 | **<u>2.9</u>** | 0.2 | 1.0 | 0.1 |
| 17 | **<u>2.8</u>** | 0.4 | **<u>2.4</u>** | 0.4 |
| 18 | **<u>2.8</u>** | 0.4 | 1.1 | 0.1 |
| 19 | **<u>2.9</u>** | 0.3 | **<u>2.0</u>** | 0.2 |
| 20 | **<u>2.8</u>** | 0.4 | **<u>1.7</u>** | 0.2 |

As Table 4.39 indicated, for Items 1, 3, 4, 5, 6, 7, 9, 11, 12, 13, 14, 15, 16, and 18, inquiry group had higher mean scores than the lecture group; for Items 2 and 8 the lecture group had higher scores than the inquiry group. These results were expected, however, for common score items, Items 10, 17, 19, and 20, the inquiry group again had higher scores. This result was different from the expected one, since these items were common for the experimental and control group, there should not be a remarkable and significant difference between them.

To examine the statistical significance of the differences shown in Table 4.39, both parametric and nonparametric tests were used. First of all, three scores were defined for both lecture and inquiry groups; inquiry score (INQ-S), lecture score (LEC-S), and common score (COM-S) were created simply by adding all the items related to each group. As the parametric test Independent Samples t-test was used, and Tables 4.40 and 4.41 presented the descriptive statistics and the results of the Independent Samples t-test. Cohen's effect size was calculated for the inquiry, lecture, and common score differences between experimental and control groups by using the formula below;

$$d = \frac{\bar{x}_1 - \bar{x}_2}{s},$$

where the standard deviation was calculated by

$$s = \sqrt{\frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2}},$$

since the sample sizes for experimental and control groups were not equal.

Table 4.40 Descriptive statistics of the One-Way ANOVA

| Dependent Variables | MOI | N | Mean | Std. Deviation | Effect Size |
|---|---|---|---|---|---|
| LEC-S | EXP | 24 | 2.14 | 0.31 | 7.80 |
| | CONT | 15 | 5.20 | 0.52 | |
| | Total | 39 | 3.32 | 1.56 | |
| INQ-S | EXP | 24 | 40.58 | 2.65 | 11.48 |
| | CONT | 15 | 16.53 | 0.83 | |
| | Total | 39 | 31.33 | 12.04 | |
| COM-S | EXP | 24 | 11.38 | 1.35 | 3.06 |
| | CONT | 15 | 8.07 | 0.52 | |
| | Total | 39 | 10.10 | 1.96 | |

Table 4.41 Test of homogeneity of variance for the Independent Samples t-Test

| Dependent Variables | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | |
|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. | Mean Difference | Std. Error Difference |
| LEC-S | Equal variances assumed | 7.16 | 0.011 | -23.20 | 37 | 0.00 | -3.06 | 0.13 |
| | Equal variances not assumed | | | -20.72 | 20.35 | 0.00 | -3.06 | 0.15 |
| INQ-S | Equal variances assumed | 12.62 | 0.001 | 34.01 | 37 | 0.00 | 24.05 | 0.71 |
| | Equal variances not assumed | | | 41.37 | 29.65 | 0.00 | 24.05 | 0.58 |
| COM-S | Equal variances assumed | 5.27 | 0.027 | 9.07 | 37 | 0.00 | 3.31 | 0.37 |
| | Equal variances not assumed | | | 10.81 | 32.37 | 0.00 | 3.31 | 0.31 |

According to Table 4.41, there were significant mean differences between lecture and inquiry groups in all of the dependent variables, LEC-S, INQ-S, and COM-S. According to Levene’s Test for Homogeneity of Variances, all the variances were different; therefore second lines, “Equal variances not assumed,” for each dependent variable were interpreted in Table 4.41. There were significant mean differences between the treatment groups in their LEC-S, INQ-S and COM-S scores. Lecture group had higher mean in LEC-S dependent variable, and the inquiry group had higher mean in INQ-S dependent variable than their counterparts did. These results were expected, since the treatments should vary in these items. However, the statistically significant mean difference in COM-S scores between groups was not expected. The inquiry group had higher mean from COM-S when compared to lecture group. Also, all the effect sizes computed for the inquiry, lecture and common score differences were large.

Since the homogeneity of variances assumption could not be met, it would be better to conduct Mann-Whitney U Test as a non-parametric counterpart, as Freankel and Wallen indicated (1996, p.217). Table 4.42 and 4.43 indicated the descriptive statistics and the results of the Mann-Whitney U test. The results of the test were in the expected direction and significant, $z = -5.53$, $p < .05$ for the dependent variable LEC-S, and inquiry group has an average rank of 12.50 while the lecture group had an average rank of 32.00. The results of the test were in the expected direction and significant, $z = -5.48$, $p < .05$ for the dependent variable INQ-S, and inquiry group has an average rank of 27.50 while the lecture group had an average rank of 8.00. The results of the test were not in the expected direction and significant, $z = -4.65$, $p < .05$ for the dependent variable COM-S, and inquiry group has an average rank of 26.31 while the lecture group had an average rank of 9.90

Table 4.42 Descriptive statistics for ranked variable of LEC-S, INQ-S, and COM-S

| | N | Mean | Std. Deviation | Minimum | Maximum |
|---|---|---|---|---|---|
| LEC-S | 39 | 20.00 | 10.712757 | 10.000 | 38.500 |
| INQ-S | 39 | 20.00 | 10.820303 | 1.000 | 30.500 |
| COM-S | 39 | 20.00 | 10.723805 | 1.000 | 30.500 |

Table 4.43 Results and Comparisons of the Mann-Whitney U test

| | MOI | N | Mean Rank | Sum of Ranks | Mann-Whitney U | Wilcoxon W | Z | Asymp. Sig. |
|---|---|---|---|---|---|---|---|---|
| LEC-S | EXP | 24 | 12.50 | 300.00 | 0.00 | 300.00 | -5.53 | 0.00 |
| | CONT | 15 | 32.00 | 480.00 | | | | |
| | Total | 39 | | | | | | |
| INQ-S | EXP | 24 | 27.50 | 660.00 | 0.00 | 120.00 | -5.48 | 0.00 |
| | CONT | 15 | 8.00 | 120.00 | | | | |
| | Total | 39 | | | | | | |
| COM-S | EXP | 24 | 26.31 | 631.50 | 28.50 | 148.50 | -4.65 | 0.00 |
| | CONT | 15 | 9.90 | 148.50 | | | | |
| | Total | 39 | | | | | | |

Thirty nine lessons from a total of one hundred and sixty eight lessons were observed; eight (five experimental, three control group lessons) of these thirty nine lessons were observed by two observers, therefore for these eight lessons, there were two scores. For the reliability concern, two research assistants with at least six year experience from the Secondary Science and Mathematics Education department at METU observed same classes for eight lessons and their observations were analyzed in order to obtain inter-rater reliability. The correlation coefficients between these two observers were presented in Table 4.44. The scores that the two observers gave for each item in the checklist were correlated for each eight lesson separately, and a correlation coefficient was computed for each lesson. According to Table 4.44, there were high correlations between two observers; this fact might indicate that the observations made by only one observer were also reliable.

Table 4.44 Correlations between two observers

| Lessons | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| | Inq. | Inq. | Inq. | Inq. | Lec. | Lec. | Lec. | Lec. |
| R | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.92 | 0.98 | 1.00 |

To conclude, descriptive statistics of the items indicated that treatment verification was supported by all the items related to treatments in the checklist. Additionally, Independent Samples t-test and Mann-Whitney U Test gave evidence that the methods were applied appropriately in lecture and inquiry groups. There should be only slight differences between the means and average ranks of the treatments groups in COM-S scores, but, there was a significant difference between the treatment groups on COM-S dependent variable. This situation pointed out that the characteristics which should be common to all treatments were not integrated equally well in the treatment and control groups. As a result, treatment verification for the application of treatments was said to be satisfied.

## 4.6 Summary of Findings

Results obtained from the current study can be summarized under each measuring tool and type of analysis as the following:

### According to Descriptive and Inferential Statistics

- The inquiry group was better in terms of gain scores obtained in the PSTACH.
- The mean of the PSTATT scores decreased in control group, but in the experimental group, change in the mean attitude scores is nearly zero. It can be concluded that treatment did not affect the attitudes of students toward the electric circuits subject for the inquiry group.

- MOI had a significant effect on the collective dependent variables of PSTACH and PSTATT, however, the interactions among several independent variables did not have a significant effect. Therefore, it can be concluded that there is a significant mean difference of achievement in and attitude toward electric circuits subject between the eleventh grade students who were exposed to lecture and inquiry instruction.
- MOI had a significant effect on the dependent variable PSTACH, however, the interactions among several independent variables did not have a significant effect. Therefore, it can be concluded that there is a significant mean difference of achievement in electric circuits subject between the eleventh grade students who were exposed to lecture and inquiry instruction
- MOI did not have a significant effect on the dependent variable PSTATT, likewise, the interactions among several independent variables did not have a significant effect. Therefore, it can be concluded that there was not a significant difference of attitude toward electric circuits subject between the eleventh grade students who were exposed to lecture and inquiry instruction.
- In general, inquiry instruction was effective than the lecture instruction with respect to PSTACH in electric circuits subject. However, there was not a significant difference in effectiveness of both methods in improving students' attitudes toward electric circuits subject. In essence, each method of instruction was not effective on improving students' attitudes toward electric circuits subject.
- Inquiry-based instruction was more effective than lecture instruction for increasing students' achievement in electric circuits subject.

According to ATI Analysis

- Although, this study could not find any statistically significant interaction effect of MOI and other independent variables on students' PSTATT scores, practical significance was investigated for the interaction terms.
- Students who achieved high scores in the achievement pretest, benefited more from the inquiry based instruction rather than the lecture. High preachiever

students exposed to inquiry instruction were more successful than the other high preachievers who were exposed to lecture instruction on PSTACH.

- Students who had grades “2”, “3”, and “4” from the previous physics courses, benefited more from the inquiry instruction then they did from the lecture instruction for increasing their achievement in electric circuits subject. Additionally, for students who had “2” from the previous physics courses, inquiry instruction was more beneficial on improving their attitudes toward electric circuits subject.
- Field dependent students who had grade “2” and grades higher than “2” from previous physics courses benefited more from inquiry instruction than they did from lecture in increasing their achievement in electric circuits subject. Nonetheless, students who had “1” from previous physics course, benefited more from the lecture method. Also, for field dependent students who had “1” and “3” as PPCG, lecture instruction was better than the inquiry-based instruction on improving students’ attitudes toward electric circuits subject.
- Inquiry instruction is more beneficial than the lecture on electric circuits subject achievement for field intermediate students who got grade “2” and higher than “2” grades. For students who got “0” and “1”, comparison of the methods could not be done. In addition, for field intermediate students who had “2” as PPCG, inquiry-based instruction was better than the lecture instruction on improving students’ attitudes toward electric circuits subject.
- For field independent students who had “2” and “3” as PPCG, inquiry method was better than the lecture method on improving achievement in electric circuits subject. Moreover, for field independent students who had “3” and “2” as PPCG, inquiry based instruction was more effective than lecture on improving their attitude toward electric circuits subject.

According to ATI Analysis for SDAL and FEN

- For students who had high achievement previously on electric circuits, inquiry-based instruction was better than lecture instruction for improving attitude toward the same subject.

- For students who had “2” as PPCG, lecture instruction was more beneficial than the inquiry based instruction on improving students’ achievement in electric circuits subject. On the other hand, for students who had “5” as PPCG, the inquiry-based instruction was better than the lecture instruction.
- For field dependent students, students who had “2” and “3” as previous physics course grade, benefited more from lecture instruction than they did from inquiry-based instruction in increasing electric circuits achievement. Additionally, for field dependent students, students who had “2” and “3” as previous physics course grade, the lecture instruction was better than the inquiry-based instruction on improving their attitudes toward electric circuits subject.
- For field intermediate students, students who had “3” and “5” as previous physics course grade, benefited more from inquiry-based instruction than they did from lecture instruction in increasing electric circuits achievement.
- For field independent students, students who had “3” and “5” as previous physics course grade, benefited more from inquiry-based instruction than they did from lecture instruction in increasing electric circuits achievement. Also, for field independent students, inquiry-based instruction was more beneficial than the lecture instruction on improving students’ attitudes toward electric circuits subject.

According to the Classroom Observation Checklist

- Analysis of the checklist items and independent samples t-test and Mann-Whitney U Test indicated that both inquiry method and lecture method were implemented due to the principles of the inquiry teaching and lecturing. There was a significant difference between these two methods.
- Observations performed by different observers, yielded high correlations.
- Common items were found to be different between inquiry groups and lecture groups. As was discussed in Chapter 5, this difference was manageable and explicable.

# CHAPTER 5

# DISCUSSION, CONCLUSION, AND IMPLICATIONS

This chapter consists of six subsections. First subsection presents the summary of the study. The discussion of the results is given in the second subsection. Third and fourth subsections present the internal and external validities of the study. Conclusions and the implications are given in the fifth and the sixth subsections, respectively. Finally, recommendations for further studies are presented.

## 5.1 Summary of the Study

This study was conducted in the second semester of 2008-2009 educational year, in the central district of Aydın. One public high school, one science high school, and three Anatolian high schools; nine physics teachers, their thirteen classes and 298 students were involved in the study. The sample of this quasi-experimental study was selected from accessible population by a convenient sampling procedure.

The researcher observed a regular physics course of each teacher to define teachers' preferred teaching styles one month before the study and scored their lessons by the observation checklist. After that, teachers were grouped as those who are instructing physics with inquiry-based or lecture methods. All of the teachers were found to be teaching with deductive methods as a result of these observations. So, the regular lessons of the teachers were accepted as lecture lessons, however, these lessons were again observed during implementation as well as the inquiry-based taught classes in order to have treatment verification.

Students in the control group were lectured, whereas students in the experimental groups were instructed based on inquiry. Treatments were given by the teachers of the students included in the sample and continued up to five weeks except tests administrations. Before the treatment began, teachers and the researcher met twice to make the implementation procedure clear to everyone. They negotiated about the important points to consider, possible students responses to the activities and how to handle them, duration of the activities, availability of the necessary materials and equipments. Also they performed these activities on their own and discussed about the possible handicaps and solutions.

Inquiry-based instruction was given to 9 classes from five different high schools and it was planned for a four week period. There were three physics lessons in a week. In the first two lessons students were given an activity sheet in which they would perform hands-on inquiry activities about electric circuits. In the last lesson, related concepts and formulas were instructed; a class discussion and quantitative problem solving session were performed. Students worked in groups of five. In the activity sheets, there were some circuit diagrams, and questions. Students set up these circuits as shown in the figures and then were asked to answer the questions by writing down these answers to the blanks between the questions. Each group should complete an activity sheet, and these sheets were collected at the end of the activity. While students were doing activities, they were required to participate in group discussions; each student was forced to share his or her group’s responsibility. To ensure this participation, and to guide when needed, teachers walked around the class and asked students questions about the activity randomly. This forces each student to be interested in the inquiry. In the end of the activities, all groups were presented their answers to the questions in the activity sheets; they discussed the similar and different observations and the inferences made from those observations. This helped them to find and construct a common ground for further learning.

In the control groups, teachers firstly presented content, fundamental principles, necessary formulas, and then solved sample quantitative problems on board; wanted their students to note them down; and finally asked students more quantitative problems similar to the ones he or she had solved.

## 5.2 Discussion of the Results

In this study, the effect of inquiry-based versus lecture instruction and their interactions with eleventh grade students' previous physics achievement, previous attitudes toward electric circuits, previous physics course grades, schools, cognitive styles on achievement and attitude toward electric circuits subject were investigated.

The null hypothesis of the study was as follows: "There were no significant effects of method of instructions, (MOI; lecture versus inquiry) and its interaction with students' cognitive styles (CoS; field-independent, field-mixed, field-dependent) and other independent variables (physics achievement pretest scores, PREACH; physics attitude pretest scores, PREATT; previous physics course grades, PPCG; school, age, and gender) on the population means of the collective dependent variables of eleventh grade students' achievement posttest scores (PSTACH) and attitude towards electric circuits unit posttest scores (PSTATT)."

According to results of MANCOVA, this hypothesis was rejected. Methods of instruction had a significant effect on the collective dependent variables PSTACH and PSTATT, however, the interactions among several independent variables did not have a significant effect.

As Table 4.15 indicates, the observed power of this study and the effect size were lower than the calculated power of the study. The reason for the difference between calculated and observed power values is the difference between the effect size values of each. Effect size was set to medium effect size at the beginning of the study, however at the end of the study it was found to be small effect size. Therefore, it can be said that this study lacked the adequate power and practical significance. However, since there were many interaction terms in the model, the computation of power and effect size value at the beginning of the study was an overestimation. Although the size of sample involved in the study (n=298) was not small, there should be a larger sample to deal with that many interactions.

There was a significant main effect of methods of instruction on students' achievement of electric circuits subject according to follow-up ANCOVAs. There was not a significant mean difference of students' attitudes toward electric circuits subject between the eleventh grade students who were exposed to lecture and inquiry instruction. Inquiry method was more effective than lecture method on increasing electric circuits achievement while it was not for increasing students' attitudes toward electric circuits.

As previously stated, the effect of interaction terms on students' achievement in and attitude toward electric circuits subject was not statistically significant. However, in some interaction terms, especially in those third and fourth degree interactions, the number of students in most of the cells were less than ten, therefore investigation of these interactions terms by effect size values would provide more insight in terms of practical significance. In the study, the effect sizes were calculated for each of the interaction term cell, but, only the medium and large effect size values were reported and discussed. Although, this study could not find any statistically significant interaction effect of MOI and other independent variables on students' PSTACH and PSTATT scores, practical significance was investigated for the interaction terms.

Students who achieved highly in the pretest of PSTACH, benefited more from the inquiry based instruction rather than the lecture. High preachiever students exposed to inquiry instruction were more successful than the other high preachievers who were exposed to lecture instruction on PSTACH. Moreover, students who had grades "2", "3", and "4" from the previous physics courses, benefited more from the inquiry instruction then they did from the lecture instruction for increasing their achievement in electric circuits subject. For students who had "1" and "0" from the previous physics course, there was a trend that they would be more successful if they had provided with lecture instruction. As a result, inquiry instruction was more beneficial for increasing electric circuits achievement mostly of successful students. As the students' prior physics achievement increases, inquiry-based instruction is a more useful method when compared to lecture to develop students' achievement in electric circuits subject. Additionally, for students who had "2" from the previous physics courses, inquiry instruction was more beneficial on improving their attitudes toward electric circuits subject. When the graph of this interaction was investigated, it would be seen that except for students who had "0" and "1" from the previous physics course, inquiry instruction did not have a different effect from the lecture method or it was better on improving students' attitudes toward electric circuits subject. Those low achiever students yet had more positive attitudes when they exposed to the lecture method.

Field dependent students who had grade "2" and grades higher than "2" from previous physics courses benefited more from inquiry instruction than they did from lecture in increasing their achievement in electric circuits subject. Nonetheless, students who had "1" from previous physics course, benefited more from the lecture method. Also, for field dependent students who had lower scores than "4" as PPCG, lecture instruction was better than the inquiry-based instruction on improving students' attitudes toward electric circuits subject. For students who had "4" and "5" as PPCG, these two methods did not have a remarkably different effect in improving students' attitudes toward electric circuits subject.

Inquiry instruction is more beneficial than the lecture on electric circuits subject achievement for field intermediate students who got grade "2" and higher than "2" grades. For students who got "0" and "1", comparison of the methods could not be done. In addition, for field intermediate students who had "2" as PPCG, inquiry-based instruction was better than the lecture instruction on improving students' attitudes toward electric circuits subject while for the students who had higher scores, there was not a difference between the two methods.

For field independent students who had “2” and “3” as PPCG, inquiry method was better than the lecture method on improving achievement in electric circuits subject. However, for students who had higher scores on PPCG, this difference in effect sizes was not worth to take into consideration, in fact, students who had “5” as PPCG showed a very small benefit more from lecture instruction. Moreover, for field independent students who had “3” and “2” as PPCG, inquiry based instruction was more effective than lecture on improving their attitude toward electric circuits subject while for the students who had higher scores, there was not a difference between the two methods.

When the means of PREACH and PSTACH were compared for experimental and control groups, it was apparent that the mean of PSTACH was lower than the mean of PREACH for some groups. Although approximately finding the same means of PREACH and PSTACH for lecture or inquiry group might indicate that the treatment given in that group did not work at all, the decrease of mean from PREACH to PSTACH was irrational. Students were expected to learn some information unintentionally even if they just sat on the desk and were present in the classroom. This situation yielded suspension in the data collection process of PSTACH. Students probably did not give much attention to the test, and they might answer the questions cooperatively. In some classes the posttests were administered after the administration of the last examination; hence students did not answer this seriously. Although the teachers were warned about this possibility, and they took cautions as telling students the scores they got in the PSTACH would be their oral exam scores, students did not consider this caution. In the two schools SDAL and FEN, both groups increased their means on PSTACH with respect to PREACH. In fact, all the possible explanations suggested above were just guess; because the real reason for the situation could not be found from now on the interaction analyses were discussed in the following paragraphs for only SDAL and FEN.

For students who had high achievement previously on electric circuits, inquiry-based instruction was better than lecture instruction for improving attitude toward the same subject. For students who had “2” as PPCG, lecture instruction was more beneficial than the inquiry based instruction on improving students’ achievement in electric circuits subject. On the other hand, for students who had “5” as PPCG, the inquiry-based instruction was better than the lecture instruction. Therefore it can be concluded that students who had high preachievements in physics benefited more from inquiry instruction whereas those who had low preachievements benefited more from lecture instruction in increasing the electric circuits achievement.

For field dependent students, students who had “2” and “3” as previous physics course grade, benefited more from lecture instruction than they did from inquiry-based instruction in increasing electric circuits achievement. Additionally, for field dependent students, students who had “2” and “3” as previous physics course grade, the lecture instruction was better than the inquiry-based instruction on improving their attitudes toward electric circuits subject. Also, successful field dependent students benefited nearly equally from both type of instructions in improving achievement in and attitude toward electric circuits subject.

For field intermediate students, students who had “3” and “5” as previous physics course grade, benefited more from inquiry-based instruction than they did from lecture instruction in increasing electric circuits achievement. For the students who had “4” as PPCG inquiry and lecture methods provided approximately the same amount of benefit in increasing the electric circuits achievement.

For field independent students, students who had “3” and “5” as previous physics course grade, benefited more from inquiry-based instruction than they did from lecture instruction in increasing electric circuits achievement. For the students who had “4” as PPCG inquiry and lecture methods provided approximately the same amount of benefit in increasing the electric circuits achievement. Also, for field independent students, inquiry-based instruction was more beneficial than the lecture instruction on improving students' attitudes toward electric circuits subject.

In order to the results discussed above to be valid, both of the methods of instruction should be implemented as intended and as planned. To verify implementation of inquiry and lecture method, and to verify that there was difference between these methods in line with the planned one, experimental and control classrooms were observed during the implementation period. Analysis of observation checklist items and independent samples t-test and Mann-Whitney U Test indicated that both inquiry method and lecture method were implemented due to the principles of the inquiry teaching and lecturing. There was a significant difference between these two methods. Additionally, observations performed by different observers, yielded high correlations. However, common items were found to be different between inquiry groups and lecture groups. These items were asking whether the students enjoyed the lesson, whether the classroom conditions were convenient for instruction, whether the students engaged in the lesson, and whether any quantitative problems were solved in the lesson or not. These facts should be attained in all groups. The percentages of these items indicated that they were attained in both groups but up to the different degree. All students attended to lessons but they did more in inquiry group. Also, quantitative problems were solved in both groups, but by lecture method's very nature, they were solved more in lecture group.

In the current study, inquiry instruction was found to be not effective in increasing students' attitudes toward electric circuits. One of the possible explanations of this result can be that the students may not have self-confidence about their ability of self-learning. In 2000, Windschitl and Buttemer reported that students often express disbelief when confronted with the notion that they can create firsthand knowledge for themselves by using inquiry as a tool. Students are too comfortable assimilating knowledge produced by others via text, direct instruction, and through overly structured lab exercises. Part of the challenge for teachers is to develop in students a belief that they are capable agents in constructing original knowledge.

Minner, Levy, and Century (2009) investigated the question "What is the impact of inquiry science instruction on K-12 student outcomes?" They synthesized the findings from researches conducted between 1984 and 2002. They stated that higher amounts of inquiry saturation especially with hands-on activities and emphasis on more student responsibility of learning yielded statistically better understanding when compared to their low level counterparts. The result of this study was in line with what Minner, Levy, and Century put forward previously. In the current study it was found that the overall effect of inquiry instruction on students' achievement in electric circuits concept was higher than that of lecture instruction. The inquiry saturation of inquiry based instruction obviously was higher than that of lecture instruction.

Tai and Sadler (2009) pointed out as a major finding of ATI research that "higher achievers responded better to less-structured learning environments, while lower achievers responded better to more-structured environments." The findings of their study evoked that "students with lower levels of high school mathematics attainment has greater success in college science when they reported more structured laboratory exercises. Students with higher high school mathematics attainment did not show much variation with differences in laboratory structure." These results were in accord with the previous literature and they extend earlier ATI research by putting forward that instructional experiences may have interactive associations with long-range impacts. Also, the results of the current study were parallel to the previous ones, since the high achiever students succedded in inquiry instruction more than their low achiever friends and the other high achievers who sent to lecture group. Additionally, low achievers benefited more from the lecture instruction.

Learner-centered teaching was said to be context-dependent; in this type of teaching the culture of the learning context was as important as the content (Brown, 2004; McCombs, 2003), in this study the results obtained considering all the schools and the results obtained considering only the SDAL and FEN were slightly different and this fact can be explained by the context dependence of the learner centered teaching. The distinguishing features revealed form the comparison of learner-centered and teacher-centered education were nearly the same for the features in the inquiry-based and traditional, and constructivist traditional contrasts (Anderson, 2007; Brown, 2004).

According to previous ATI research results, the more the required information processing instruction performs for the learner, the better it is for low ability learners. Therefore, while low ability students benefit more from programmed instruction, advance organizers in the form of preliminary abstracts or summaries, deductive methods and simple diagrams, figures, symbolic constructions, high ability students usually benefit more from inductive methods, highly verbal and abstract conceptual treatments (Koran & Koran, 1984). Additionally, field-independent learners achieved best with deductive instruction, and field-dependent learners performed best in instruction based on examples (Davis, 1991; Messick, 1994). However, in the current study, the high achievers of the both cognitive styles were benefited almost equally from the both instruction, the difference was observed for the middle and low achievers. Middle and low achiever field independent and field mixed students were benefited more from the inquiry instruction, whereas low achievers of field dependent students benefited more from the lecture instruction. This was an expected result, since the field dependent learners require the knowledge presented in a structured form, while the field independent learners construct their own one for the knowledge. Lastly, research findings have shown that the higher level of the prior achievement, the less the instructional support required to accomplish the given task (Abramson & Kagen, 1975; Salomon, 1974; Tobias, 1973; Tobias & Frederico, 1984; Tobias & Ingber, 1976). According to the results of this study, students who had high grades from the previous physics courses benefited more from the inquiry instruction, whereas the low achiever students benefited more from the lecture instruction.

## 5.3 Internal Validity of the Study

A quasi-experimental study design was used in this study because it was not possible to randomly assign subjects to both experimental and control groups. There were some threats to internal validity in quasi-experimental research such as subject characteristics, mortality, location, instrumentation (instrument decay, data collector characteristics and data collector bias), testing, history, maturation, attitude of subjects, regression, and implementer bias.

Research design of this study (matching only pretest-posttest control group design) is effective to some degree in controlling the following threats (Fraenkel & Wallen, 1996, p.285): subject characteristics, mortality, instrument decay, testing, history, maturation and regression. However, it is possible that these threats may occur in this design.

In one of the schools the treatment could not be applied, and in an experimental group, students were absent in the posttesting procedure although they had taken the inquiry-based instruction. Therefore, these students' pretest scores were deleted from the whole data. The missing values in the remaining data were examined; since the missing values did not exceed the 10% of the whole data, they were changed with the series means. As a result, mortality threat was limited through the use of above procedures.

Data collector bias was not assumed to be a threat for the current study because the data collectors were trained to ensure standard procedures. Moreover, administering the tests to all groups at the same time controlled history and location threats. There was no remarkable difference in the locations that might affect student performance.

Since the intact groups were used in this study, subject characteristics may differ from group to group. To check this factor, groups were compared with respect to their previous physics course grades and gender distribution. Students had nearly even gender distribution and groups were approximately equal on previous physics achievement. Additionally, by using ANCOVA, subjects in the groups were matched on some variables, as PREACH, and PREATT. All these procedures reduced the potential effect of subject characteristics threat.

Both students in the experimental and control groups were aware of the treatments, since they were together out of class activities and in the private courses. Although the teachers said that there was nothing new, students were probably talking about the implementation of their physics courses and noticed that something strange was going on. To control these factors, experimental and control groups might be chosen from different schools but this time more serious threats possibly occurred.

This study was implemented in five schools but pretests were administered in six schools and posttests were administered in five schools. So, researcher could not be the sole data collector. Teachers of the classes were data collectors, while the researcher was present to check the implementation of tests. Furthermore, teachers were warned about the possible interaction between students when they were answering the test questions. Since the teachers were experienced in the profession and they were warned also, they did not let students to cheat, or talk with their friends. Additionally, the teachers did not know which class would be experimental or control before the implementation of the pretests. Also, they were informed about the purpose of the testing procedure and how the results would be used. They were ensured that the results would not be used to make inferences about their success or failure in teaching physics. The possible effect of data collector characteristics and data collector bias was tried to be diminished by standardizing the test administration process.

In some of the high schools, there were not any laboratories, so the first two lessons of the week in the inductive classes were done in the classrooms. In the other schools, these lessons were done in the laboratories. This may cause a location threat. In order to prevent this threat, students were told to make groups and to design desks in groups of three in every physics lesson. However, this might not be a healthy solution to this threat. For the exact solution, both schools should have laboratories.

To control implementation threat, the researcher did not instruct the classes herself, teachers of the classes instructed their class. The teachers were trained to standardize the conditions. They were provided with an instruction guide, also. However, it cannot be ensured that teachers did not treat in an unbiased way. Therefore, treatment verification was conducted, as explained in Chapter 3.

Students' attitude toward and achievement in electric circuits subject were measured by test which were consisting of multiple choice and objective type test items. This type of tests was robust in controlling instrument decay threat.

Students were tested both before and after the implementation of treatments, and this fact might cause awareness in students of something new and strange was going to happen. In fact, a testing threat was possible to affect the results of this study. Since both experimental and control groups were pre and posttested, and there were at least a month time break between the administration of pre and posttests, this threat was minimum for this study.

The implementer teachers did not report any unexpected or unplanned events that might affect students' responses during the study. In fact, the current study was free from the history threat. Since the students were approximately about the same ages and were living across Aydın, the aging and experience of students was not a serious maturation threat to this study.

Fraenkel and Wallen (2008, p.55) stated that there are three important ethical principles that should be addressed in every research. These were protecting participants from harm, ensuring confidentiality of research data and deception. In this study protecting participants from harm was not a problem since there were no physical or psychological harm and danger that might arise due to research procedures. Ensuring confidentiality was also not important in this study. Once the data were collected, the researcher made sure that no one else had access to the data and the names of the subjects were removed from all data collection forms. All subjects were assured that any data collected from them would be held in confidence. The names of the individual subjects would be never used in any publications. Consent form was signed to the subjects' parents where the purpose of the research was announced to the participants in detailed. Everything was clearly explained to the subjects of the study. Therefore, deception also was not the concern of this study.

5.4 External Validity of the Study

According to the MANCOVA, there is no statistically significant mean difference between the inquiry-based and lecture instruction with respect to attitude toward electric circuits subject. Therefore both instructions have the same effect in the students' attitude toward this subject. There was a significant main effect of methods of instruction on students' achievement of electric circuits subject according to MANCOVA. Inquiry method was more effective than lecture method in increasing electric circuits achievement. The sample characteristics was described in Chapter 3, the number of students in the study (n=298) exceeds the 10% of the accessible population, therefore the results of this study can be generalized to the accessible population of the study. Consequently the results of this study can be generalized to other populations if they have similar characteristics of the current study explained in Chapter 3.

A relatively high rate of loss of subjects in the posttests may be considered as a limitation in generalization of the results. For example, students who did not take the posttest would be expected to be low achievers whereas students who take the posttests would be expected to be high achievers. However, this is not true. In order to see whether students who entered the posttests differ from students who did not enter the posttests, independent samples t-test was conducted on students' PREACH and PREATT scores. The analysis yielded the following results at $\alpha=0.05$. For the PREACH, $F=4.897$; $t=5.904$; $df=126.847$; $p=0.00$, for the PREATT, $F=1.874$; $t=-0.481$; $df=432$; $p=0.63$. Hence there was no statistically significant mean difference on the PREATT while there was a statistically significant mean difference on PREACH. As the second step, since one of the two public high schools was deleted from the data, whether the students' means in the excluded public high school were different from the students' means in the other public high school was examined through the independent samples t-test. The results were as follows: For the PREACH, $F=2.030$; $t=1.241$; $df=138$; $p=0.217$, for the PREATT, $F=2.217$; $t=-0.029$; $df=142$; $p=0.977$. Therefore, there was no statistically significant mean difference on PREACH between the two public high schools and one of them was included in the sample. When the experimental class without posttest scores in one of the Anatolian High Schools was examined, no statistically significant mean difference was found on PREACH between the experimental classes of that Anatolian High School. There was three experimental classes and one control class at that Anatolian High school, to examine whether they have statistically significant mean differences from each other ANOVA was conducted. It yielded that there were statistically significant mean differences between the 16 classes on PREACH but there were not any statistically significant mean difference between the classes of the Anatolian High School at which one of the experimental class students could not be posttested.

The current study was carried out in May. The weather was getting hotter as days passed. The study was conducted at last quarter of the second semester. Moreover in some schools there were not any laboratories. Treatment was given in the regular class time. Tests were administered in classes within one lecture hour. The experimental classes were provided with the necessary equipments such as batteries, bulb, cables, and electric motors. Results of this study were valid under these conditions. These results can be generalized to other high schools if they have similar conditions to the ones mentioned above.

5.5 Conclusions

The presented conclusion statements below are extended to the population of the current study and only to other subjects or population if and only if they are similar to the sample and population characteristics of the current study, described previously.

The results of this study support that inquiry-based instruction was more effective than the lecture instruction in increasing students' achievement in and attitude toward the electric circuit concepts. Additionally, there is statistical significance ($p<0.05$) in favor of the inquiry instruction but it lacks practical significance ($\eta^2=0.046$).

The results of this study support that inquiry-based instruction was more effective than the lecture instruction in increasing students' achievement in the electric circuit concepts. Additionally, there is statistical significance ($p<0.05$) in favor of the inquiry instruction but it lacks practical significance ($\eta^2=0.046$).

The results of this study support that inquiry based instruction was as effective as the lecture instruction in increasing students' attitude toward the electric circuit concepts. However, there is no statistical ($p>0.05$) and practical significance ($\eta^2=0.000$) in favor of the inquiry instruction.

There were interaction effects on students' achievement of electric circuits subject. These interactions were observed between the independent variables PREACH, PREATT, CoS, PPCG, and MOI when gender was controlled. Although, this study could not find any statistically significant interaction effect of MOI and other independent variables on students' PSTACH and PSTATT scores, practical significance was investigated for the interaction terms.

The results of this study support that inquiry instruction was more beneficial for increasing electric circuits achievement mostly of successful students. This study practically supports that as students' prior physics achievement increases, inquiry-based instruction is a more useful method when compared to lecture to develop students' achievement in electric circuits subject.

For field dependent and field mixed successful students, the results of this study practically support the use of inquiry method in teaching electric circuits subject, whereas they support to use of lecture method for field dependent and field mixed unsuccessful students. However, this study's results practically support that for field independent students who have an intermediate level of success, inquiry instruction is more beneficial, whereas for field independent students who had higher level of success these methods do not differ in their effect on electric circuits achievement.

The results of this study practically support that the usage of inquiry or lecture methods do not reveal a different effect on attitudes of high achiever students regardless of their cognitive styles in terms of field dependency or independency.

In inquiry-based classes, students were active both mentally and physically. In lecture group, they could be mentally active or not, but they did not do any physical activity except standing up while answering the question posed by teacher.

There were some difficulties related to implementation of inquiry-based instruction at classes. First of all, laboratories at schools were not designed appropriately to perform individual or group experiments and then a discussion. Even, at some schools there was not any laboratory. Secondly, students and teachers were not familiar with group work and inquiry. Teachers had and students had been taught by lecture or expository methods up to eleventh grade.

5.6 Implications

The implications below are offered based on the findings of this study.

According to the results of the current study, inquiry instruction was more beneficial for increasing electric circuits achievement mostly of successful students. As the students' prior physics achievement increases, inquiry-based instruction is a more useful method when compared to lecture to develop students' achievement in electric circuits subject. Therefore, in order to increase the achievement of students who get scores greater than "1," teachers can use inquiry-based instruction. Although lecture method was found to be more effective for students who are low achievers, this does not mean that lecture method should be used for low achievers. On the contrary, these students should be provided with necessary skills and strategies to inquire. Since the mere aim of physics education is not to get high grades, students should gain the abilities and skills as analytical and critical thinking, life-long learning, metacognitive skills, and an understanding of nature of science.

For field dependent and field mixed successful students, the results of this study practically support the use of inquiry method in teaching electric circuits subject, whereas they support to use of lecture method for field dependent and field mixed unsuccessful students. However, this study's results practically support that for field independent students who have an intermediate level of success, inquiry instruction is more beneficial, whereas for field independent students who had higher level of success these methods do not differ in their effect on electric circuits achievement. Therefore, for high achiever students, teacher can use inquiry instruction regardless of their cognitive styles, to teach electric circuits concept. However, for field dependent and field mixed low achiever students, teachers can use lecture instruction, or more preferably, they can teach students necessary strategies required by inquiry instruction. All high and low achiever field independent students benefited more from inquiry instruction in increasing the electric circuits achievement. Hence, physics teachers can use inquiry instruction to teach electric circuits topic to field independent students.

According to the results of this study, for field dependent students in science and Anatolian high schools, students who had “2” and “3” as previous physics course grade, benefited more from lecture instruction than they did from inquiry-based instruction in increasing electric circuits achievement. Additionally, for field dependent students, students who had “2” and “3” as previous physics course grade, the lecture instruction was better than the inquiry-based instruction on improving their attitudes toward electric circuits subject. Also, successful field dependent students benefited nearly equally from both type of instructions in improving achievement in and attitude toward electric circuits subject. Therefore, for field-dependent students in science and Anatolian high schools, teachers can use lecture method or more preferably they can teach students necessary learning strategies for inquiry learning in order to increase the achievement of students.

In this study, the results indicated that field intermediate and field independent students benefited more from inquiry-based instruction than they did from lecture instruction in increasing electric circuits achievement. Hence, for field-independent or field-intermediate students in science and Anatolian high schools, teachers can use inquiry-based instruction in order to increase the achievement of students.

## 5.7 Recommendation for Further Research

Students and teachers have difficulty at the beginning of the inquiry-based instruction since they are expected to take new roles to which they are not used to. Thus, it is strongly suggested that researchers start to give inquiry-based instruction in the former unit before the main study start, although this doubles the workload of the researcher.

Current study was conducted in laboratories in some of the high schools and in classroom in the others. This might be a confounding factor to the results of the inquiry teaching studies. Therefore, it is valuable to investigate the effect of laboratory environment on outcomes of inductive instruction.

Authentic and alternative assessment techniques should be used as well as the traditional assessment techniques in order to see the effect of inquiry-based instruction.

Although this study was conducted with a sample of 298 students, there was still lack of students in some interaction cells. ATI studies require great number of participants, in Cronbach and Snow (1977), it was emphasized that the number of students for each treatment aptitude cell should be at least a hundred. In the current study, the number of students assigned to each method of instruction was greater than a hundred, however, for the third and fourth order interactions; the number of students was less than 10 almost in all of the cells. Therefore, for the further ATI studies, the sample size should be remarkably great, or the interactions should not have too many numbers of cells.

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# APPENDIX A

## FIRST VERSION OF THE OBJECTIVES

1. Üreteçlerin eşdeğer E.M.K.larını hesaplar.
2. Pillerin dayanma sürelerinin üzerlerinden geçen akımla ters orantılı olduğunu kavrar.
3. Bir devrenin gücünü hesaplar.
4. Kısa devre, paralel bağlı devre ve seri bağlı devreyi birbirinden ayırt eder.
5. Paralel ve seri bağlı dirençlerin eşdeğer dirençlerini hesaplar.
6. Seri bağlı devrelerde, güç kaynağı tarafından sağlanan potansiyel farkın devre elemanlarınca dirençleriyle doğru orantılı olarak paylaşıldığını kavrar.
7. Elektrik akımının veya yüklü parçacıkların akabilmesi için kapalı bir devre olması gerektiğini bilir.
8. Karışık devrelerde eşdeğer direnci hesaplar.
9. Lambaların parlaklıklarının güçleriyle doğru orantılı olduğunu bilerek parlaklıkları karşılaştırır.
10. Seri bağlı devrelerde devre elemanlarının uçları arasındaki potansiyel farkı bulur.
11. Seri bağlı devrelerde her bir devre elemanından geçen akımın birbirine eşit olduğunu kavrar.
12. Paralel ve seri bağlı devreleri farklı şekillerde gösterildiklerinde tanır.
13. Paralel bağlı devrelerde ana koldan ve paralel kollardan geçen akımı karşılaştırır.
14. Akımın devre elemanlarınca tüketilmediğini sindirir.
15. Bir iletkenin direncinin sadece yapıldığı maddeye, uzunluğuna, kesit alanına ve sıcaklığına bağlı olduğunu kavrar.
16. Bir elektrik devresinde potansiyel fark, akım, ve eşdeğer direnç arasındaki ilişkiyi açıklar.

17. Bir elektrik devresinde belli noktalardan geçen akımın dirençlerin farklı bağlanmasına göre nasıl değişeceğini açıklar.
18. Özdeş lambaların parlaklıklarının üzerlerinden geçen akımla doğru orantılı olduğunu keşfeder.
19. Paralel ve seri bağlı üreteçlerde üreteçlerden geçen akım değerini hesaplar.
20. Bir elektrik devresinin elemanlarını, devri daim yapan daha tanıdık başka bir sistemin elemanlarıyla eşleştirir.
21. Elektrik akımı güç, enerji gibi büyüklüklerin birbirleriyle olan ilişkilerini analiz eder.
22. Bir devre parçasında akım, potansiyel fark, ve direnç arasında ilişki kurarak istenilen büyüklüğü hesaplar.
23. Bir devre parçasında ana koldan ve paralel kollardan geçen akımı Ohm Kanunu'nu kullanarak hesaplar.
24. Bir motoru döndürebilmek için gereken işi hesaplar.
25. Bir elektrik devresinde üreteçten sağlanan enerjinin devre elemanlarına nasıl transfer edildiğini keşfeder.
26. Akımın direncin en küçük olduğu yolu seçeceği bilgisini kullanır.
27. Bir devrede iki nokta arasındaki potansiyel farkı hesaplar.
28. Bir devrede paralel kolların uçlarındaki potansiyel farkın birbirine eşit olduğunu bilir.
29. Direnç kavramını yalıtkanlık ve iletkenlik özelliklerini kullanarak açıklar.
30. Seri bağlı devrelerde direnç veya lamba sayısı arttıkça eşdeğer direncin artacağını bilir.
31. Devre elemanlarını sembolleriyle eşleştirir.

SECOND VERSION OF THE OBJECTIVES

1. Elektrik enerjisinin iletilebilmesi için kapalı bir devre olması gerektiğini bilir.
2. Kısa devre, paralel bağlı devre ve seri bağlı devreyi birbirinden ayırt eder.
3. Paralel ve seri bağlı devreleri farklı şekillerde gösterildiklerinde tanır.
4. Devre elemanlarını sembolleriyle eşleştirir.
5. Direnç kavramını yalıtkanlık ve iletkenlik özelliklerini kullanarak açıklar.
6. Bir iletkenin direncinin yapıldığı maddeye, uzunluğuna, kesit alanına ve sıcaklığına bağlı olduğunu kavrar.
7. Seri ve paralel bağlı dirençlerin birlikte bulunduğu devrelerde eşdeğer direnci hesaplar.
    a. Seri bağlı devrelerde direnç veya lamba sayısı arttıkça eşdeğer direncin artacağını bilir.
    b. Paralel veya seri bağlı dirençlerin eşdeğer dirençlerini hesaplar.
8. Seri bağlı devrelerde, güç kaynağı tarafından sağlanan potansiyel farkın devre elemanlarınca dirençleriyle doğru orantılı olarak paylaşıldığını kavrar.
9. Seri bağlı devrelerde devre elemanlarının uçları arasındaki potansiyel farkı bulur.
10. Bir devrede paralel kolların uçlarındaki potansiyel farkın birbirine eşit olduğunu bilir.
11. Seri bağlı devrelerde her bir devre elemanından geçen akımın birbirine eşit olduğunu kavrar.
    a. Akımın devre elemanlarınca tüketilmediğini sindirir.
12. Seri ve paralel bağlı devre elemanlarının birlikte bulunduğu devrelerde ana koldan ve paralel kollardan geçen akımı karşılaştırır.
    a. Bir elektrik devresinde belli noktalardan geçen akımın dirençlerin farklı bağlanmasına göre nasıl değişeceğini açıklar.
13. Bir elektrik devresinde eşdeğer potansiyel fark, akım, ve eşdeğer direnç arasındaki ilişkiyi kullanarak problem çözer.

a. Bir devre parçasında akım, potansiyel fark, ve direnç arasında ilişki kurarak istenilen büyüklüğü hesaplar.
b. Bir devre parçasında ana koldan ve paralel kollardan geçen akımı Ohm Kanunu'nu kullanarak hesaplar.

14. Bir elektrik devresinde kısa devreyi fark ederek problem çözer.
15. Seri ve/veya paralel bağlanan üreteçlerin devreye sağladıkları eşdeğer potansiyel farkları hesaplar.
16. Pillerin kullanım sürelerinin ürettikleri akımla ters orantılı olduğunu kavrar.
17. Bir devre elemanın ürettiği veya harcadığı elektriksel enerjiyi hesaplar.
18. Bir devre elemanının elektriksel gücünü hesaplar.
19. Bir elektrik devresinde lambaların parlaklıklarının güçleriyle doğru orantılı olduğunu bilerek parlaklıkları karşılaştırır.
    a. Özdeş lambaların parlaklıklarının üzerlerinden geçen akımla doğru orantılı olduğunu keşfeder.
20. Elektriksel güç, enerji gibi büyüklüklerin ilişkilerini birimlerini kullanarak analiz eder.
21. Bir elektrik devresinin elemanlarını, devri daim yapan daha tanıdık başka bir sistemin elemanlarıyla eşleştirir.

# LAST VERSION OF THE OBJECTIVES

1. Verilen elektrik devrelerinin içinden elektrik enerjisinin iletildiği devreyi seçer.
    a. Kapalı devreyi tanımlar.
    b. Açık devreyi tanımlar.
2. Kısa devre, paralel bağlı devre ve seri bağlı devreyi birbirinden ayırt eder.
3. Paralel ve seri bağlı devreleri farklı şekillerde gösterildiklerinde tanır.
4. Devre elemanlarını sembolleriyle eşleştirir.
5. Direnç kavramını yalıtkanlık ve iletkenlik özelliklerini kullanarak açıklar.
6. Bir iletkenin direncinin nelere bağlı olduğunu açıklar.
7. Seri ve/veya paralel bağlı dirençlerin birlikte bulunduğu devrelerde eşdeğer direnci hesaplar.
    a. Seri bağlı devrelerde direnç veya lamba sayısı arttıkça eşdeğer direncin artacağını bilir.
8. Seri bağlı devrelerde, güç kaynağı tarafından sağlanan potansiyel farkın devre elemanlarınca nasıl paylaşıldığını hesaplar.
9. Bir devrede paralel kolların uçlarındaki potansiyel farkın birbirine eşit olduğunu belirtir.
10. Seri bağlı devrelerde problem çözmek için, her bir devre elemanından geçen akımın birbirine eşit olduğu bilgisini kullanır.
    a. Akımın devre elemanlarınca tüketilmediğini sindirir.
11. Seri ve paralel bağlı devre elemanlarının birlikte bulunduğu devrelerde ana koldan ve paralel kollardan geçen akımı karşılaştırır.
    a. Bir elektrik devresinde belli noktalardan geçen akımın dirençlerin farklı bağlanmasına göre nasıl değişeceğini açıklar.
12. Bir elektrik devresinde eşdeğer potansiyel fark, akım, ve eşdeğer direnç arasındaki ilişkiyi kullanarak problem çözer.
    a. Bir devre parçasında akım, potansiyel fark, ve direnç arasında ilişki kurarak istenilen büyüklüğü hesaplar.

   b. Bir devre parçasında ana koldan ve paralel kollardan geçen akımı Ohm Kanunu'nu kullanarak hesaplar.

13. Bir elektrik devresinde kısa devreyi fark ederek problem çözer.
14. Seri ve/veya paralel bağlanan üreteçlerin devreye sağladıkları eşdeğer potansiyel farkları hesaplar.
15. Elektrik devrelerindeki pillerin kullanım sürelerini karşılaştırır.
16. Bir devre elemanın ürettiği veya harcadığı elektriksel enerjiyi hesaplar.
17. Bir devre elemanının elektriksel gücünü hesaplar.
18. Bir elektrik devresinde lambaların parlaklıklarının güçleriyle doğru orantılı olduğunu bilerek parlaklıkları karşılaştırır.
    a. Özdeş lambaların parlaklıklarının üzerlerinden geçen akımla doğru orantılı olduğunu keşfeder.
19. Elektriksel güç, enerji gibi büyüklüklerin ilişkilerini birimlerini kullanarak analiz eder.
20. Bir elektrik devresinin elemanlarını, devri daim yapan daha tanıdık başka bir sistemin elemanlarıyla eşleştirir.

# APPENDIX B

## TABLE OF TEST SPECIFICATIONS

| Konu \ Kazanım Düzeyi | Bilme | Kavrama | Uygulama | Analiz | Sentez | Değerlen. | Toplam | Yüzdelik |
|---|---|---|---|---|---|---|---|---|
| **1. ELEKTRİK DEVRELERİ**<br>**a.** Devre Elemanları<br>**b.** Potansiyel Farkının Ölçülmesi<br>**c.** Direnç ve Ölçülmesi<br>**i.** Ohm Yasası<br>**ii.** İletkenlerin Direncinin Bağlı Olduğu Faktörler ve Öz Direnç<br>**d.** Elektrik Devrelerinde Akım<br>**i.** Seri Devrede Akım<br>**ii.** Paralel Devrede Akım<br>**iii.** Ana Kol Ve Paralel Kollarda Akım | 1 (7),<br>3 (11),<br>4 (28,29,30),<br>9 (25) | 2 (4),<br>5 (26),<br>6 (13),<br>10 (**10**),<br>11 (12,**15**,**21**),<br>13 (24) | 7 (5,8,19,27),<br>8 (6, **10**),<br>12 (14,**15**,**21**,23) | 20 (18) | | | 14(22) | 70 (73) |
| **2. ELEKTRİK AKIMININ YAPTIĞI İŞ-JOULE KANUNU**<br>**a.** Elektromotor Kuvvet (e.m.k.)<br>**b.** Motorun Verimi | | | 16 (22),<br>17 (3),<br>18 (9, 16) | 19 (20) | | | 4 (5) | 20 (17) |
| **3. ÜRETEÇLERİN BAĞLANMASI**<br>**a.** Üreteçlerin Seri Bağlanması<br>**b.** Üreteçlerin Paralel Bağlanması | | 15 (2) | 14 (1, 17) | | | | 2 (3) | 10 (10) |
| **Toplam** | 4 (6) | 7 (9) | 7 (13) | 2 (2) | | | 20 (30) | 100 (100) |
| **Yüzdelik** | 20 (20) | 35 (30) | 35 (43) | 10 (7) | 0 | 0 | 100 | 100 (100) |

Numbers without parantesis shows the number of objective.

Numbers in paranthesis shows the number of the related item in the PACT

# APPENDIX C

## ACHIEVEMENT TEST FEEDBACK FORM

— Kazanımlar Elektrik Devreleri konusundaki bütün alt konuları ve kavramları yansıtıyor mu?

— Sorular Elektrik Devreleri konusuna dair yazılmış bütün kazanımları kapsıyor mu?

— Sorular Elektrik Devreleri konusundaki bütün alt konuları ve kavramları yansıtıyor mu?

— Testin dili 11. sınıf öğrencileri için uygun seviyede mi?

— Testte okunamayan soru kökü, şık, ya da anlaşılamayan şekil var mı? Test genel olarak okunabilir ve anlaşılır mı?

— Bu test bir ders saati içinde uygulanması düşünülerek hazırlanmıştır. Sizce öğrenciler bu testi bir ders saati içinde rahatlıkla cevaplayabilirler mi? Test daha uzun veya daha kısa sürede tamamlanabilir mi?

— Test maddelerinin zorluk seviyesi sizce nasıl? Öğrencilerinizin seviyesine uygun mu?

— Cevap anahtarında verilen cevaplar doğru mu?

# APPENDIX D

## THREE VERSIONS OF THE PHYSICS ACHIEVEMENT TEST

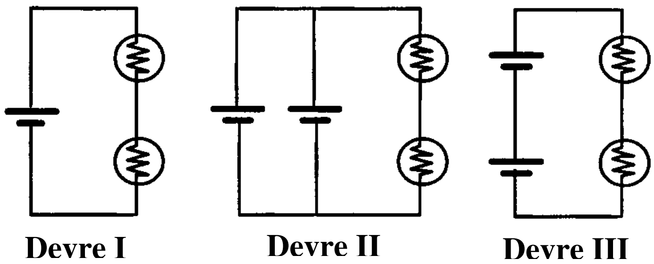
In this section, three versions of the Physics Achievement Test (PACT) are presented. Prior versions were revised and only the last third version of the test was administered in this study as pretest and posttest. Because the format of the pages will be distorted, all versions of the PACT are presented in the following pages.

PACT Version 1

1. Bir ampulün yanması için, elektrik yüklerinin harcanarak ışığa dönüşmesi gerekir mi?

a. Evet, filaman üzerinde hareket eden yüklerin sebep olduğu sürtünme filamanın ısınmasına ve ışık üretilmesine yol açar.
b. Evet, elektrik yükleri harcanarak ısı ve ışığa dönüşür
c. Evet, elektrik yükleri yayılır.
d. Hayır, elektrik yükleri korunarak, temelde başka bir form olan ısı ve ışığa dönüşür.
e. Hayır, elektrik yükleri korunarak, filaman üzerinde hareket eden yüklerin sebep olduğu sürtünme filaman ısınmasına ve ışık üretilmesine yol açar.

2.



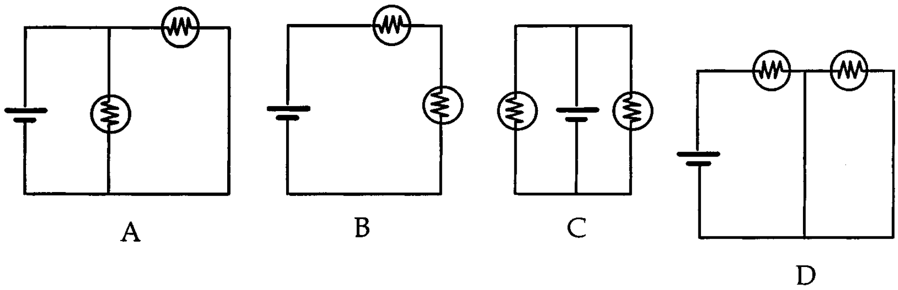

Yukarıdaki elektrik devrelerini inceleyiniz. Hangi devre ya da devrelerde birim zamanda açığa çıkan enerji miktarı en fazladır?

a. Devre I
b. Devre II
c. Devre III
d. Devre I = Devre II
e. Devre II = Devre III

3. R direnci iç direnci önemsenmeyen bir üretece seri olarak bağlanmıştır. Bununla özdeş başka bir direnç daha devreye seri olarak bağlanırsa;

a. Üretecin uçları arasındaki potansiyel fark artar.
b. Üretecin uçları arasındaki potansiyel fark azalır.
c. İkinci direnç bağlandıktan sonra devreden yayılan toplam ısı, sadece bir direnç bağlıyken yayılan toplam ısının iki katı kadardır.
d. İkinci direnç bağlandıktan sonra devreden yayılan toplam ısı, sadece bir direnç bağlıyken yayılan toplam ısının yarısı kadardır.
e. İkinci direnç bağlandıktan sonra devreden yayılan toplam ısı, sadece bir direnç bağlıyken yayılan toplam ısı kadardır.

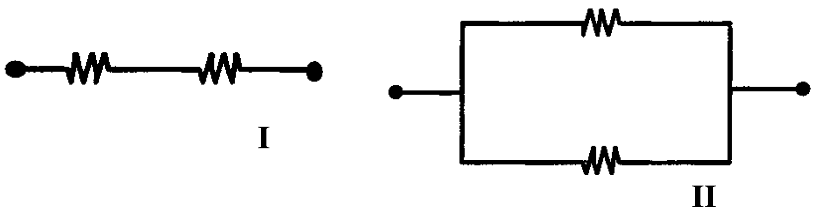
**4.**




Yukarıdaki devreleri inceleyiniz. Bu devrelerden hangisi ya da hangileri bir üreteç ve paralel bağlı iki lambadan oluşur?

a. A
b. B
c. C
d. A ve C
e. A, C ve D

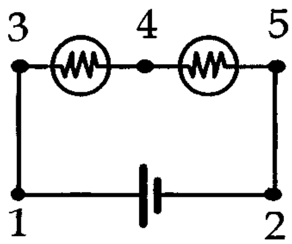
**5.**




I ve II durumunda gösterilen devre parçasındaki eşdeğer direnci karşılaştırdığınızda, hangisi daha küçüktür?

a. I
b. II
c. I=II
d. Devreden geçen akıma bağlıdır.
e. A-B noktaları arasındaki potansiyel farka bağlıdır.

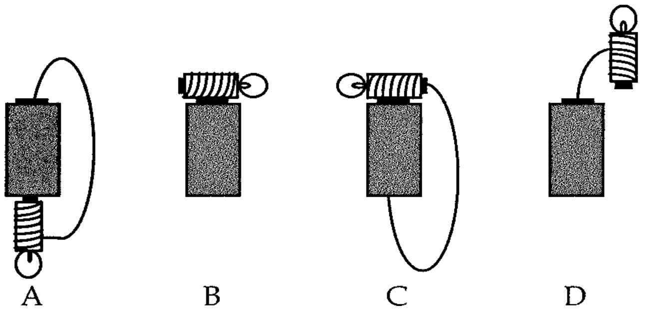
**6.**




1 ve 2, 3 ve 4, 4 ve 5 noktaları arasındaki potansiyel farkı büyükten küçüğe doğru sıralayınız?

a. 1 ve 2; 3 ve 4; 4 ve 5
b. 1 ve 2; 4 ve 5; 3 ve 4
c. 3 ve 4; 4 ve 5; 1 ve 2
d. 3 ve 4 = 4 ve 5; 1 ve 2
e. 1 ve 2; 3 ve 4 = 4 ve 5

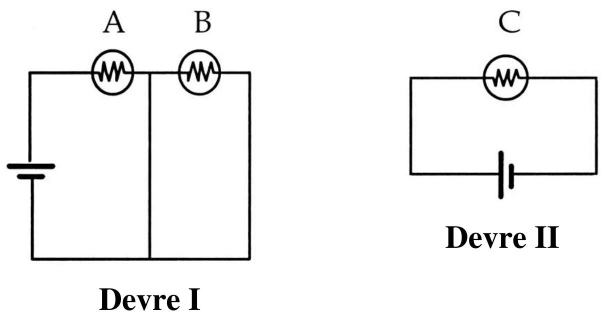
**7.**




Yukarıdaki devrelerin hangilerinde lamba yanar?

a. A
b. C
c. D
d. A ve C
e. B ve D

**8.**



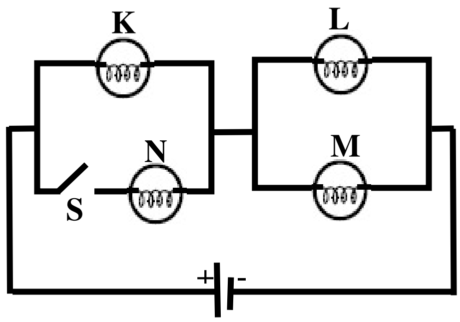

Devre I' deki A ve B lambalarının parlaklığını Devre II' deki C lambasının parlaklığı ile karşılaştırınız. Hangi lamba veya lambalar en parlak yanar?

a. A
b. B
c. C
d. B = C
e. A = C

**9.** Neden düğmeye bastığımız anda lamba yanar?

a. Devre tamamlandığında akım, zaten kabloda olan elektrik yüklerinin ufak hareketleri ile çok hızlı bir şekilde iletilir.
b. Yükler enerji depolar; devre tamamlandığında bu enerji serbest bırakılır.
c. Kablodaki yükler çok hızlı hareket ederler.
d. Elektrik tesisatı paralel bağlanmış devrelerden oluşur; bu yüzden zaten bir akım mevcuttur.
e. Filamanda beklemekte olan elektrik yükleri, devre tamamlandığında ışımaya başlar.

**10.**

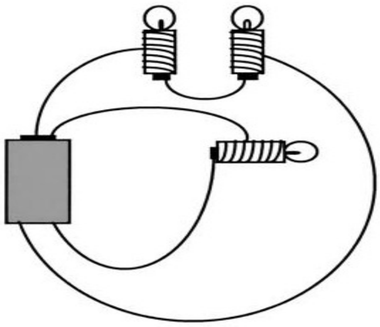



Özdeş K, L, M, N lambalarından oluşan şekildeki devrede S anahtarı açıkken K, L, M lambaları ışık veriyor.

S anahtarı kapatılırsa K, L, M lambalarından hangilerinin parlaklığı artar? (Üreteçlerin iç direnci önemsenmeyecektir.)?

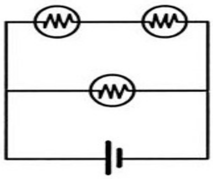
a. Yalnız K nin
b. Yalnız L nin
c. K ve L nin
d. L ve M nin
e. K, L ve M nin

**11.**

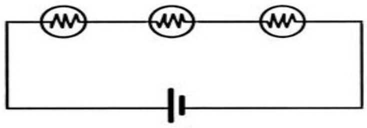


Yandaki devrenin şematik çizimi aşağıdakilerden hangisinde doğru olarak gösterilmiştir?

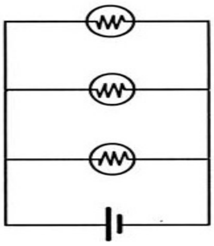
a.



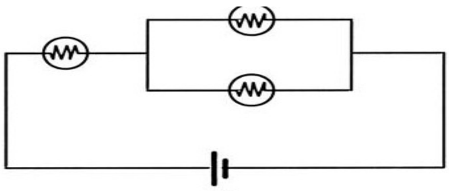
b.



c.

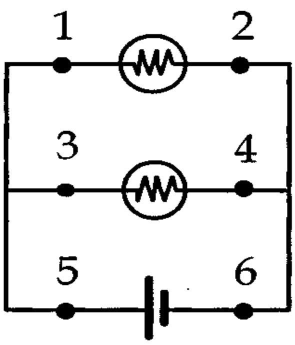


d.



e. Hiçbiri

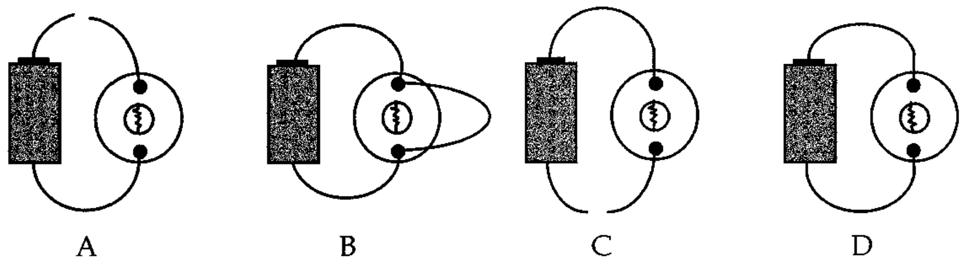
**12**




1, 2, 3, 4, 5, ve 6 noktalarından geçen akımları büyükten küçüğe doğru sıralayınız

a. 5, 1, 2, 3, 4, 6
b. 5, 3, 1, 4, 2, 6
c. 5=6, 3=4, 1=2
d. 5=6, 1=2=3=4
e. 1=2=3=4=5=6

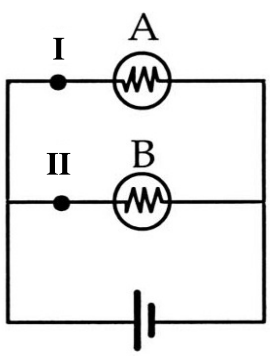
**13.**




Yukarıdaki devrelerin hangi ya da hangilerinde lamba yanar?

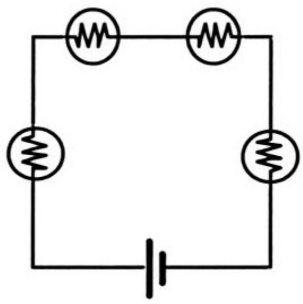
a. A
b. B
c. C
d. B ve D
e. A ve C

**14.**

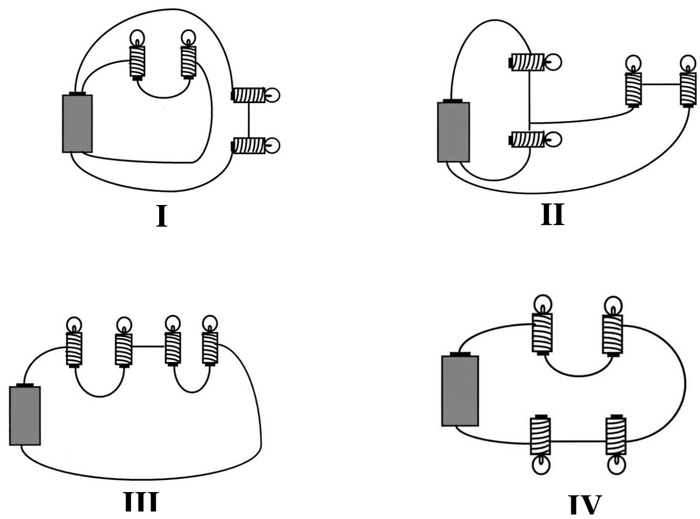



Şekildeki devrede I ve II noktalarının arasına bir kablo bağlandığında A ve B lambalarının parlaklıkları nasıl değişir?

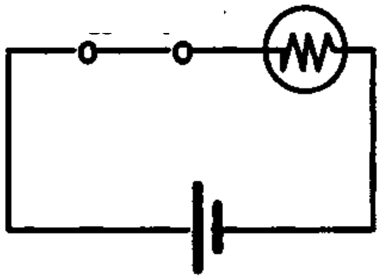
a. Artar.
b. Azalır.
c. Aynı kalır.
d. A, B’ den daha parlak yanar.
e. Her iki lamba da söner.

**15.** 

Yandaki şema aşağıdaki devrelerden hangisine aittir?




a. II
b. III
c. IV
d. I ve II
e. III ve IV

**16.** 

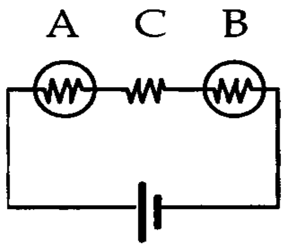
Anahtar açıldıktan hemen sonra, lambanın direnci nasıl değişir?

a. Artar
b. Azalır
c. Değişmez
d. Önce azalır, sonra artar
e. Sıfırlanır.

**17.** Üreteçten geçen akım iki katına çıkarılırsa, üretecin uçları arasındaki potansiyel fark da iki katına çıkar mı?

a. Evet, çünkü Ohm yasasına göre V=IxR dir.
b. Evet, çünkü direnci arttığı için potansiyel farkı da artar.
c. Hayır, çünkü akımı iki katına çıktığı için potansiyel fark yarıya düşer.
d. Hayır, çünkü potansiyel fark üretecin bir özelliğidir.
e. Hayır, çünkü potansiyel fark tüm devre elemanlarının bir özelliğidir.

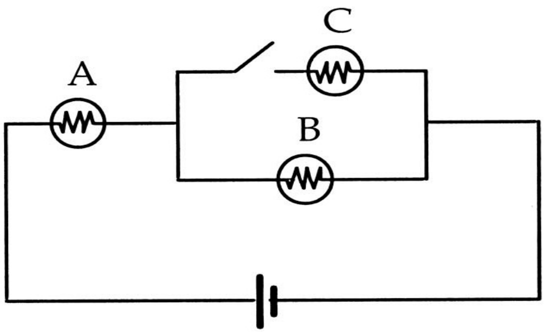
**18**




C direnci arttırılırsa, A ve B lambalarının parlaklıkları nasıl değişir?

a. A aynı kalır, B söner.
b. A söner, B aynı kalır.
c. İkisinin de parlaklığı artar.
d. İkisinin de parlaklığı artar.
e. İkisinin de parlaklığı aynı kalır

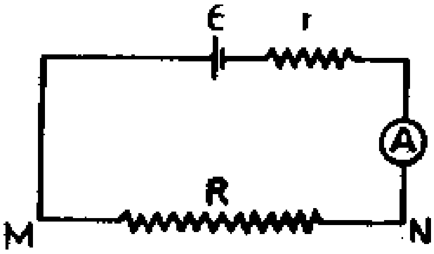
**19.**




Anahtar kapatıldığında A ve B lambalarının parlaklığı nasıl değişir?

a. A aynı kalır, B söner.
b. A nın parlaklığı artar, B söner.
c. İkisinin de parlaklığı artar.
d. İkisinin de parlaklığı artar.
e. İkisinin de parlaklığı aynı kalır.

**20.**

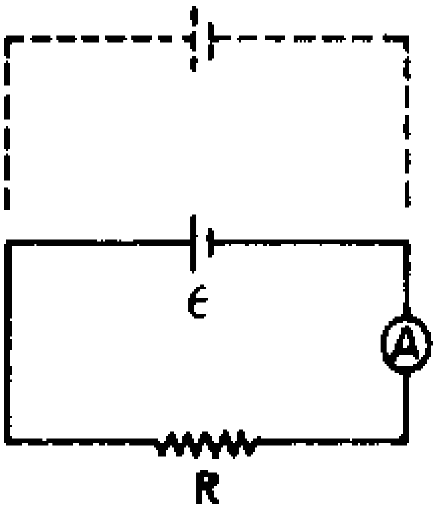



Şekildeki devrede, ampermetre I değerini göstermektedir. Bir R değerine sahip bir direnç daha M-N noktaları arasındaki diğer R direncine paralel olarak bağlanıyor.

Bunun sonucunda;

a. I değeri değişmez, R ve Ŕ dirençleri büyüklükleriyle ters orantılı olarak akımı. paylaşırlar.
b. M ve N noktalarının arasındaki potansiyel fark değişmez.
c. I değeri artar, M ve N noktaları arasındaki potansiyel fark azalır.
d. R direncinde açığa çıkan ısı değişmez.
e. I değeri de, M ve N noktaları arasındaki potansiyel fark da artar.

**21.**

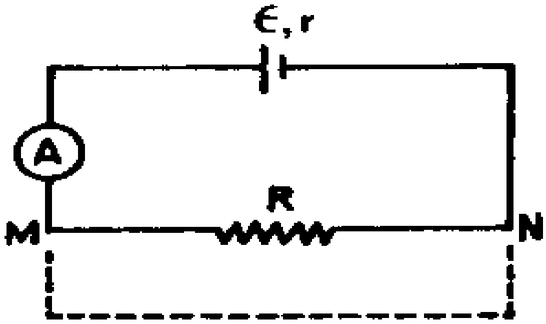



Şekilde verilen devredeki ampermetre belli bir akım değerini göstermektedir. Şekildekiyle özdeş ikinci bir üreteç, birinci üretece paralel olarak bağlanmaktadır. (Üreteçlerin iç direnci önemsenmemektedir.)

Bunun sonucunda,

a. Ampermetrede okunan değer artar.
b. R direncinin uçları arasındaki potansiyel fark artar.
c. R direncinin uçları arasındaki potansiyel fark azalır.
d. Birinci üretecin üzerinden geçen akım azalır.
e. Birinci üretecin üzerinden geçen akım değişmez.

**22.**




Bir direnç, bir ampermetre, ve iç direnci r, E.M.K.sı Є olan bir üreteç şekilde görüldüğü gibi seri olarak bağlanmıştır.

M ve N noktaları kısa ve kalın bir bakır telle birleştirilirse;

a. R direncinden geçen akımda belirgin bir değişiklik gözlenmez.
b. R direncinden geçen akım artar.
c. Kablonun uçları arasındaki potansiyel fark çok düşük olduğu için, üzerinden geçen akım da küçüktür.
d. Ampermetreden geçen akım değişmez, ancak devredeki toplam akımın büyük bir kısmı telin üzerinden geçer.
e. Ampermetreden geçen akım artar ve devredeki toplam akımın büyük bir kısmı telin üzerinden geçer.

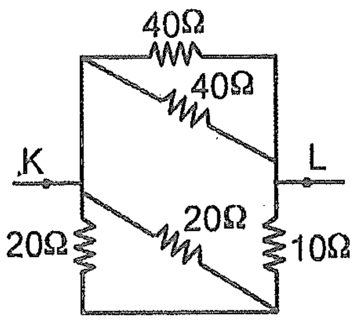
**23.** Yüksek yapılarda, kent suyunu üst katlara çıkarmak için kullanılan düzenekte:

I. Su pompası,
II. Su sayacı,
III. Basınç ölçer aygıtları vardır.

Bu düzenek bir elektrik devresine benzetilirse, yukarıdaki aygıtlar, elektrik devresindeki aygıtların hangisinin yerini tutar?

a. I. Üreteç, II. Akımölçer, III. Gerilimölçer
b. I. Direnç, II. Gerilimölçer, III. Akımölçer
c. I. Direnç, II. Akımölçer, III. Gerilimölçer
d. I. Üreteç, II. Direnç, III. Gerilimölçer
e. I. Üreteç, II. Akımölçer, III. Direnç

**24.**



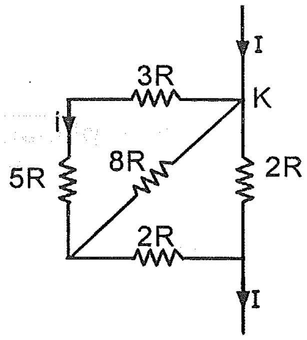

Şekle göre K-L arasındaki eşdeğer direnç kaç Ω (ohm) dur?

a. 10
b. 20
c. 40
d. 50
e. 130

**25.** $\dfrac{\text{watt}}{\text{joule/coulomb}}$ ifadesi aşağıdaki niceliklerden hangisini verir?

a. ampere olarak akım şiddetini
b. volt olarak potansiyel farkı
c. ohm olarak direnç
d. coulomb olarak elektrik yükü
e. joule olarak enerji

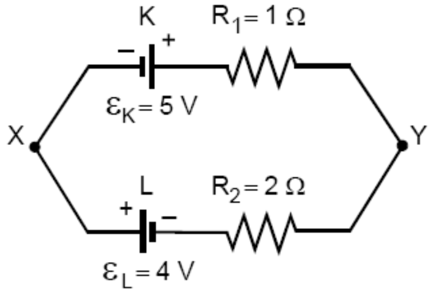
**26.**




Şekildeki devre parçasında 5R lik dirençten geçen akımın şiddeti i ise, K noktasına gelen I akımının şiddeti kaç i dir?

a. 10
b. 8
c. 4
d. 3
e. 2

**27.**



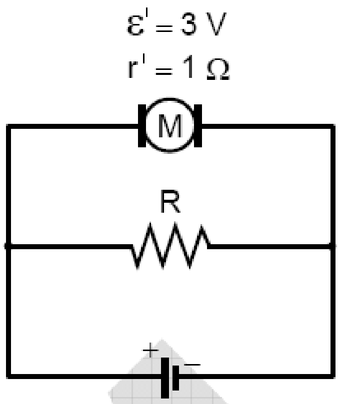

Şekildeki elektrik devresinde X, Y noktaları arasındaki potansiyel farkı ($V_X$-$V_Y$) kaç V tur? (Üreteçlerin içdirençleri önemsizdir.)

a. 2
b. 3
c. 4
d. 5
e. 8

**28.** Zıt e.m.k. sı ɛ́ olan bir motor, e.m.k. sı ε=120 volt olan bir doğru akım üreteci ile döndürülüyor. Motor dönerken 10A, dönmesi engellendiğinde de 30A akım çektiğine göre ɛ́ kaç volt tur?

a. 20
b. 40
c. 80
d. 120
e. 160

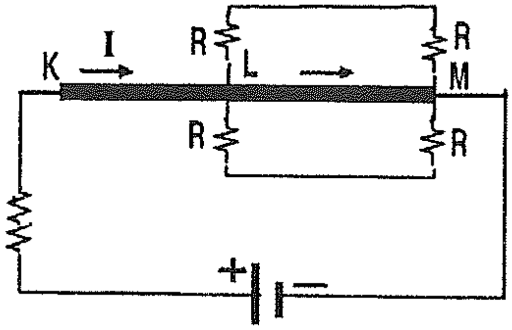
**29.**




Şekildeki elektrik devresinde motor çalışırken hem motordan hem de R direncinden 2A büyüklüğünde akım geçiyor.

Motorun zıt elektromotor kuvveti ɛ́ = 3V, iç direnci de ŕ = 1Ω olduğuna göre, R direncinin değeri kaç Ω dur?

a. 1
b. $\frac{3}{2}$
c. 2
d. $\frac{5}{2}$
e. 3

**30.** 


Çok küçük dirençli KM çubuğuna, dirençleri KM ninkinden çok büyük olan dört tane R direnci şekildeki gibi bağlanmıştır.

Devrenin KL kesiminden geçen akımın şiddeti I olduğuna göre, LM kesiminden geçen akımın şiddeti için aşağıdakilerden hangisi doğrudur?

a. I ya yakın

b. $\frac{I}{2}$ ye yakın

c. 2I ya yakın

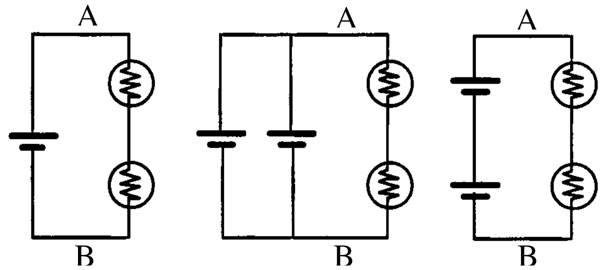
d. $\frac{I}{4}$ e yakın

e. I ya yakın

PACT version 2

**Açıklama:** 1. 2. ve 3. soruları aşağıda verilen devreleri göz önünde bulundurarak cevaplayınız.

**1.**




**Devre** **Devre II** **Devre**

Yukarıdaki devrelerde A ve B noktaları arasındaki potansiyel farkını karşılaştırınız. Aşağıdaki seçeneklerden hangisi A-B noktaları arasındaki potansiyel farkı doğru olarak göstermektedir?

a. $V_1<V_2<V_3$
b. $V_1=V_2<V_3$
c. $V_1=V_2>V_3$
d. $V_1>V_2>V_3$
e. $V_1<V_2=V_3$

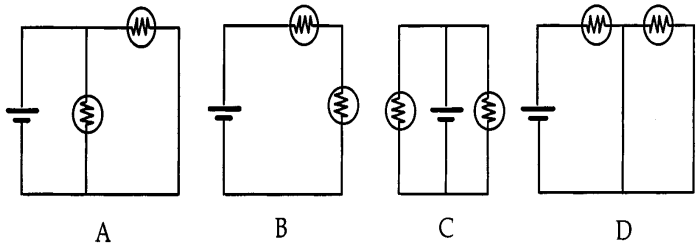
**2.** Yukarıdaki devrelerde özdeş piller kullanılmıştır. Hangi devre ya da devrelerde kullanılan piller en uzun süre dayanır?

a. II=III>I
b. I<II<III
c. II=III<I
d. I=III<II
e. III<I<II

**3.** Yukarıdaki elektrik devrelerini inceleyiniz. Hangi devre ya da devrelerde birim zamanda açığa çıkan enerji miktarı en fazladır?

a. Devre I
b. Devre II
c. Devre III
d. Devre I = Devre II
e. Devre II = Devre III

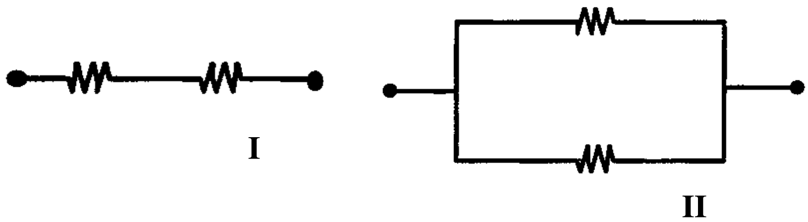
**4.**




Yukarıdaki devreleri inceleyiniz. Bu devrelerden hangisi ya da hangileri bir üreteç ve paralel bağlı iki lambadan oluşur?

a. A
b. B
c. C
d. A ve C
e. A, C ve D

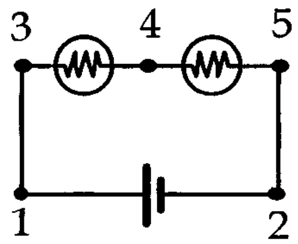
**5.**




I ve II durumunda gösterilen devre parçasındaki eşdeğer direnci karşılaştırdığınızda, hangisi daha küçüktür?

a. I
b. II
c. I=II
d. Devreden geçen akıma bağlıdır.
e. A-B noktaları arasındaki potansiyel farka bağlıdır.

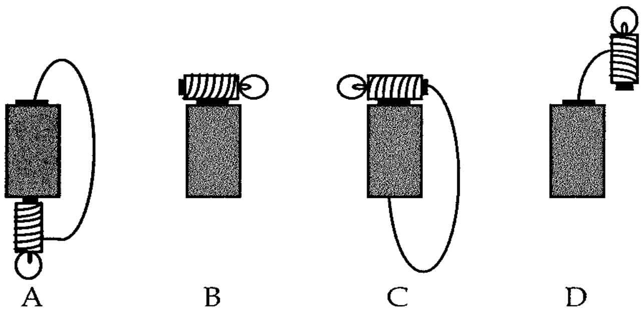
**6.**




1 ve 2, 3 ve 4, 4 ve 5 noktaları arasındaki potansiyel farkı büyükten küçüğe doğru sıralayınız?

a. $V_{1-2}>V_{3-4}>V_{4-5}$
b. $V_{1-2}>V_{4-5}>V_{3-4}$
c. $V_{3-4}>V_{4-5}>V_{1-2}$
d. $V_{3-4}=V_{4-5}>V_{1-2}$
e. $V_{1-2}>V_{3-4}=V_{4-5}$

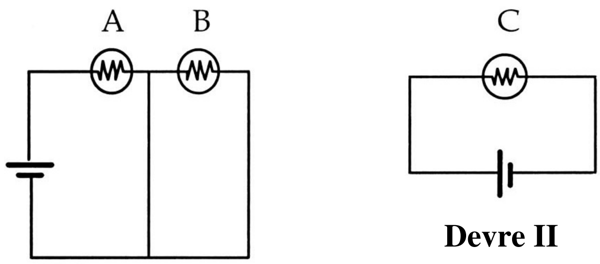
**7.**




Yukarıdaki devrelerin hangilerinde lamba yanar?

a. A
b. C
c. D
d. A ve C
e. B ve D

**8.**




Devre I ve Devre II'deki A, B ve C lambaları özdeş ve her birinin direnci R'dir. Devrelerin eşdeğer dirençleri hangi seçenekte doğru verilmiştir?

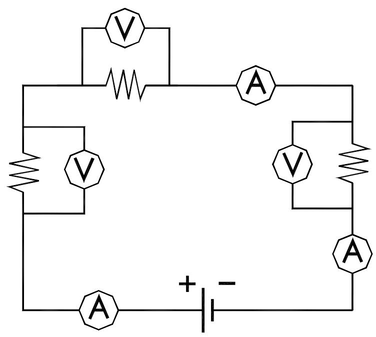
a. $R_{eş1}=2R$ ve $R_{eş2}=R$
b. $R_{eş1}=R$ ve $R_{eş2}=R$
c. $R_{eş1}=R/2$ ve $R_{eş2}=R$
d. $R_{eş1}=2R$ ve $R_{eş2}=R/2$
e. $R_{eş1}=R/2$ ve $R_{eş2}=R/2$

**9.** Devre I' deki A ve B lambalarının parlaklığını Devre II' deki C lambasının parlaklığı ile karşılaştırınız. Hangi lamba veya lambalar en parlak yanar?

a. A
b. B
c. C
d. B = C
e. A = C

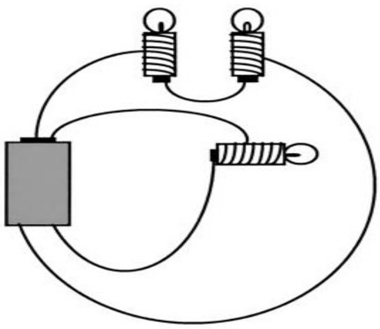
**10.**

Şekilde gösterilenen devrede ampermetrenin okuduğu değerler $I_1$, $I_2$, $I_3$ ve voltmetrenin okuduğu değerler $V_1$, $V_2$, $V_3$ tür. $I_1$, $I_2$, $I_3$ ve, $V_1$, $V_2$, $V_3$ değerlerinin arasındaki ilişki nedir?

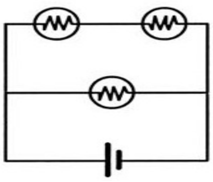


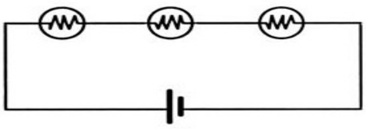

**a)** $V_1 > V_2 > V_3$ $\quad$ $I_1 = I_2 = I_3$
**b)** $V_3 > V_1 > V_2$ $\quad$ $I_1 > I_2 > I_3$
**c)** $V_2 > V_3 > V_1$ $\quad$ $I_3 > I_1 > I_2$
**d)** $V_2 > V_3 > V_1$ $\quad$ $I_1 = I_2 = I_3$
**e)** $V_2 > V_1 > V_3$ $\quad$ $I_1 = I_2 = I_3$

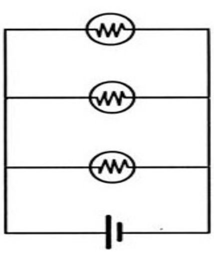
**11.**

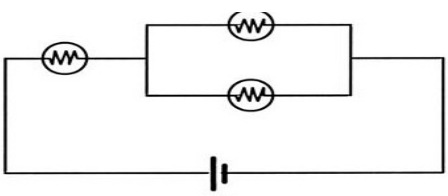


Yandaki devrenin şematik çizimi aşağıdakilerden hangisinde doğru olarak gösterilmiştir?

a.


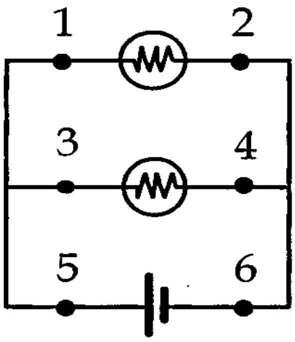
b.


c.


d.


e. Hiçbiri

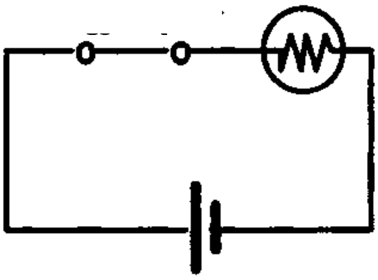
**12**




1, 2, 3, 4, 5, ve 6 noktalarından geçen akımları büyükten küçüğe doğru sıralayınız

a. 5, 1, 2, 3, 4, 6
b. 5, 3, 1, 4, 2, 6
c. 5=6, 3=4, 1=2
d. 5=6, 1=2=3=4
e. 1=2=3=4=5=6

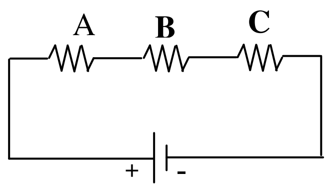
**13.**



Anahtar açıldıktan hemen sonra, lambanın direnci
nasıl değişir?

a. Artar
b. Azalır
c. Değişmez
d. Önce azalır, sonra artar
e. Sıfırlanır.

**14.** Şekildeki devrede A direnci yerine daha yüksek rezistanslı direnç konulduğunda, devredeki akım bu değişiklikten nasıl etkilenir?




**a)** Dirençler üzerinden geçen akımda bir değişiklik olmaz çünkü güç kaynağı sabit akım kaynağıdır ve devreye aynı akımı vermeye devam etmektedir.

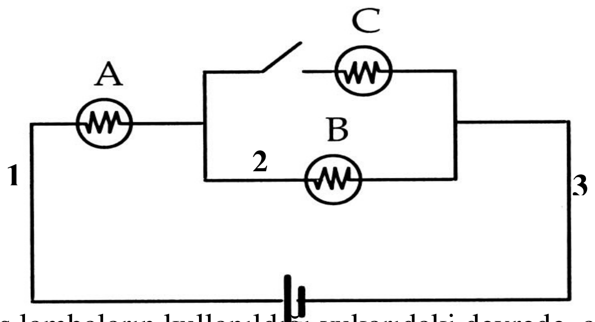
**b)** B ve C dirençlerinden geçen akımlar eşit olarak azalır çünkü devreye seri olarak bağlanan büyük rezistanslı direnç devrenin toplam direncini arttırıp, devreden geçen akımı düşürür.

**c)** Sadece B ve C dirençleri bu değişiklikten etkilenir çünkü bu iki direnç, devrede, değiştirilen A direncinden sonra yeralmaktadırlar.

**d)** B ve C dirençleri bu değişiklikten etkilenmez çünkü devrenin herhangi bir bölümünde yapılan bir değişiklik sadece o bölgeyi etkiler.

**e)** C direncinden geçen akım B'den geçen akıma göre daha çok azalır, çünkü devreden geçen akım B direncinde bir miktar harcandıktan sonra C direncinden geçmektedir.

**15.**



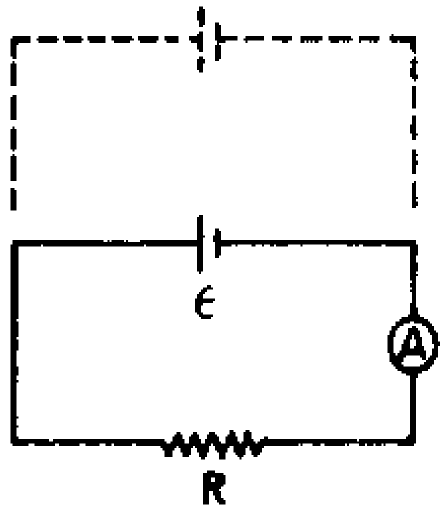

Özdeş lambaların kullanıldığı yukarıdaki devrede, anahtar kapatıldığında 1, 2 ve 3 noktalarından geçen akım değerleri nasıl değişir?

a. $I_1$ azalır, $I_2$ değişmez, $I_3$ artar.
b. $I_1$ ve $I_3$ artar, $I_2$ değişmez.
c. $I_1$ ve $I_3$ azalır, $I_2$ değişmez.
d. $I_1$ artar, $I_2$ ve $I_3$ azalır.
e. $I_1$ ve $I_2$ artar, $I_3$ değişmez.

**16.** Anahtar kapatıldığında A ve B lambalarının parlaklığı nasıl değişir?

a. A aynı kalır, B söner.
b. A nın parlaklığı artar, B söner.
c. İkisinin de parlaklığı artar.
d. İkisinin de parlaklığı artar.
e. İkisinin de parlaklığı aynı kalır.

**17.**




Şekilde verilen devredeki ampermetre belli bir akım değerini göstermektedir. Şekildekiyle özdeş ikinci bir üreteç, birinci üretece paralel olarak bağlanmaktadır. (Üreteçlerin iç direnci önemsenmemektedir.)

Bunun sonucunda seçeneklerde verilen durumlardan hangisi gerçekleşir?

a. Ampermetrede okunan değer artar.
b. R direncinin uçları arasındaki potansiyel fark artar.
c. R direncinin uçları arasındaki potansiyel fark azalır.
d. Birinci üretecin üzerinden geçen akım azalır.
e. Birinci üretecin üzerinden geçen akım değişmez.

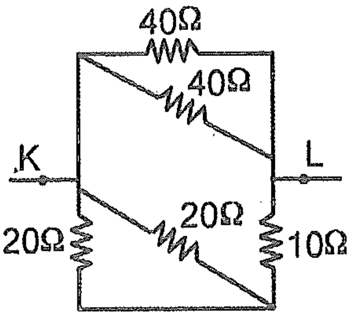
**18.** Yüksek yapılarda, kent suyunu üst katlara çıkarmak için kullanılan düzenekte:

IV. Su pompası,
V. Su sayacı,
VI. Basınç ölçer aygıtları vardır.

Bu düzenek bir elektrik devresine benzetilirse, yukarıdaki aygıtlar, elektrik devresindeki aygıtların hangisinin yerini tutar?

| | | | |
|---|---|---|---|
| a. | I. Üreteç, | II. Akımölçer, | III. Gerilimölçer |
| b. | I. Direnç, | II. Gerilimölçer, | III. Akımölçer |
| c. | I. Direnç, | II. Akımölçer, | III. Gerilimölçer |
| d. | I. Üreteç, | II. Direnç, | III. Gerilimölçer |
| e. | I. Üreteç, | II. Akımölçer, | III. Direnç |

**19**



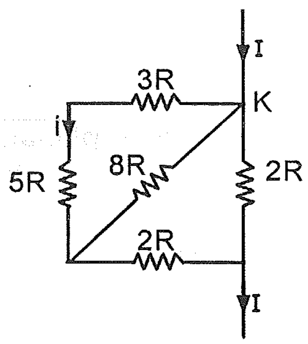

Şekle göre K-L arasındaki eşdeğer direnç kaç Ω (ohm) dur?

a. 10
b. 20
c. 40
d. 50
e. 130

**20.** $\dfrac{\text{watt}}{\text{joule/coulomb}}$ ifadesi aşağıdaki niceliklerden hangisini verir?

a. ampere olarak akım şiddetini
b. volt olarak potansiyel farkı
c. ohm olarak direnç
d. coulomb olarak elektrik yükü
e. joule olarak enerji

**21.**




Şekildeki devre parçasında 5R lik dirençten geçen akımın şiddeti i ise, K noktasına gelen I akımının şiddeti kaç i dir?

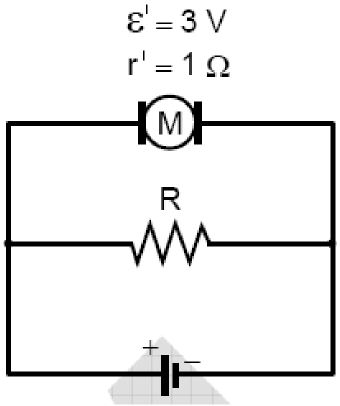
a. 10
b. 8
c. 4
d. 3
e. 2

**22.**

Zıt e.m.k. sı έ olan bir motor, e.m.k. sı ε=120 volt olan bir doğru akım üreteci ile döndürülüyor. Motor dönerken 10A, dönmesi engellendiğinde de 30A akım çektiğine göre έ kaç volt tur?

a. 20
b. 40
c. 80
d. 120
e. 160

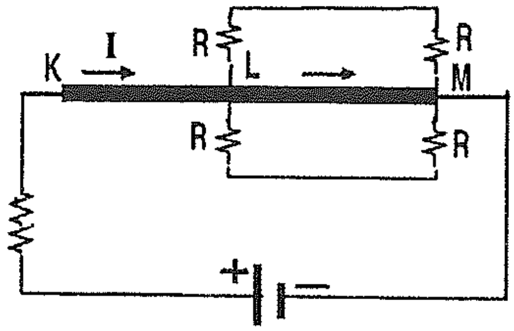
**23**




Şekildeki elektrik devresinde motor çalışırken hem motordan hem de R direncinden 2A büyüklüğünde akım geçiyor.
Motorun zıt elektromotor kuvveti $\acute{\varepsilon} = 3V$, iç direnci de $\acute{r} = 1\Omega$ olduğuna göre, R direncinin değeri kaç Ω dur?

a. 1
b. $\frac{3}{2}$
c. 2
d. $\frac{5}{2}$
e. 3

**24.**




Çok küçük dirençli KM çubuğuna, dirençleri KM ninkinden çok büyük olan dört tane R direnci

Devrenin KL kesiminden geçen akımın şiddeti I olduğuna göre, LM kesiminden geçen akımın şiddeti için aşağıdakilerden hangisi doğrudur?

a. I ya yakın
b. $\frac{I}{2}$ ye yakın
c. 2I ya yakın
d. $\frac{I}{4}$ e yakın
e. 4I ya yakın

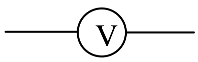
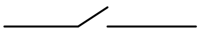
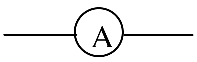
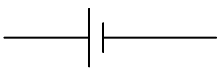
**<u>Açıklama</u>**: *Aşağıdaki cümleleri okuduktan sonra doğru olduğunu düşündüğünüz cümlelerin önündeki "D" harfini, yanlış olduğunu düşündüğünüz cümlelerin önündeki "Y" harfini parantez içine alınız*

D Y **25.** Paralel bağlı devrelerde, her bir kolun uçları arasındaki potansiyel fark, üretecin uçları arasındaki potansiyel farka eşittir.

D Y **26.** İletkenlerin direnci yüksek, yalıtkanların direnci ise düşüktür.

D Y **27.** Seri bağlı devrelerdeki lamba sayısı arttıkça devrenin eşdeğer direnci azalır.

**<u>Açıklama</u>**: *Aşağıdaki "A" sütununda devre elemanları, "B" sütununda ise devre elemanlarının sembolik olarak gösterilişleri yer almaktadır. Her bir elemanın solundaki boşluğa o elemanın sembolünün önündeki harfi yazınız. "B" sütunundaki bazı semboller hiç kullanılmayabilir veya bir defadan fazla da kullanılabilir.*

| | | "A" sütunu | "B" sütunu | |
|---|---|---|---|---|
| .......... | **28.** | Direnç | A. |  |
| .......... | **29.** | Pil | B. |  |
| .......... | **30.** | Anahtar | C. |  |
| | | | D. |  |
| | | | E. |  |

PACT version 3 (Last Version)

## ELEKTRİK DEVRELERİ BAŞARI TESTİ

**Adı Soyadı:**
**Doğum Tarihi:** Ay ….. Yıl ……..
**Cinsiyeti:** Kız ☐ Erkek ☐
**I. Dönem Fizik Notu:** …….
**Yıl Sonu Not Ortalaması:** …….
**Okulu:** **Sınıfı/No.su:**

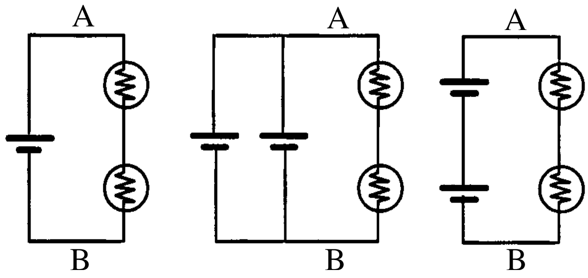
Sevgili Öğrenciler,

Bu test Elektrik Ünitesindeki Elektrik Devreleri konusu ile ilgili olarak ÖSS sorularından, test kitaplarından ve yabancı kaynaklardan derlenerek hazırlanmış 30 sorudan oluşan bir başarı testidir.

Testin sonuçları sizlere daha iyi ve anlaşılır bir fizik dersinin geliştirilmesine katkıda bulunabileceğinden önem taşımaktadır. Aldığınız notlar kesinlikle ortalamanızı etkilemeyecektir. Lütfen tüm soruları cevaplamaya çalışınız. Sınav süresi 45 dakikadır. Katılımınız için teşekkür ederim.

**Açıklama**: *Aşağıda verilen devrelerde özdeş lambalar ve özdeş üreteçler kullanılmıştır. 1. 2. ve 3. soruları bu devreleri göz önünde bulundurarak cevaplayınız.*

**1.**




**Devre** **Devre** **Devre**

Yukarıdaki devrelerde A ve B noktaları arasındaki potansiyel farkını karşılaştırınız. Aşağıdaki seçeneklerden hangisi A-B noktaları arasındaki potansiyel farkı doğru olarak göstermektedir?

a. $V_1<V_2<V_3$
b. $V_1=V_2<V_3$
c. $V_1=V_2>V_3$
d. $V_1>V_2>V_3$
e. $V_1<V_2=V_3$

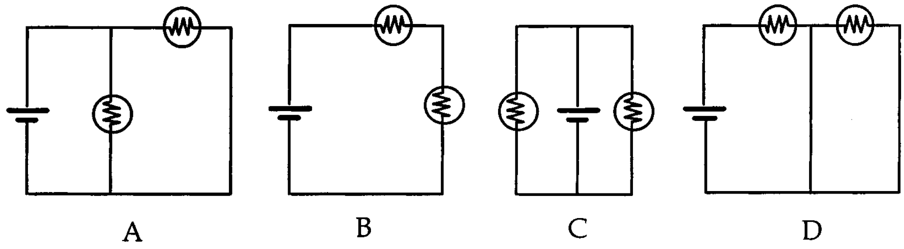
**2.** Yukarıdaki devrelerde özdeş piller kullanılmıştır. Hangi devre ya da devrelerde kullanılan piller en uzun süre dayanır?

a. II=III>I
b. I<II<III
c. II=III<I
d. I=III<II
e. III<I<II

**3.** Yukarıdaki elektrik devrelerini inceleyiniz. Hangi devre ya da devrelerde birim zamanda açığa çıkan enerji miktarı en fazladır?

a. Devre I
b. Devre II
c. Devre III
d. Devre I = Devre II
e. Devre II = Devre III

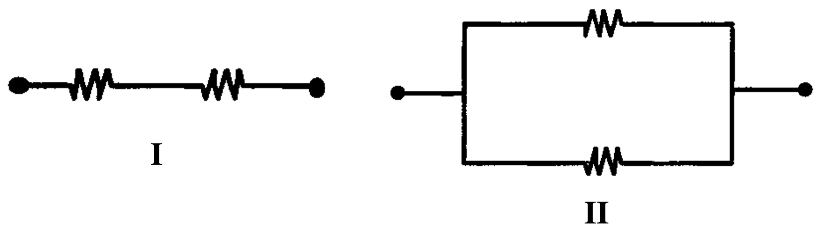
**4.**




Yukarıdaki devreleri inceleyiniz. Bu devrelerden hangisi ya da hangileri bir üreteç ve paralel bağlı iki lambadan oluşur?

a. A
b. B
c. C
d. A ve C
e. A, C ve D

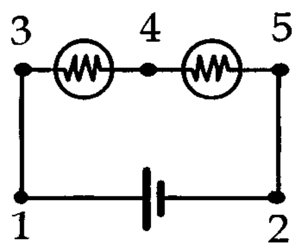
**5.**




I ve II durumunda gösterilen devre parçasındaki eşdeğer direnci karşılaştırdığınızda, hangisi daha küçüktür? (Dirençler özdeştir.)

a. I
b. II
c. I=II
d. Devreden geçen akıma bağlıdır.
e. A-B noktaları arasındaki potansiyel farka bağlıdır.

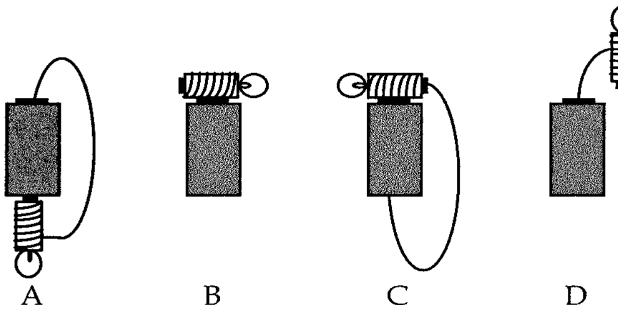
**6.**




1 ve 2, 3 ve 4, 4 ve 5 noktaları arasındaki potansiyel farkı büyükten küçüğe doğru sıralayınız? (Lambalar özdeştir.)

a. $V_{1-2}>V_{3-4}>V_{4-5}$
b. $V_{1-2}>V_{4-5}>V_{3-4}$
c. $V_{3-4}>V_{4-5}>V_{1-2}$
d. $V_{3-4}=V_{4-5}>V_{1-2}$
e. $V_{1-2}>V_{3-4}=V_{4-5}$

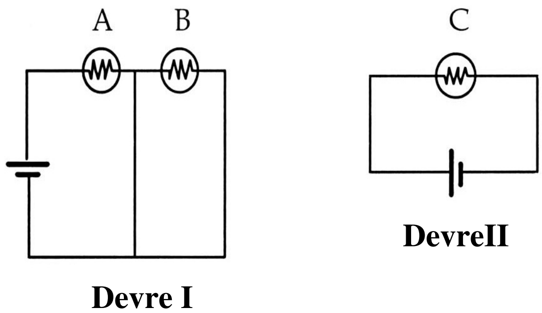
**7.**




Yukarıdaki devrelerin hangisinde veya hangilerinde lamba yanar?

a. A
b. C
c. D
d. A ve C
e. B ve D

**8.**




Devre I ve Devre II'deki A, B ve C lambaları özdeş ve her birinin direnci R'dir. Devrelerin eşdeğer dirençleri hangi seçenekte doğru verilmiştir?

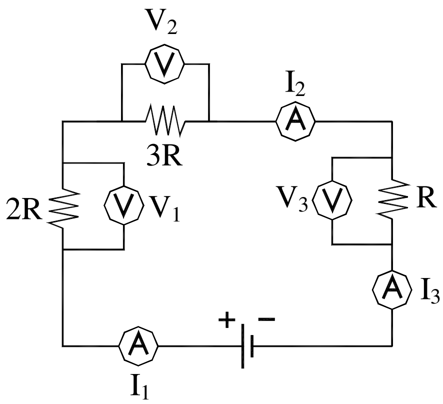
a. $R_{eş1}=2R$ ve $R_{eş2}=R$
b. $R_{eş1}=R$ ve $R_{eş2}=R$
c. $R_{eş1}=R/2$ ve $R_{eş2}=R$
d. $R_{eş1}=2R$ ve $R_{eş2}=R/2$
e. $R_{eş1}=R/2$ ve $R_{eş2}=R/2$

**9.** Devre I' deki A ve B lambalarının parlaklığını Devre II' deki C lambasının parlaklığı ile karşılaştırınız. Hangi lamba veya lambalar en parlak yanar?

a. A
b. B
c. C
d. B = C
e. A = C

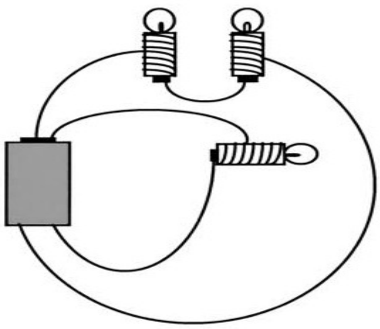
**10.**

Şekilde gösterilenen devrede ampermetrenin okuduğu değerler $I_1$, $I_2$, $I_3$ ve voltmetrenin okuduğu değerler $V_1$, $V_2$, $V_3$ tür. Bu değerlerin arasındaki ilişki nedir?



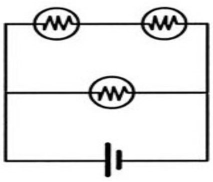

| | | |
|---|---|---|
| a. | $V_1 > V_2 > V_3$ | $I_1 = I_2 = I_3$ |
| b. | $V_3 > V_1 > V_2$ | $I_1 > I_2 > I_3$ |
| c. | $V_2 > V_3 > V_1$ | $I_3 > I_1 > I_2$ |
| d. | $V_2 > V_3 > V_1$ | $I_1 = I_2 = I_3$ |
| e. | $V_2 > V_1 > V_3$ | $I_1 = I_2 = I_3$ |

**11.**

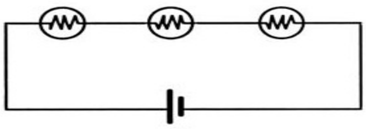


Yandaki devrenin şematik çizimi aşağıdakilerden hangisinde doğru olarak gösterilmiştir?

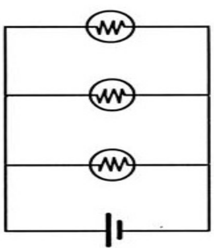
a.



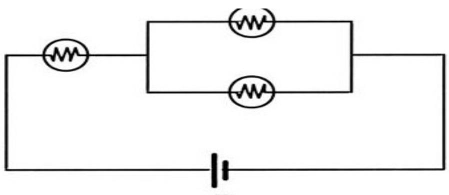
b.



c.

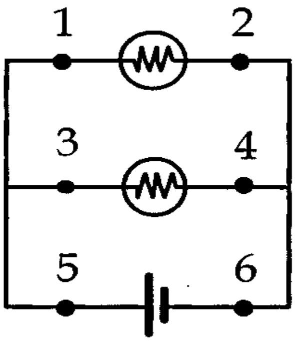


d.



e. Hiçbiri

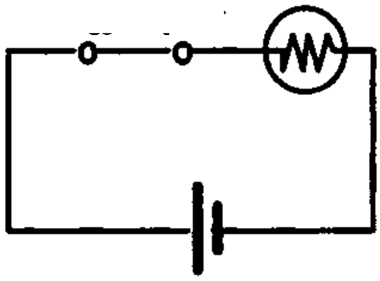
**12**




1, 2, 3, 4, 5, ve 6 noktalarından geçen akımları büyükten küçüğe doğru sıralayınız. (Lambalar özdeştir.)

a. 5, 1, 2, 3, 4, 6
b. 5, 3, 1, 4, 2, 6
c. 5=6, 3=4, 1=2
d. 5=6, 1=2=3=4
e. 1=2=3=4=5=6

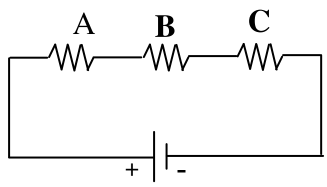
**13.**



Anahtar açıldıktan hemen sonra, lambanın direnci nasıl değişir?

a. Artar
b. Azalır
c. Değişmez
d. Önce azalır, sonra artar
e. Sıfırlanır.

**14.** Şekildeki devrede A direnci yerine daha yüksek direnç konulduğunda, devredeki akım bu değişiklikten nasıl etkilenir?




**a)** Dirençler üzerinden geçen akımda bir değişiklik olmaz çünkü güç kaynağı sabit akım kaynağıdır ve devreye aynı akımı vermeye devam etmektedir.

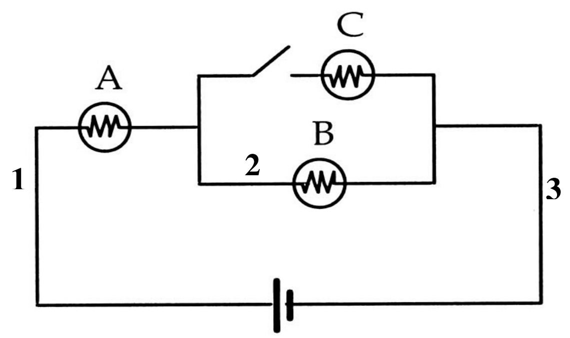
**b)** B ve C dirençlerinden geçen akımlar eşit olarak azalır çünkü devreye seri olarak bağlanan büyük rezistanslı direnç devrenin toplam direncini arttırıp, devreden geçen akımı düşürür.

**c)** Sadece B ve C dirençleri bu değişiklikten etkilenir çünkü bu iki direnç, devrede, değiştirilen A direncinden sonra yeralmaktadırlar.

**d)** B ve C dirençleri bu değişiklikten etkilenmez çünkü devrenin herhangi bir bölümünde yapılan bir değişiklik sadece o bölgeyi etkiler.

**e)** C direncinden geçen akım B'den geçen akıma göre daha çok azalır, çünkü devreden geçen akım B direncinde bir miktar harcandıktan sonra C direncinden geçmektedir.

**15.**



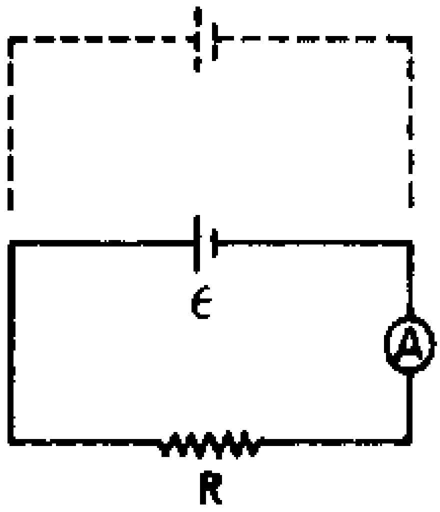

Özdeş lambaların kullanıldığı yukarıdaki devrede, anahtar kapatıldığında 1, 2 ve 3 noktalarından geçen akım değerleri nasıl değişir?

a. $I_1$ ve $I_3$ artar, $I_2$ azalır.
b. $I_1$ ve $I_3$ artar, $I_2$ değişmez.
c. $I_1$ ve $I_3$ azalır, $I_2$ artar.
d. $I_1$ artar, $I_2$ ve $I_3$ azalır.
e. $I_1$ ve $I_2$ artar, $I_3$ değişmez.

**16.** Anahtar kapatıldığında A ve B lambalarının parlaklığı nasıl değişir?

a. A nın parlaklığı aynı kalır, B nin parlaklığı azalır.
b. A nın parlaklığı artar, B nin parlaklığı azalır.
c. İkisinin de parlaklığı azalır.
d. İkisinin de parlaklığı artar.
e. İkisinin de parlaklığı aynı kalır.

**17.**




Şekilde verilen devredeki ampermetre belli bir akım değerini göstermektedir. Şekildekiyle özdeş ikinci bir üreteç, birinci üretece paralel olarak bağlanmaktadır. (Üreteçlerin iç direnci önemsenmemektedir.)

Bunun sonucunda seçeneklerde verilen durumlardan hangisi gerçekleşir?

a. Ampermetrede okunan değer artar.
b. R direncinin uçları arasındaki potansiyel fark artar.
c. R direncinin uçları arasındaki potansiyel fark azalır.
d. Birinci üretecin üzerinden geçen akım azalır.
e. Birinci üretecin üzerinden geçen akım değişmez.

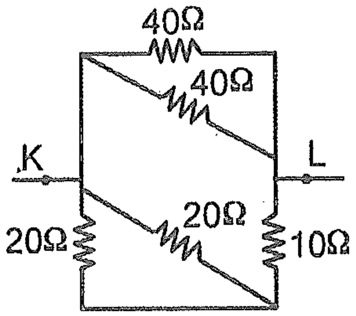
**18.** Yüksek yapılarda, kent suyunu üst katlara çıkarmak için kullanılan düzenekte:

I. Su pompası,
II. Su sayacı,
III. Basınç ölçer aygıtları vardır.

Bu düzenek bir elektrik devresine benzetilirse, yukarıdaki aygıtlar, elektrik devresindeki aygıtların hangisinin yerini tutar?

a. I. Üreteç, II. Akımölçer, III. Gerilimölçer
b. I. Direnç, II. Gerilimölçer, III. Akımölçer
c. I. Direnç, II. Akımölçer, III. Gerilimölçer
d. I. Üreteç, II. Direnç, III. Gerilimölçer
e. I. Üreteç, II. Akımölçer, III. Direnç

**19.**



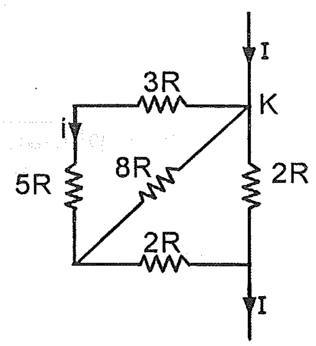

Şekle göre K-L arasındaki eşdeğer direnç kaç Ω (ohm) dur?

a. 10
b. 20
c. 40
d. 50
e. 130

**20.** $\dfrac{\text{watt}}{\text{joule/coulomb}}$ ifadesi aşağıdaki niceliklerden hangisini verir?

a. ampere olarak akım şiddetini
b. volt olarak potansiyel farkı
c. ohm olarak direnç
d. coulomb olarak elektrik yükü
e. joule olarak enerji

**21.**



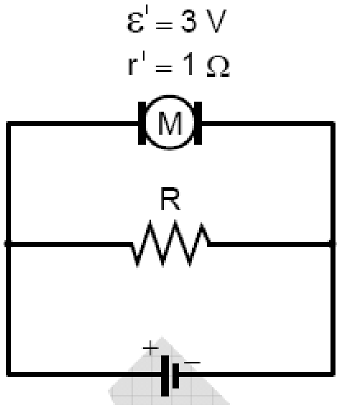

Şekildeki devre parçasında 5R lik dirençten geçen akımın şiddeti i ise, K noktasına gelen I akımının şiddeti kaç i dir?

a. 10
b. 8
c. 4
d. 3
e. 2

**22.** Zıt e.m.k. sı $\varepsilon'$ olan bir motor, e.m.k. sı $\varepsilon$=120 volt olan bir doğru akım üreteci ile döndürülüyor. Motor dönerken 10A, dönmesi engellendiğinde de 30A akım çektiğine göre $\varepsilon'$ kaç volt tur?

a. 20
b. 40
c. 80
d. 120
e. 160

**23.**

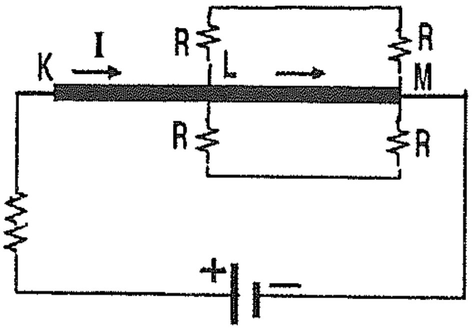



Şekildeki elektrik devresinde motor çalışırken hem motordan hem de R direncinden 2A büyüklüğünde akım geçiyor.

Motorun zıt elektromotor kuvveti $\acute{\varepsilon} = 3V$, iç direnci de $\acute{r} = 1\Omega$ olduğuna göre, R direncinin değeri kaç Ω dur?

a. 1
b. $\frac{3}{2}$
c. 2
d. $\frac{5}{2}$
e. 3

**24.**




Çok küçük dirençli KM çubuğuna, dirençleri KM ninkinden çok büyük olan dört tane R direnci şekildeki gibi bağlanmıştır.

Devrenin KL kesiminden geçen akımın şiddeti I olduğuna göre, LM kesiminden geçen akımın şiddeti için aşağıdakilerden hangisi doğrudur?

a. I ya yakın
b. $\frac{I}{2}$ ye yakın
c. 2I ya yakın
d. $\frac{I}{4}$ e yakın
e. 4I ya yakın

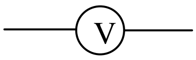
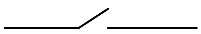
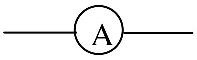
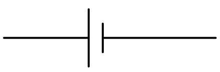
**<u>Açıklama</u>**: *Aşağıdaki cümleleri okuduktan sonra doğru olduğunu düşündüğünüz cümlelerin önündeki "D" harfini, yanlış olduğunu düşündüğünüz cümlelerin önündeki "Y" harfini parantez içine alınız*

D Y **25.** Paralel bağlı devrelerde, her bir kolun uçları arasındaki potansiyel fark, üretecin uçları arasındaki potansiyel farka eşittir.

D Y **26.** İletkenlerin direnci yüksek, yalıtkanların direnci ise düşüktür.

D Y **27.** Seri bağlı devrelerdeki lamba sayısı arttıkça devrenin eşdeğer direnci azalır.

**<u>Açıklama</u>**: *Aşağıdaki "A" sütununda devre elemanları, "B" sütununda ise devre elemanlarının sembolik olarak gösterilişleri yer almaktadır. Her bir elemanın solundaki boşluğa o elemanın sembolünün önündeki harfi yazınız. "B" sütunundaki bazı semboller hiç kullanılmayabilir veya bir defadan fazla da kullanılabilir.*

| | | "A" sütunu | "B" sütunu |
|---|---|---|---|
| .......... | **28.** | Direnç | A.  |
| .......... | **29.** | Pil | B.  |
| .......... | **30.** | Anahtar | C.  |
| | | | D.  |
| | | | E.  |

ANSWERS OF THE FINAL VERSION OF THE PACT

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

# APPENDIX E

Table A.1 PrePACT PostPACT Comparison-Experimental Group

| Item No | Choices | Pretest | Posttest | Item Diff | Pretest | Posttest | P Diff. |
|---|---|---|---|---|---|---|---|
| Item 1 | A | 0.117 | 0.164 | P | 0.322 | 0.621 | 0.299 |
| | B | 0.322 | 0.621 | | | | |
| | C | 0.084 | 0.067 | | | | |
| | D | 0.044 | 0.046 | | | | |
| | E | 0.311 | 0.087 | | | | |
| | Omit | 0.121 | 0.015 | | | | |
| Item 2 | A | 0.209 | 0.118 | P | 0.139 | 0.308 | 0.169 |
| | B | 0.256 | 0.138 | | | | |
| | C | 0.095 | 0.082 | | | | |
| | D | 0.187 | 0.292 | | | | |
| | E | 0.139 | 0.308 | | | | |
| | Omit | 0.114 | 0.062 | | | | |
| Item3 | A | 0.084 | 0.092 | P | 0.421 | 0.528 | 0.107 |
| | B | 0.11 | 0.128 | | | | |
| | C | 0.421 | 0.528 | | | | |
| | D | 0.062 | 0.103 | | | | |
| | E | 0.179 | 0.092 | | | | |
| | Omit | 0.143 | 0.056 | | | | |
| Item 4 | A | 0.04 | 0.077 | P | 0.557 | 0.672 | 0.115 |
| | B | 0.018 | 0.051 | | | | |
| | C | 0.231 | 0.072 | | | | |
| | D | 0.557 | 0.672 | | | | |
| | E | 0.121 | 0.123 | | | | |
| | Omit | 0.033 | 0.005 | | | | |
| Item 5 | A | 0.201 | 0.113 | P | 0.513 | 0.667 | 0.154 |
| | B | 0.513 | 0.667 | | | | |
| | C | 0.015 | 0.036 | | | | |
| | D | 0.172 | 0.118 | | | | |
| | E | 0.051 | 0.067 | | | | |
| | Omit | 0.048 | 0 | | | | |
| Item 6 | A | 0.051 | 0.067 | P | 0.436 | 0.579 | 0.143 |
| | B | 0.044 | 0.062 | | | | |
| | C | 0.07 | 0.159 | | | | |
| | D | 0.245 | 0.118 | | | | |
| | E | 0.436 | 0.579 | | | | |
| | Omit | 0.154 | 0.015 | | | | |
| Item 7 | A | 0.187 | 0.164 | P | 0.52 | 0.585 | 0.065 |
| | B | 0.106 | 0.103 | | | | |
| | C | 0.051 | 0.056 | | | | |
| | D | 0.52 | 0.585 | | | | |
| | E | 0.029 | 0.067 | | | | |
| | Omit | 0.106 | 0.026 | | | | |

Table A.1 (continued)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Item 8 | A | 0.223 | 0.138 | P | 0.377 | 0.569 | 0.192 |
| | B | 0.377 | 0.569 | | | | |
| | C | 0.205 | 0.164 | | | | |
| | D | 0.026 | 0.077 | | | | |
| | E | 0.037 | 0.036 | | | | |
| | Omit | 0.132 | 0.015 | | | | |
| Item 9 | A | 0.022 | 0.056 | P | 0.366 | 0.564 | 0.198 |
| | B | 0.018 | 0.067 | | | | |
| | C | 0.487 | 0.221 | | | | |
| | D | 0.026 | 0.082 | | | | |
| | E | 0.366 | 0.564 | | | | |
| | Omit | 0.081 | 0.01 | | | | |
| Item 10 | A | 0.059 | 0.103 | P | 0.341 | 0.564 | 0.223 |
| | B | 0.253 | 0.097 | | | | |
| | C | 0.062 | 0.118 | | | | |
| | D | 0.059 | 0.092 | | | | |
| | E | 0.341 | 0.564 | | | | |
| | Omit | 0.227 | 0.026 | | | | |
| Item 11 | A | 0.777 | 0.713 | P | 0.777 | 0.713 | -0.064 |
| | B | 0.04 | 0.103 | | | | |
| | C | 0.007 | 0.056 | | | | |
| | D | 0.081 | 0.082 | | | | |
| | E | 0.037 | 0.031 | | | | |
| | Omit | 0.059 | 0.015 | | | | |
| Item 12 | A | 0.029 | 0.062 | P | 0.278 | 0.574 | 0.296 |
| | B | 0.066 | 0.041 | | | | |
| | C | 0.26 | 0.19 | | | | |
| | D | 0.278 | 0.574 | | | | |
| | E | 0.278 | 0.113 | | | | |
| | Omit | 0.088 | 0.021 | | | | |
| Item 13 | A | 0.073 | 0.108 | P | 0.154 | 0.359 | 0.205 |
| | B | 0.187 | 0.097 | | | | |
| | C | 0.154 | 0.359 | | | | |
| | D | 0.062 | 0.046 | | | | |
| | E | 0.432 | 0.379 | | | | |
| | Omit | 0.092 | 0.01 | | | | |
| Item 14 | A | 0.168 | 0.2 | P | 0.348 | 0.523 | 0.175 |
| | B | 0.348 | 0.523 | | | | |
| | C | 0.117 | 0.133 | | | | |
| | D | 0.088 | 0.077 | | | | |
| | E | 0.077 | 0.036 | | | | |
| | Omit | 0.201 | 0.031 | | | | |

Table A.1 (continued)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Item 15 | A | 0.282 | 0.533 | P | 0.282 | 0.533 | 0.251 |
| | B | 0.103 | 0.123 | | | | |
| | C | 0.092 | 0.108 | | | | |
| | D | 0.187 | 0.097 | | | | |
| | E | 0.125 | 0.123 | | | | |
| | Omit | 0.212 | 0.015 | | | | |
| Item 16 | A | 0.443 | 0.226 | P | 0.201 | 0.451 | 0.25 |
| | B | 0.201 | 0.451 | | | | |
| | C | 0.125 | 0.133 | | | | |
| | D | 0.055 | 0.087 | | | | |
| | E | 0.081 | 0.082 | | | | |
| | Omit | 0.095 | 0.021 | | | | |
| Item 17 | A | 0.223 | 0.169 | P | 0.136 | 0.231 | 0.095 |
| | B | 0.106 | 0.067 | | | | |
| | C | 0.139 | 0.149 | | | | |
| | D | 0.136 | 0.231 | | | | |
| | E | 0.172 | 0.323 | | | | |
| | Omit | 0.223 | 0.062 | | | | |
| Item 18 | A | 0.549 | 0.574 | P | 0.549 | 0.574 | 0.025 |
| | B | 0.062 | 0.072 | | | | |
| | C | 0.128 | 0.138 | | | | |
| | D | 0.037 | 0.082 | | | | |
| | E | 0.099 | 0.108 | | | | |
| | Omit | 0.125 | 0.026 | | | | |
| Item 19 | A | 0.363 | 0.585 | P | 0.363 | 0.585 | 0.222 |
| | B | 0.044 | 0.077 | | | | |
| | C | 0.267 | 0.138 | | | | |
| | D | 0.11 | 0.092 | | | | |
| | E | 0.11 | 0.056 | | | | |
| | Omit | 0.106 | 0.051 | | | | |
| Item 20 | A | 0.172 | 0.333 | P | 0.172 | 0.333 | 0.161 |
| | B | 0.103 | 0.108 | | | | |
| | C | 0.319 | 0.144 | | | | |
| | D | 0.099 | 0.113 | | | | |
| | E | 0.084 | 0.226 | | | | |
| | Omit | 0.223 | 0.077 | | | | |
| Item 21 | A | 0.099 | 0.128 | P | 0.172 | 0.395 | 0.223 |
| | B | 0.172 | 0.395 | | | | |
| | C | 0.289 | 0.267 | | | | |
| | D | 0.106 | 0.072 | | | | |
| | E | 0.121 | 0.103 | | | | |
| | Omit | 0.212 | 0.036 | | | | |

Table A.1 (continued)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Item 22 | A | 0.022 | 0.072 | P | 0.209 | 0.513 | 0.304 |
| | B | 0.245 | 0.113 | | | | |
| | C | 0.209 | 0.513 | | | | |
| | D | 0.161 | 0.154 | | | | |
| | E | 0.066 | 0.097 | | | | |
| | Omit | 0.297 | 0.051 | | | | |
| Item 23 | A | 0.051 | 0.113 | P | 0.117 | 0.462 | 0.345 |
| | B | 0.289 | 0.118 | | | | |
| | C | 0.128 | 0.2 | | | | |
| | D | 0.117 | 0.462 | | | | |
| | E | 0.066 | 0.062 | | | | |
| | Omit | 0.348 | 0.046 | | | | |
| Item 24 | A | 0.209 | 0.359 | P | 0.209 | 0.359 | 0.15 |
| | B | 0.165 | 0.185 | | | | |
| | C | 0.136 | 0.144 | | | | |
| | D | 0.132 | 0.185 | | | | |
| | E | 0.088 | 0.072 | | | | |
| | Omit | 0.271 | 0.056 | | | | |
| Item 25 | D | 0.729 | 0.821 | P | 0.729 | 0.821 | 0.092 |
| | Y | 0.179 | 0.133 | | | | |
| | Omit | 0.092 | 0.046 | | | | |
| Item 26 | D | 0.3 | 0.318 | P | 0.619 | 0.641 | 0.022 |
| | Y | 0.619 | 0.641 | | | | |
| | Omit | 0.081 | 0.041 | | | | |
| Item 27 | D | 0.436 | 0.344 | P | 0.469 | 0.61 | 0.141 |
| | Y | 0.469 | 0.61 | | | | |
| | Omit | 0.095 | 0.046 | | | | |
| Item 28 | A | 0.066 | 0.036 | P | 0.828 | 0.892 | 0.064 |
| | B | 0.828 | 0.892 | | | | |
| | C | 0 | 0 | | | | |
| | D | 0.033 | 0 | | | | |
| | E | 0.007 | 0.01 | | | | |
| | Omit | 0.066 | 0.062 | | | | |
| Item 29 | A | 0.04 | 0.036 | P | 0.853 | 0.872 | 0.019 |
| | B | 0.029 | 0.015 | | | | |
| | C | 0 | 0.026 | | | | |
| | D | 0.011 | 0.005 | | | | |
| | E | 0.853 | 0.872 | | | | |
| | Omit | 0.066 | 0.046 | | | | |
| Item 30 | A | 0 | 0.021 | P | 0.919 | 0.908 | -0.011 |
| | B | 0 | 0 | | | | |
| | C | 0.919 | 0.908 | | | | |
| | D | 0.004 | 0.005 | | | | |
| | E | 0.015 | 0.021 | | | | |
| | Omit | 0.062 | 0.046 | | | | |

APPENDIX F

Table A.2 PrePACT PostPACT Comparison-Control Group

| Item No | Choices | Pretest | Posttest | Item Diff | Pretest | Posttest | P Diff. |
|---|---|---|---|---|---|---|---|
| Item 1 | A | 0.168 | 0.071 | P | 0.463 | 0.688 | 0.225 |
| | B | 0.463 | 0.688 | | | | |
| | C | 0.114 | 0.098 | | | | |
| | D | 0.067 | 0.045 | | | | |
| | E | 0.148 | 0.089 | | | | |
| | Omit | 0.04 | 0.009 | | | | |
| Item 2 | A | 0.201 | 0.089 | P | 0.195 | 0.304 | 0.109 |
| | B | 0.188 | 0.143 | | | | |
| | C | 0.101 | 0.107 | | | | |
| | D | 0.242 | 0.321 | | | | |
| | E | 0.195 | 0.304 | | | | |
| | Omit | 0.074 | 0.036 | | | | |
| Item3 | A | 0.094 | 0.179 | P | 0.47 | 0.446 | -0.024 |
| | B | 0.134 | 0.125 | | | | |
| | C | 0.47 | 0.446 | | | | |
| | D | 0.107 | 0.116 | | | | |
| | E | 0.128 | 0.098 | | | | |
| | Omit | 0.067 | 0.036 | | | | |
| Item 4 | A | 0.081 | 0.107 | P | 0.664 | 0.625 | -0.039 |
| | B | 0.02 | 0.045 | | | | |
| | C | 0.141 | 0.063 | | | | |
| | D | 0.664 | 0.625 | | | | |
| | E | 0.094 | 0.152 | | | | |
| | Omit | 0 | 0.009 | | | | |
| Item 5 | A | 0.154 | 0.089 | P | 0.617 | 0.705 | 0.088 |
| | B | 0.617 | 0.705 | | | | |
| | C | 0.027 | 0.063 | | | | |
| | D | 0.141 | 0.063 | | | | |
| | E | 0.047 | 0.071 | | | | |
| | Omit | 0.013 | 0.009 | | | | |
| Item 6 | A | 0.107 | 0.125 | P | 0.523 | 0.554 | 0.031 |
| | B | 0.054 | 0.071 | | | | |
| | C | 0.06 | 0.08 | | | | |
| | D | 0.195 | 0.152 | | | | |
| | E | 0.523 | 0.554 | | | | |
| | Omit | 0.06 | 0.018 | | | | |
| Item 7 | A | 0.168 | 0.152 | P | 0.624 | 0.58 | -0.044 |
| | B | 0.114 | 0.152 | | | | |
| | C | 0.06 | 0.045 | | | | |
| | D | 0.624 | 0.58 | | | | |
| | E | 0.02 | 0.054 | | | | |
| | Omit | 0.013 | 0.018 | | | | |

Table A.2 (continued)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Item 8 | A | 0.248 | 0.232 | P | 0.463 | 0.545 | 0.082 |
| | B | 0.463 | 0.545 | | | | |
| | C | 0.141 | 0.08 | | | | |
| | D | 0.034 | 0.089 | | | | |
| | E | 0.04 | 0.045 | | | | |
| | Omit | 0.074 | 0.009 | | | | |
| Item 9 | A | 0.027 | 0.036 | P | 0.45 | 0.554 | 0.104 |
| | B | 0.04 | 0.063 | | | | |
| | C | 0.423 | 0.277 | | | | |
| | D | 0.04 | 0.054 | | | | |
| | E | 0.45 | 0.554 | | | | |
| | Omit | 0.02 | 0.018 | | | | |
| Item 10 | A | 0.067 | 0.045 | P | 0.537 | 0.598 | 0.061 |
| | B | 0.141 | 0.107 | | | | |
| | C | 0.081 | 0.161 | | | | |
| | D | 0.114 | 0.08 | | | | |
| | E | 0.537 | 0.598 | | | | |
| | Omit | 0.06 | 0.009 | | | | |
| Item 11 | A | 0.705 | 0.616 | P | 0.705 | 0.616 | -0.089 |
| | B | 0.02 | 0.098 | | | | |
| | C | 0.054 | 0.125 | | | | |
| | D | 0.067 | 0.071 | | | | |
| | E | 0.128 | 0.071 | | | | |
| | Omit | 0.027 | 0.018 | | | | |
| Item 12 | A | 0.02 | 0.045 | P | 0.483 | 0.518 | 0.035 |
| | B | 0.087 | 0.089 | | | | |
| | C | 0.201 | 0.098 | | | | |
| | D | 0.483 | 0.518 | | | | |
| | E | 0.174 | 0.232 | | | | |
| | Omit | 0.034 | 0.018 | | | | |
| Item 13 | A | 0.094 | 0.107 | P | 0.168 | 0.304 | 0.136 |
| | B | 0.161 | 0.125 | | | | |
| | C | 0.168 | 0.304 | | | | |
| | D | 0.02 | 0.054 | | | | |
| | E | 0.537 | 0.402 | | | | |
| | Omit | 0.02 | 0.009 | | | | |
| Item 14 | A | 0.289 | 0.152 | P | 0.416 | 0.455 | 0.039 |
| | B | 0.416 | 0.455 | | | | |
| | C | 0.081 | 0.17 | | | | |
| | D | 0.101 | 0.098 | | | | |
| | E | 0.027 | 0.036 | | | | |
| | Omit | 0.087 | 0.089 | | | | |

Table A.2 (continued)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Item 15 | A | 0.483 | 0.509 | P | 0.483 | 0.509 | 0.026 |
| | B | 0.128 | 0.054 | | | | |
| | C | 0.148 | 0.161 | | | | |
| | D | 0.074 | 0.089 | | | | |
| | E | 0.101 | 0.161 | | | | |
| | Omit | 0.067 | 0.027 | | | | |
| Item 16 | A | 0.369 | 0.188 | P | 0.342 | 0.438 | 0.096 |
| | B | 0.342 | 0.438 | | | | |
| | C | 0.094 | 0.089 | | | | |
| | D | 0.04 | 0.188 | | | | |
| | E | 0.107 | 0.063 | | | | |
| | Omit | 0.047 | 0.036 | | | | |
| Item 17 | A | 0.174 | 0.08 | P | 0.134 | 0.295 | 0.161 |
| | B | 0.121 | 0.143 | | | | |
| | C | 0.094 | 0.179 | | | | |
| | D | 0.134 | 0.295 | | | | |
| | E | 0.309 | 0.259 | | | | |
| | Omit | 0.168 | 0.045 | | | | |
| Item 18 | A | 0.557 | 0.5 | P | 0.557 | 0.5 | -0.057 |
| | B | 0.06 | 0.045 | | | | |
| | C | 0.094 | 0.17 | | | | |
| | D | 0.161 | 0.098 | | | | |
| | E | 0.081 | 0.17 | | | | |
| | Omit | 0.047 | 0.018 | | | | |
| Item 19 | A | 0.503 | 0.598 | P | 0.503 | 0.598 | 0.095 |
| | B | 0.081 | 0.098 | | | | |
| | C | 0.208 | 0.143 | | | | |
| | D | 0.054 | 0.063 | | | | |
| | E | 0.094 | 0.054 | | | | |
| | Omit | 0.06 | 0.045 | | | | |
| Item 20 | A | 0.208 | 0.295 | P | 0.208 | 0.295 | 0.087 |
| | B | 0.181 | 0.259 | | | | |
| | C | 0.201 | 0.08 | | | | |
| | D | 0.161 | 0.188 | | | | |
| | E | 0.081 | 0.116 | | | | |
| | Omit | 0.168 | 0.063 | | | | |
| Item 21 | A | 0.04 | 0.089 | P | 0.235 | 0.295 | 0.06 |
| | B | 0.235 | 0.295 | | | | |
| | C | 0.309 | 0.304 | | | | |
| | D | 0.148 | 0.161 | | | | |
| | E | 0.107 | 0.125 | | | | |
| | Omit | 0.161 | 0.027 | | | | |

Table A.2 (continued)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Item 22 | A | 0.054 | 0.089 | P | 0.255 | 0.518 | 0.263 |
| | B | 0.302 | 0.125 | | | | |
| | C | 0.255 | 0.518 | | | | |
| | D | 0.081 | 0.08 | | | | |
| | E | 0.054 | 0.161 | | | | |
| | Omit | 0.255 | 0.027 | | | | |
| Item 23 | A | 0.107 | 0.134 | P | 0.141 | 0.411 | 0.27 |
| | B | 0.215 | 0.188 | | | | |
| | C | 0.148 | 0.143 | | | | |
| | D | 0.141 | 0.411 | | | | |
| | E | 0.074 | 0.071 | | | | |
| | Omit | 0.315 | 0.054 | | | | |
| Item 24 | A | 0.174 | 0.366 | P | 0.174 | 0.366 | 0.192 |
| | B | 0.168 | 0.286 | | | | |
| | C | 0.168 | 0.089 | | | | |
| | D | 0.148 | 0.152 | | | | |
| | E | 0.06 | 0.063 | | | | |
| | Omit | 0.282 | 0.045 | | | | |
| Item 25 | D | 0.685 | 0.732 | P | 0.685 | 0.732 | 0.047 |
| | Y | 0.161 | 0.125 | | | | |
| | Omit | 0.154 | 0.143 | | | | |
| Item 26 | D | 0.282 | 0.286 | P | 0.604 | 0.563 | -0.041 |
| | Y | 0.604 | 0.563 | | | | |
| | Omit | 0.114 | 0.152 | | | | |
| Item 27 | D | 0.463 | 0.259 | P | 0.409 | 0.58 | 0.171 |
| | Y | 0.409 | 0.58 | | | | |
| | Omit | 0.128 | 0.161 | | | | |
| Item 28 | A | 0.047 | 0.054 | P | 0.758 | 0.786 | 0.028 |
| | B | 0.758 | 0.786 | | | | |
| | C | 0.007 | 0.018 | | | | |
| | D | 0.027 | 0 | | | | |
| | E | 0 | 0.009 | | | | |
| | Omit | 0.161 | 0.134 | | | | |
| Item 29 | A | 0.02 | 0.027 | P | 0.785 | 0.768 | -0.017 |
| | B | 0.013 | 0.045 | | | | |
| | C | 0 | 0.009 | | | | |
| | D | 0.007 | 0.018 | | | | |
| | E | 0.785 | 0.768 | | | | |
| | Omit | 0.174 | 0.134 | | | | |
| Item 30 | A | 0 | 0 | P | 0.772 | 0.83 | 0.058 |
| | B | 0 | 0.009 | | | | |
| | C | 0.772 | 0.83 | | | | |
| | D | 0.034 | 0.009 | | | | |
| | E | 0.007 | 0.009 | | | | |
| | Omit | 0.188 | 0.143 | | | | |

# APPENDIX G

## PHYSICS ATTITUDE SCALE

### ELEKTRİK DEVRELERİ TUTUM ÖLÇEĞİ

Adı-soyadı:

Sınıfı-no :

Sevgili Öğrenciler

Bu ölçek Madde ve Elektrik Ünitesindeki Elektrik Devreleri konusu ilişkin tutum cümleleri ile her cümlenin karşısında KESİNLİKLE KATILIYORUM, KATILIYORUM, KARARSIZIM, KATILMIYORUM ve KESİNLİKLE KATILMIYORUM olmak üzere beş seçenek verilmiştir. Her cümleyi dikkatle okuduktan sonra kendinize uygun olan seçeneği işaretleyiniz.

Ölçeğin sonuçları sizlerin bu konulara olan tutumunuzun ne ölçüde olduğunu göstereceğinden, tutumun olumlu yönde geliştirilebilmesi yönünde katkıda bulunabileceğinden önem taşımaktadır. Katılımınız için teşekkür ederim.

**GENEL AÇIKLAMA:** Bir görüş veya yargı bildiren aşağıdaki cümleleri dikkatlice okuyunuz. Bu görüşe ne ölçüde katılıp katılmadığınızı sağ taraftaki sütunda yanıt olarak verilen beş seçenekten birini X işareti yazarak belirtiniz. Seçenekler "kesinlikle katılıyorum", "katılıyorum", "kararsızım", "katılmıyorum", "kesinlikle katılmıyorum" dur.

| **ELEKTRİK DEVRELERİ**<br>A) Bir elektrik devresinde devre elemanları<br>B) Potansiyel farkının ölçülmesi<br>C) Direnç ve ölçülmesi<br>a. Akım, potansiyel farkı ve direnç arasındaki bağıntı (OHM Yasası)<br>b. İletkenlerin direncinin bağlı olduğu faktörler ve özdirenç<br>D) Elektrik devrelerinde akım<br>a. Seri devrelerde akım<br>b. Paralel devrede akım<br>c. Ana kol ve paralel kollarda akım | **Kesinlikle katılıyorum** | **Katılıyorum** | **Kararsızım** | **Katılmıyorum** | **Kesinlikle katılmıyorum** |
|---|---|---|---|---|---|
| 1. "Elektrik devreleri" konularını severim. | | | | | |
| 2. "Elektrik devreleri" konularına karşı olumlu hislerim vardır. | | | | | |
| 3. "Elektrik devreleri" konularından öğrendiklerimin hayatımı kolaylaştıracağına inanıyorum. | | | | | |
| 4. "Elektrik devreleri" konularının gelecekte öneminin artacağına inanmıyorum. | | | | | |
| 5. "Elektrik devreleri" konularının, ileride ki çalışmalarımda bana yararlı olacağına inanıyorum. | | | | | |
| 6. "Elektrik devreleri" konularında başarılı olmak için elimden geleni yaparım. | | | | | |
| 7. "Elektrik devreleri" konularında elimden gelenin en iyisini yapmaya çalışırım. | | | | | |
| 8. " Elektrik devreleri" konularında başarısız olduğumda daha çok çabalamam. | | | | | |
| 9. "Elektrik devreleri" konularını öğrenebileceğimden eminim. | | | | | |
| 10. "Elektrik devreleri" konularında başarılı olabileceğimden eminim. | | | | | |
| 11. "Elektrik devreleri" konularının kullanıldığı zor problemleri yapabileceğimden eminim. | | | | | |
| 12. "Elektrik devreleri" konularının geçerli olduğu problemler ne kadar zor olursa olsun, elimden geleni yaparım. | | | | | |
| 13. "Elektrik devreleri" konular ının ilerideki meslek hayatımda önemli bir yeri olacağını düşünmüyorum. | | | | | |
| 14. "Elektrik devreleri" konularından öğrendiklerimin, gündelik hayatta işime yarayacağını düşünüyorum. | | | | | |
| 15. "Elektrik devreleri" konuları veya teknolojideki uygulamaları ile ilgili kitaplar okumaktan hoşlanırım. | | | | | |
| 16. "Elektrik devreleri" konuları benim için eğlencelidir. | | | | | |
| 17. Okulda "Elektrik devreleri" konularını çalışmaktan hoşlanmam. | | | | | |
| 18. Daha zor "Elektrik devreleri" ile ilgili problemler ile başa çıkabileceğimden eminim. | | | | | |
| 19. Okuldan sonra arkadaşlarla "Elektrik devreleri" konuları hakkında konuşmak zevklidir. | | | | | |
| 20. Bana hediye olarak "Elektrik devreleri" ile ilgili bir kitap veya konu ile ilgili aletler, araçlar verilmesinden hoşlanırım. | | | | | |
| 21. Yeterince vaktim olursa en zor "Elektrik devreleri" ile ilgili problemleri bile çözebileceğimden eminim. | | | | | |
| 22. Arkadaşlarla "Elektrik devreleri" konuları veya teknolojideki uygulamaları ile ilgili meseleleri konuşmaktan hoşlanırım. | | | | | |
| 23. "Elektrik devreleri" konuları el becerilerimin gelişmesinde etkilidir. | | | | | |
| 24. "Elektrik devreleri" konuları ile ilgili ders saatlerinin daha çok olmasını istemem. | | | | | |

APPENDIX H

# GROUP EMBEDDED FIGURES TEST-SAMPLE BOOKLET

GROUP
EMBEDDED
FIGURES TEST

By Philip K. Oltman, Evelyn Raskin,
& Herman A. Witkin

Name___________________________

Sex ___________

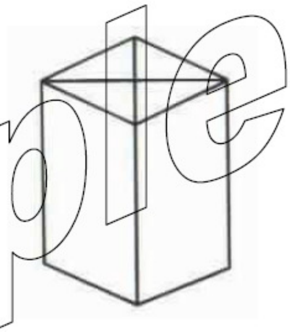
Today's date ___________________

Birth date ___________________

INSTRUCTIONS: This is a test of your ability to find a simple form when it is hidden within a complex pattern.

Here is a simple form which we have labeled "X":


This simple form, named "X", is hidden within the more complex figure below:



Try to find the simple form in the complex figure and trace it *in pencil* directly over the lines of the complex figure. It is the SAME SIZE, in the SAME PROPORTIONS, and FACES IN THE SAME DIRECTION within the complex figure as when it appeared alone.

When you finish, turn the page to check your solution.

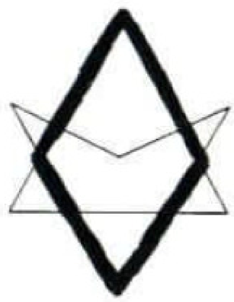
This is the correct solution, with the simple form traced over the lines of the complex figure:

Note that the top right-hand triangle is the correct one; the top left-hand triangle is similar, but faces in the opposite direction and is therefore *not* correct.

Now try another practice problem. Find and trace the simple form named "Y" in the complex figure below it:

Look at the next page to check your solution.

Solution:



In the following pages, problems like the ones above will appear. On each page you will see a complex figure and under it will be a letter corresponding to the simple form which is hidden in it. For each problem, look at the BACK COVER of this booklet to see which simple form to find. Then try to trace it in pencil over the lines of the complex figure. Note these points:

1. Look back at the simple forms as often as necessary.

2. ERASE ALL MISTAKES.

3. Do the problems in order. Don't skip a problem unless you are absolutely "stuck" on it.

4. Trace ONLY ONE SIMPLE FORM IN EACH PROBLEM. You may see more than one, but just trace *one* of them.

5. The simple form is always present in the complex figure in the SAME SIZE, the SAME PROPORTIONS, and FACING IN THE SAME DIRECTION as it appears on the back cover of this booklet.

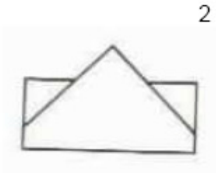
*Do not turn the page until the signal is given*

FIRST SECTION

1

Find Simple Form "B"

2

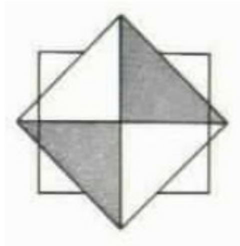


Find Simple Form "G"

*Go on to the next page*

SECOND SECTION

1



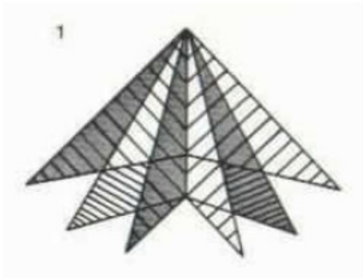
Find Simple Form "G"

2

Find Simple Form "A"

*Go on to the next page*

THIRD SECTION



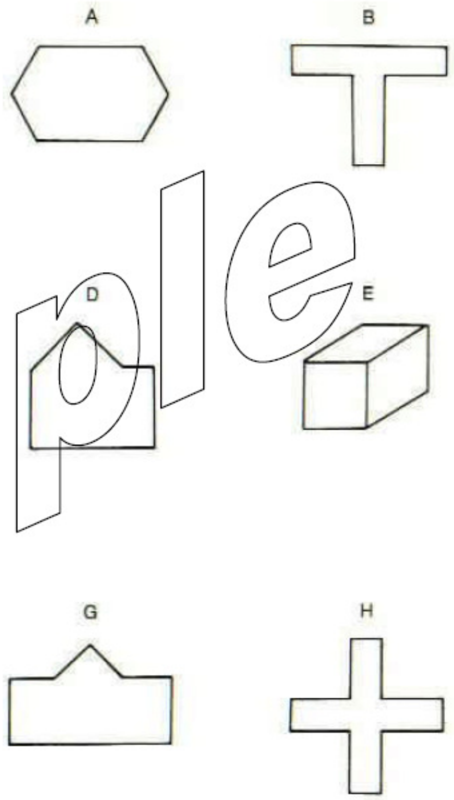
Find Simple Form “F”

2

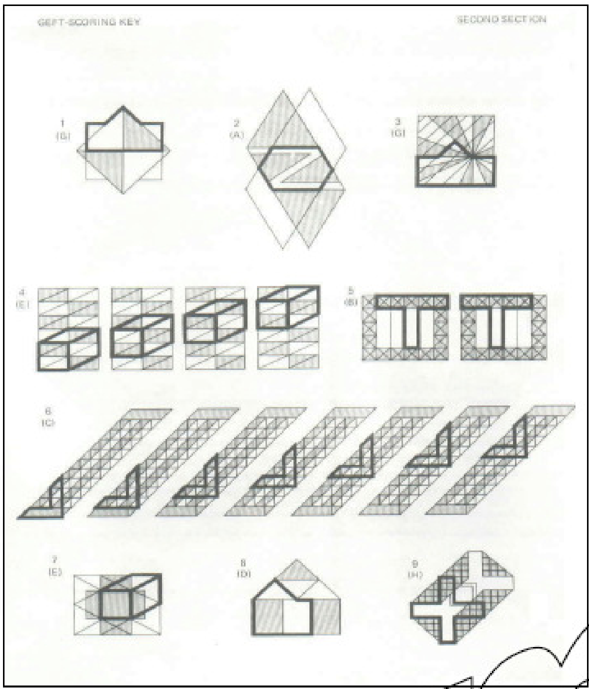
Find Simple Form “G”

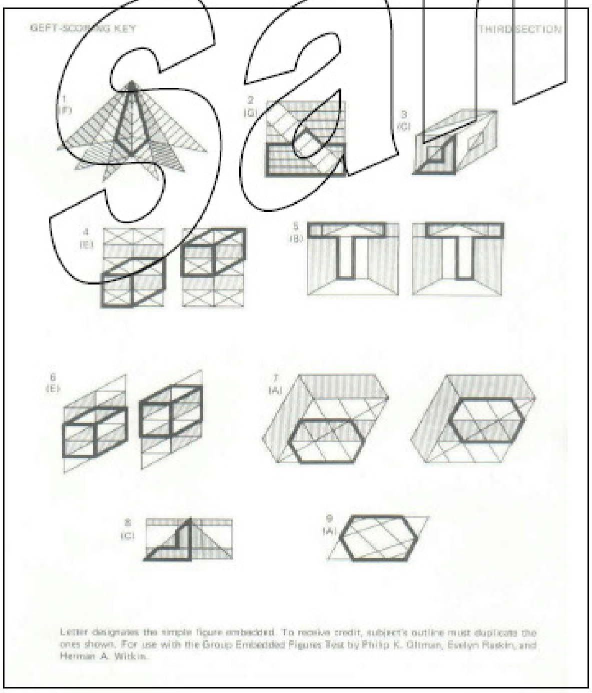
*Go on to the next page*

SIMPLE FORMS



GEFT Scoring Keys



# APPENDIX I

## CLASSROOM OBSERVATION CHECKLIST

Table A.3 Classroom Observation Checklist

| **Sınıf Gözlem Formu** | **Evet** | **Kısmen** | **Hayır** | **Uygulanamaz** |
|---|---|---|---|---|
| 1. Sınıfta grup çalışması için kümeler oluşturulmuş mu? | | | | |
| 2. Ders öğretmenin konuyla ilgili ana ilkeleri anlatmasıyla başladı mı? | | | | |
| 3. Ders öğrencilerin kendilerine verilen etkinlikleri yapmalarıyla başladı mı? | | | | |
| 4. Öğrenciler konuyu öğrenmek için ihtiyaç hissetmeye başladılar mı? | | | | |
| 5. Temel kavramlar ve bunların birbirleriyle ilişkileri öğrenciler bunlara gerek duyduğunda verildi mi? | | | | |
| 6. Öğrenme sorumluluğu çoğunlukla öğrencilerin üzerinde mi? | | | | |
| 7. Öğretmen öğrencilere düşündürücü sorular sordu mu? | | | | |
| 8. Öğretmen öğrenciye sürekli bilgi veren bir rol üstlendi mi? | | | | |
| 9. Öğretmen öğrencilere öğrenme sürecinde rehberlik yaptı mı? | | | | |
| 10. Öğrenciler derse katıldılar mı? | | | | |
| 11. Öğrenciler grup içi çalışma yaptılar mı? | | | | |
| 12. Öğretmen grupça çalışmaları için öğrencileri yüreklendirdi mi? | | | | |

| Sınıf Gözlem Formu | Evet | Kısmen | Hayır | Uygulanamaz |
|---|---|---|---|---|
| 13. Öğrenciler yapılan etkinlikteki adımlarla ilgili sorulara cevap verdiler mi? | | | | |
| 14. Ders öğrencilere dağıtılan etkinlik kağıtları üzerinden işlendi mi? | | | | |
| 15. Öğrenciler etkinlik kağıtlarında belirtilen adımlara uydular mı? | | | | |
| 16. Etkinliklerden sonra ilgili kavramlar, formüller verildi mi? | | | | |
| 17. Sayısal problem çözümü yapıldı mı? | | | | |
| 18. Dersin sonunda öğrenilen konu, yapılan etkinlik hakkında sınıfça tartışıldı mı? | | | | |
| 19. Sınıfın fiziksel koşulları (sıcaklık, aydınlatma, oturma düzeni, vb.) dersin planlandığı gibi işlenmesine elverişli mi? | | | | |
| 20. Öğrenciler dersin işlenişinden hoşlandılar mı? | | | | |

Sınıf:

Tarih:

Ders Süresi:

Değerlendiren Kişinin Adı Soyadı:

# APPENDIX J

## LESSON PLANS as ACTIVITY SHEETS

In this section, lesson plans used in the treatment groups of this study for three weeks are presented. Because the format of the pages is going to be distorted, lesson plans are presented in the following pages.

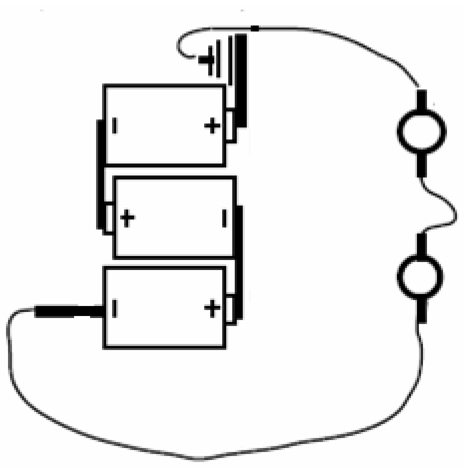
# BÖLÜM 1: TELLERDE NELER OLUYOR?

## GİRİŞ

Elektrik genellikle görünmezdir. Yıldırımların veya kıvılcımların dışında, günlük hayatta asla göremeyiz. Fakat, elektriksel bir şeyler olduğu zaman, elektrik lambaları ve manyetik pusula bize bunu gösterebilir. Bunların davranışlarını gözlemleyerek ve birkaç varsayımda bulunarak elektriğe dair fikirler edinmeye başlayabiliriz. Bu tarz düşünme tarzına "model kurma" denir.

## İNCELEME 1: BİR LAMBAYI YAKMAK İÇİN NE GEREKİR?

### ETKİNLİK 1: BİR İLMEKTEKİ LAMBAYI YAKMAK




**Şekil 1: Temel Kapalı İlmek**

Şekildeki düzeneği kuralım. Lambalar yanmalı ve aynı parlaklıkta olmalılar. Piller, kablolar, ve lambalar şimdi bir "kapalı ilmek" oluşturdu.

1. Pillerin bir ucundaki kablonun bağlantısını keserek ilmeği kıralım, sonra kabloyu tekrar bağlayalım. Her iki lambanın da aynı anda yandığını mı gördünüz? Bütün lambaların aynı anda yanacağına inanıyor musunuz? Bütün lambalar aynı anda sönecek gibi görünüyor mu? (Bu soruya daha sonra tekrar döneceğiz, şimdilik gözlemlerinizi en doğru şekilde rapor ediniz.)

2. Kabloyu tekrar bağladıktan sonra, kabloların bağlantısını başka bir yerden keselim. Bunu çeşitli yerlerde deneyelim. Her seferinde ilmeği sadece bir noktadan kırdığınıza emin olun. Bağlantıyı koparmanıza rağmen, lambalardan birinin ya da ikisinin birden yanık kaldığı bir nokta var mı?

3. Bir kablonun bağlantısını keselim. Sonra bu kabloyu kestiğimiz noktaya mümkün olduğu kadar değdirmeden yaklaştıralım. Bu işlemi kabloyla bağlantı noktası arasındaki uzaklığı gözeterek yavaşça ve dikkatlice gerçekleştirelim.

Lambalar yandı mı?

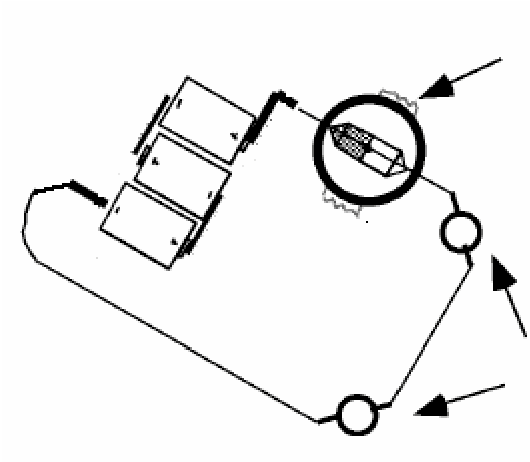
Lambaların sürekli olarak yanması için mutlak bir kontakt gerektiğini düşünüyor musunuz?

**İNCELEME 2: KABLOLARIN İÇİNDE BİR ŞEY OLUYOR MU?**

**ETKİNLİK 2: KAPALI BİR İLMEĞİ İNCELEMEK İÇİN PUSULA KULLANMAK**

Lamba yanıkken kablolardaki elektriksel etkinliği tespit etmek bir pusula için kullanılabilir. Aşağıdaki yönergeleri dikkatlice okuyalım ve takip edelim.

1. Pusulayı masanın üzerine herhangi bir metal kısımdan olabildiğince uzakta olacak şekilde yerleştirelim. Pusulayı masaya bantlayalım. Bantı pusulanın altında kalacak şekilde yerleştirelim. Pusulanın hiçbir kabloya bağlı olmadığını görelim. Pusula sadece kablonun içinde neler olduğunu tespit etmek için kullanacağımız bir detektördür.



Şekil 2: Mıknatısın bantlanması

2. İlmeği olabildiğince genişletelim, pilleri pusuladan yapabildiğimiz kadar uzağa koyalım (Pillerin çelik kasaları manyetikleşebilir ve bu da pusulayı etkileyebilir).

3. İlmeği bir yerden kıralım. Bir ucu pillere bağlı kabloyu pusulanın üzerinden geçecek şekilde yerleştirelim. Kabloyu pusulanın iğnesine paralel olacak şekilde tam iğnenin üzerine yerleştirmeye dikkat edelim.

Şekil 2'de gösterildiği gibi ilmeği kurduğumuzda, bir kablonun bağlantısını birkaç defa kesip tekrar bağlayalım, bu sırada pusulanın iğnesini gözlemlemeyi unutmayalım. Bir kişi pusulanın üzerindeki kabloyu sıkıca tutarken diğerinin bağlantıyı kesip tekrar kurması iyi bir fikir olabilir.

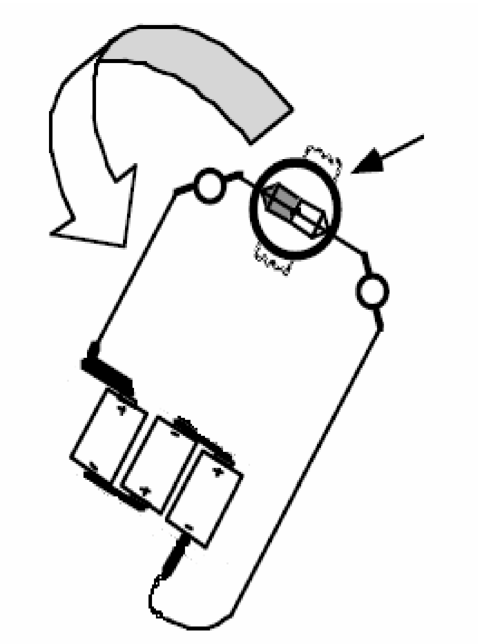
1. İlmeği kapatmak için kabloyu bağladığımızda pusulanın iğnesi saat yönünde mi yoksa saat yönünün aksi yönünde mi döndü? İlmeği kırmak için kablonun bağlantısını kestiğimizde pusulanın iğnesine ne oldu?

Kapalı ilmek: Saat yönünde Saatin aksi yönünde (yuvarlak içine alalım.)

Açık ilmek: Saat yönünde Saatin aksi yönünde (yuvarlak içine alalım.)

2. İlmek kırık olduğu sürece, pusulanın üzerindeki kabloda bir şeyler olduğuna dair bir kanıt var mı? Olumlu ya da olumsuz bir delil varsa, nedir?

Pusulayı yerinden oynatmayalım. İlmeği kırıp tüm ilmeği –pilleri, kabloları ve lambaları- bu sefer lambaların arasındaki kablo pusulanın üzerine gelecek ve pusula iğnesine paralel olacak şekilde döndürelim (Şekil 3). İlmeği pusula pillerden olabildiğince uzak olacak şekilde genişletelim.



Şekil 3: İlmeği döndürelim

Kabloyu bağlamadan önce, ilmeği kapattığımızda pusula iğnesinin ne tarafa döneceğini tahmin edelim.

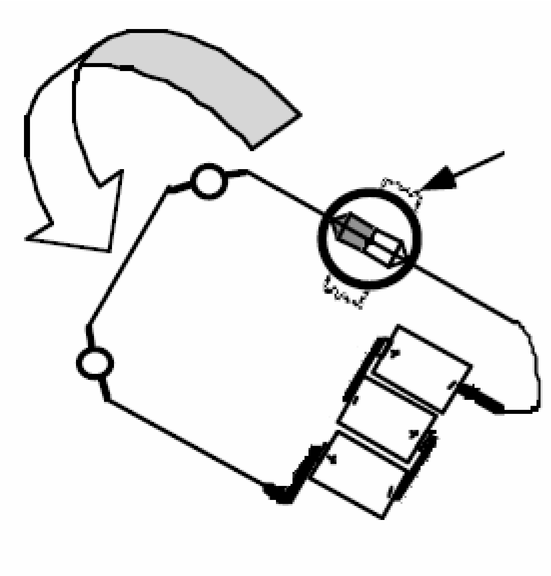
**Tahminimiz:**

İlmeği kırıp tekrar bağlayalım, pusula iğnesini gözlemleyelim.

3. Pusula ilk telin altında döndüğü yöne doğru mu saptı? Aynı miktarda mı saptı?

İlmeği bu kez üçüncü kablo pusulanın üzerine gelecek şekilde döndürelim (Şekil 4). Kabloyu bağlamadan önce, ilmeği kapattığımızda pusula iğnesinin ne tarafa döneceğini tahmin edelim.

**Tahminimiz**:



**Şekil 4: Pusulanın üzerine 3. kablo gelecek şekilde döndürelim.**

4. Pusulanın iğnesi nasıl saptı? İğnenin dönme yönünü önceki durumlarla karşılaştıralım.

5. Sizce ilmek boyunca tüm kablolarda aynı şey mi oluyor? Neden?

Pillerin ucundaki kabloları çıkararak, pilleri ters çevirip kabloları tekrar bağlayalım. Böylece kabloları ilk baştaki uçlara değil, ters uçlara bağlamış olacağız. Bu işlemi yapmadan önce neler olacağını tahmin edelim.

**Tahminimiz**:

6. Pillerin yönünü değiştirdikten sonra ilmeği kapattığımızda pusulanın ne tarafa doğru saptığını gözlemlediniz? İlmeği kırdığımızda neler gözlemlediniz?

Kapalı ilmek:...Saat yönünde   Saatin aksi yönünde   (Yuvarlak içine alalım.)

Açık ilmek:......Saat yönünde   Saatin aksi yönünde   (Yuvarlak içine alalım.)

Bu sonuçları 1. Soruda gözlemlediklerimizle karşılaştıralım.

7. Pillerin yönünü değişince diğer iki kablo için de pusuladaki sapmaları inceleyelim. Neler gözlemlediniz?

**AÇIKLAMA: DEVRE NEDİR?**

Sürekli iletken bir yol meydana getiren elektriksel elemanların oluşturduğu, herhangi bir kapalı ilmeğe **DEVRE** denir. DEVRE terimi devir yapmak, dönüp durmak kelimelerinden yola çıkılarak türetilmiştir.

**ALIŞTIRMA: MODEL İNŞA TARTIŞMASI**

1. Pillerin yönünü değiştirdiğimizde, pusula iğnesinin ters yöne sapmasına ne yol açmış olabilir? Açıklayınız…

2. Bazı kişiler kabloların içinde hareket eden bir şeylerin olduğunu öne sürüyorlar. Bunun direkt bir kanıtı var mıdır? Açıklayınız…

3. Eğer kabloların içinde bir şey hareket ediyorsa, her üç kablodaki hareketin yönü ve miktarı aynı mı görünüyordu? Delillendiriniz…

4. Sizce bir pil devrede ne işe yarıyor? Neden?

5. Bir kablodaki hareketin yönünün tespiti için pusula kullanılabilir mi? Dikkatlice açıklayınız…

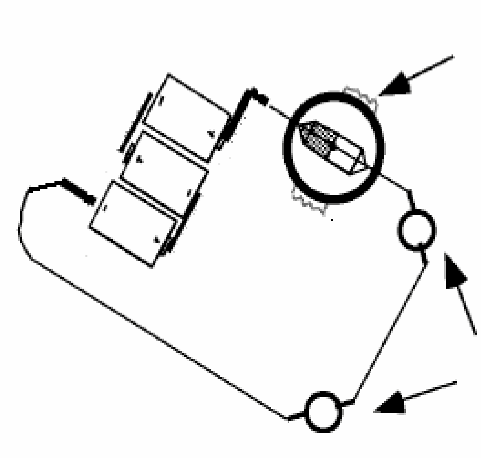
**AÇIKLAMA: HAREKET EDEN NEDİR?**

Kabloların içinde hareket eden şeyin ne olduğunu kimse göremez, fakat hareket eden maddeyle alakalı bir şey pusula iğnesinin sapmasına yol açar. Sözü geçen maddenin iğneyi saptırtan özelliğine YÜK denir. Biraz önce yaptığımız deneyler, bize kabloların içinde yüklerin taşındığına dair kanıt sunmaktadır fakat henüz bu yüklerin yapısına dair bir kanıtımız yok.

**AÇIKLAMA: HANGİ YÖNDE HAREKET EDİYOR?**

Pillerin yönünü değiştirdiğimizde aynı zamanda pusula iğnesinin yönünün değişmesi, devredeki yük akışının yönünün de değiştiğini göstermektedir. Fakat yük akışının, pillerin yönü değişmeden önce hangi yönde olduğuna dair bir bilgi vermemektedir. Bilim insanları yüzyıllar boyunca yüklerin hangi yönde hareket ettiklerini araştırmışlar, fakat 1800'lü yılların sonuna kadar yüklerin hareket yönünü bulmayı başaramamışlardır. Herhangi bir kanıtları olmamasına rağmen, hareket için bir yön varsaymaya karar vermişlerdir. Böyle bir varsayım akdidir –yani, gerçekten doğru ya da yanlış olmasına gerek yoktur, iletişimi kolaylaştırdığı için kullanışlı olan bir anlaşmadır. Uluslar arası uzlaşmaya göre, devrede devri daim yapan yükler pillerin pozitif (+) ucundan çıkıp, devreyi dolaştıktan sonra pillerin negatif (-) ucundan tekrar girerek pillerden geçerler. Daha sonraki bölümlerde, bu kabul edilmiş akdi yönün uygun olup olmadığına dair kanıt toplayacağız.

## ALIŞTIRMA: BİR DEVREDEKİ AKDİ AKIM YÖNÜ HANGİSİDİR?

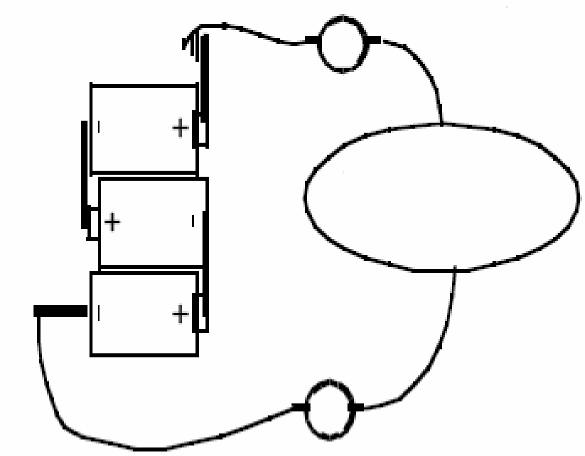


1. Şekilde daha önce kurduğumuz bir devre gösteriliyor. Her üç kablonun yanına o kablolardaki yük hareketinin akdi yönünü gösteren oklar çizelim.

2. Pillerin yönü değiştirilirse, kablolardaki yüklerin hareket yönü nasıl olur? Çizerek gösterelim.

**Şekil 5: Devredeki yük akışının akdi yönünü çizelim.**

## İNCELEME 3: İLETKEN VE YALITKANLARI TEST ETME



**Şekil 6: İletkenleri test etme devresi**

Daha önce kullandığımız devreyi kullanalım fakat bu sefer devreye bir kablo daha ekleyelim.

Bu devre "Test Devresi" olarak anılacaktır. Yuvarlağın içinde test etmek istediğimiz herhangi bir şey olabilir. Örneğin, anahtar, tarak, kauçuk, vs.

Test sonuçlarımızı aşağıdaki tabloya not edelim.

Test yuvarlağının yerine yerleştirdiğimizde lambaların yanmasına izin veren herhangi bir materyal “İLETKEN”dir.

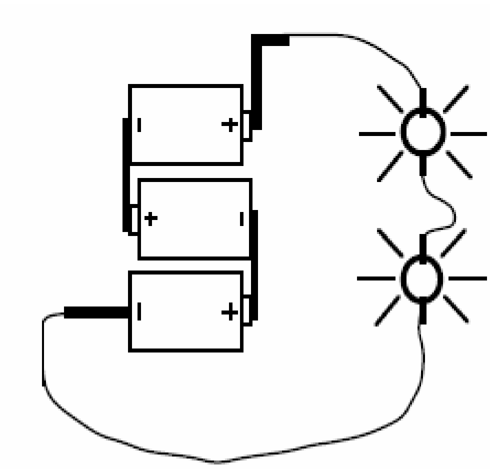
Test yuvarlağının yerine yerleştirdiğimizde lambaların yanmasını engelleyen herhangi bir materyal “YALITKAN”dır.

| Test Nesnesi | Tahmin (İletken ya da yalıtkan) | Gözlem (Lamba yandı ya da yanmadı) | Sınıflandırma (İletken ya da yalıtkan) |
|---|---|---|---|
| Anahtar | | | |
| Yağlı kağıt | | | |
| Alüminyum folyo | | | |
| Ayakkabı bağcığı | | | |
| Kurşun kalemin tahta kısmı | | | |
| Kurşun kalemin kurşun kısmı | | | |
| Diğer nesneler | | | |

1. İletkenlerin çoğu ya da tümünün ortak bir özelliği var mı? Varsa bu nedir? Genel bir ifade yazalım.

2. Yalıtkanların çoğu ya da tümünün ortak bir özelliği var mı? Varsa bu nedir? Genel bir ifade yazalım.

## ÖZET ALIŞTIRMASI




**1., 2. ve 3. soruları cevaplarken soldaki şekilden yararlanınız.**

1. Bu devrede hiç kesik ya da yalıtkan var mı? Varsa, şekilde işaretleyin.

2. Bu devre sürekli iletken bir yol mu? Cevabınızı destekleyici kanıtlar sunun.

3. Yandaki şekilde, yüklerin hareket ettiğini düşündüğünüz yolu renkli bir çizgi çizerek belirtiniz. Yüklerin hareket yönünü belirtmek için akdi hareket yönünü temel alarak oklar çiziniz.

4. Lambalar yandığında kablolarda bir şeyler olduğuna dair bir kanıt olabilecek ne sunabilirsiniz?

5. Lambalar yanıkken kablolarda ne olduğuna dair şu anki geçerli hipoteziniz nedir?

6.Pillerin bağlanma yönleri ters çevrildiğinde kablolarda neler olur? Kanıtınız nedir?

7. Lambalar yanıkken pil ne işe yarıyor?

8. Lambalar yanıkken kablolarda bir şeylerin hareket ettiği varsayımına dayanarak, bu hareketin yöne bütün kablolarda aynı mıdır, yoksa farklı kısımlarda değişir mi? Cevabınızı destekleyecek kanıtınız nedir?

9. Bu noktaya kadar gözlemlediklerinize dayanarak, "elektrik" terimini nasıl tanımlarsınız?

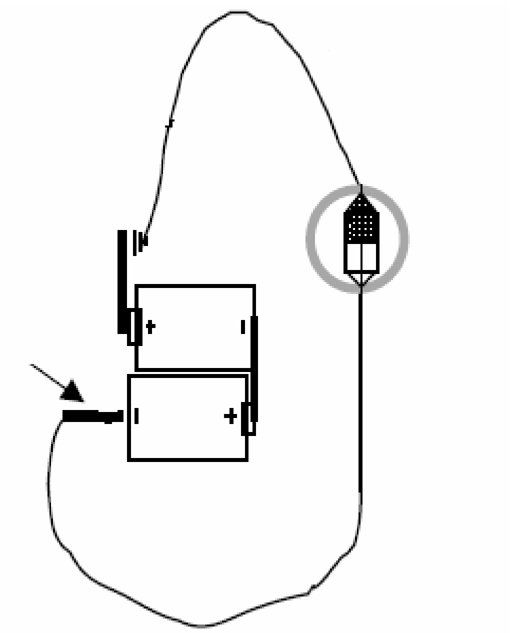
# BÖLÜM 2: LAMBALAR HAREKET EDEN YÜKLERE NE YAPARLAR?

## GİRİŞ

Lambaların içindeki flamanların (lambaların içindeki tungsten elementinden yapılmış sarım halindeki tel) pillere bağlandıkları zaman ışık ve ısı yaydıklarını biliyoruz. Şimdi ise lambaların flamanlarının devrede dolaşan yüklerin akış oranlarını nasıl etkilediğini inceleyeceğiz. İncelemeye ışık yaymayan "direnç"lerin akış oranını nasıl etkilediğini araştırmakla başlayalım.

## İNCELEME 1: DİRENÇLER YÜK AKIŞINI NASIL ETKİLER?

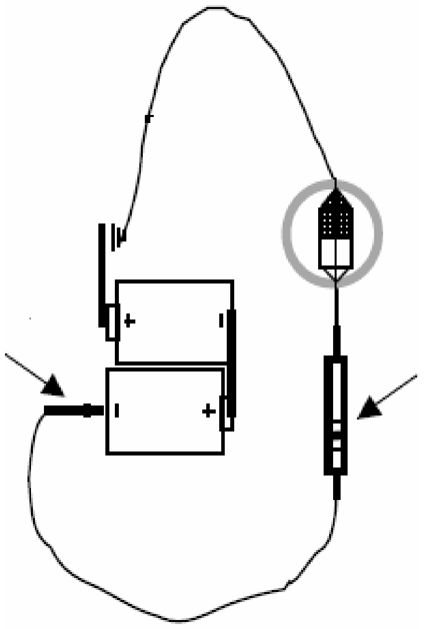
### ETKİNLİK 2.1: DİRENÇLER YÜK AKIŞINI NASIL ETKİLERLER?



**Şekil 2.1 a Kablo ve pillerden oluşan devre**

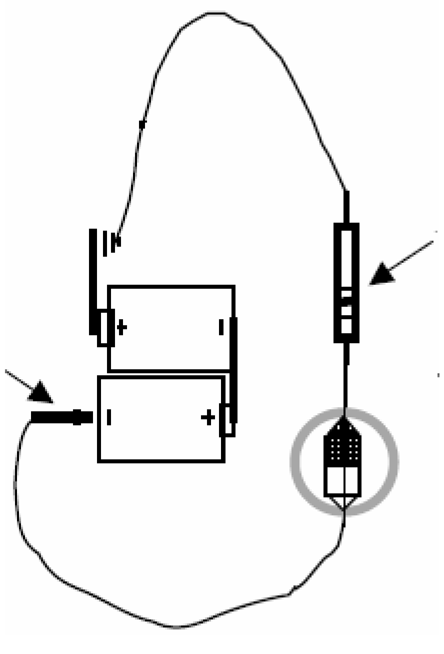
Şekildeki devreyi kuralım fakat pillerin bir ucundaki kabloyu henüz bağlamayalım. Elektrik kablosunu pusula iğnesinin üzerine iğneye paralel olacak şekilde yerleştirelim.

Sonra kabloyu pilin ucuna bağlayarak ilmeği birkaç kez kapatıp açalım. Bu işlemi çok çabuk yapmalıyız. Pusula iğnesinin ne kadar saptığını not edelim.



Şekil 2.1 b Devreye direnç bağlanması

1. Öğretmenimizden bir direnç alıp bunu ilmeğe ekleyerek şekildeki devreyi kuralım. İlmeği kapattığınızda pusula neler gözlemlediniz?



Şekil 2.1 c Pusula direncin diğer tarafında

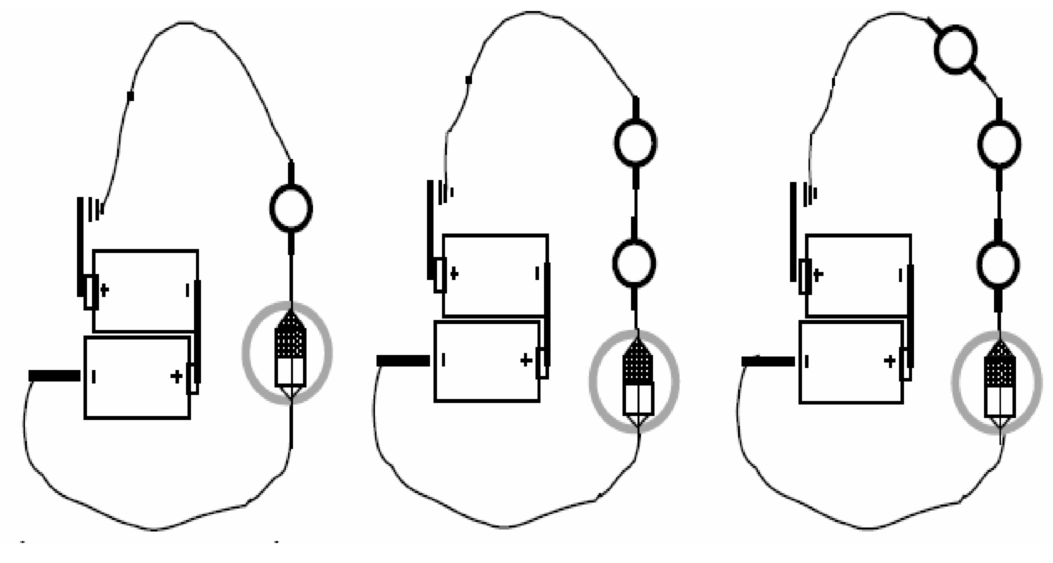
2. Şekil 2.1 b'de direncin yukarısında bulunan kablodaki yük akışının pusulayı saptırma miktarıyla, şekil 2.1 c'de direncin altında bulunan kablodaki yük akışının pusulayı saptırma miktarını karşılaştıralım.

3. Dirençten geçerken hiç yük harcandı mı? Pusula iğnesinin sapma miktarından yola çıkarak cevabımızı delillendirelim.

4. Acaba direnç devrede hareket eden yüke ne yapıyor? Fikrimizi aşağıdaki kutuya yazalım.

5. Devreye ikinci bir direnç ekleyelim. Her dört kablonun altında, pusula iğnesinin sapma miktarını gözlemleyelim. Devrede tek bir direnç varken gözlemlediğimiz sapma miktarları ile bu sapma miktarlarını karşılaştıralım.

## ETKİNLİK 2.2 DİRENÇLERİ LAMBALARLA DEĞİŞTİRMEK



Şekil 2.2a Bir lamba | Şekil 2.2b İki lamba | Şekil 2.2c Üç lamba

Etkinlik 2.1'deki bütün adımları dirençlerin yerine lamba kullanarak tekrar yapalım. İlk önce hiç lamba kullanmayalım, sonra bir lamba ekleyelim. Daha sonra aynı adımları iki lamba ile, en sonunda ise üç lamba ile tekrar edelim.

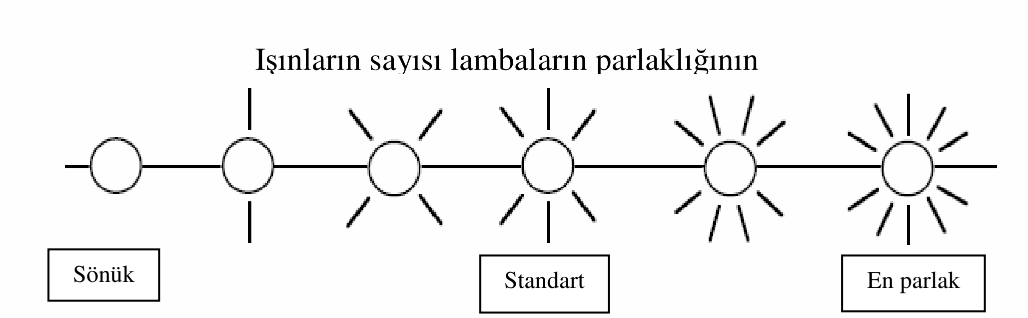
Şekil 2.2a da, devrede sadece **bir** lamba varken lambanın parlaklığına ve pusuladaki sapma miktarına dikkat edelim.

1. Şekil 2.2b deki gibi devreye **ikinci** bir lamba daha bağlandığında ne gibi değişiklikler gözlemledik?

2. Şekil 2.2c deki gibi devreye **üçüncü** bir lamba daha bağlandığında ne gibi değişiklikler gözlemledik?

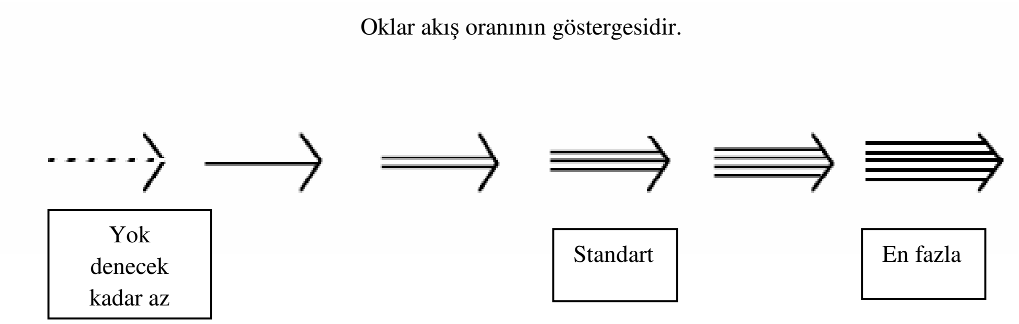
3. Acaba bir lambadaki flaman devredeki yüklerin hareketini nasıl etkiler? Fikrimizi aşağıdaki kutuya yazalım.

# ETKİNLİK 2.3 DEVRE ŞEMALARI İÇİN EK SEMBOLLER




1. Etkinlik 2.1 deki devre şemalarında, direnç eklenmesinin lambaların parlaklığını nasıl etkilediğini göstermek için ışınlar çizelim.

2. Etkinlik 2.2 deki devre şemalarında, ikinci ve daha sonra üçüncü lambanın eklenmesinin ilk lambanın parlaklığını nasıl etkilediğini göstermek için ışınlar çizelim.




Okların yönü yüklerin akım yönünü gösterir.

Okların sayısı akımın yoğunluğunu gösterir.

3. Şekil 2.2a, 2.2b, ve 2.2c'de her lambanın yanına o lambadan geçen yük miktarının yönünü ve yoğunluğunu gösteren bir ok çizelim.

## AÇIKLAMA 2.4: DİRENÇ VE AKIM YOĞUNLUĞU

Daha önce nesneleri ve maddeleri iletken ve yalıtkan olarak sınıflandırmıştık. Test ettiğimiz birçok nesne ya

üzerinden yüklerin geçmesine izin verdi-**iletkenler**

ya da

üzerinden hiç akım geçirtmedi-**yalıtkanlar**

Fakat birçok madde bu iki uç tavrın arasında bir tavır takınır. Bu maddeler biraz akım geçmesine izin verirler fakat bu akımın yoğunluğu iletkenlerden geçen akımın yoğunluğundan çok daha azdır. Bunun gibi yüklerin bir kısmının geçmesine izin veren maddelerden yapılan devre elemanlarına DİRENÇ denir.

Dirençlerin yüklerin geçişine engel olma miktarlarını gösteren özelliklerine REZİSTANS denir. Yüklerin kendi üzerinden geçmesine kolaylıkla izin veren dirençler düşük rezistanslı dirençlerken, yükler için aşması daha zor bir engel oluşturanlar yüksek rezistanslı dirençlerdir.

Elektriksel direncin birimi adını Alman fizikçi ve öğretmen Georg Ohm'dan alan OHM'dur, sembolü ise **Ω** (omega) dır. Bu cisimlerin rezistanslarını yapıldıkları maddenin dışında fiziksel tasarımları (büyüklüğü ve şekli) da etkiler. Örneğin bakır iyi bir iletkendir, cam veya grafitle karşılaştırıldığında daha düşük bir dirence sahiptir. Yapıldığı maddenin dışında, direncin şekli ve büyüklüğü de rezistansını etkiler. Daha sonraki bölümlerde inceleyeceğimiz lambaların Flamanları bunlara iyi bir örnek teşkil eder.

Devrede hareket eden yüklerin akım yoğunluğunu ifade etmek için ders kitaplarının çoğunluğu AKIM terimini kullanır.

Akım yoğunluğunun birimi adını Fransız fizikçi Andr□ Ampere'den alan AMPER'dir.

**Akım yoğunluğu sürat ile aynı şey değildir.** Akım yoğunluğu devrenin bir parçasından birim zamanda geçen net yük miktarıdır. Sürat ise küçük bir yük miktarınca birim zamanda kat edilen mesafedir.

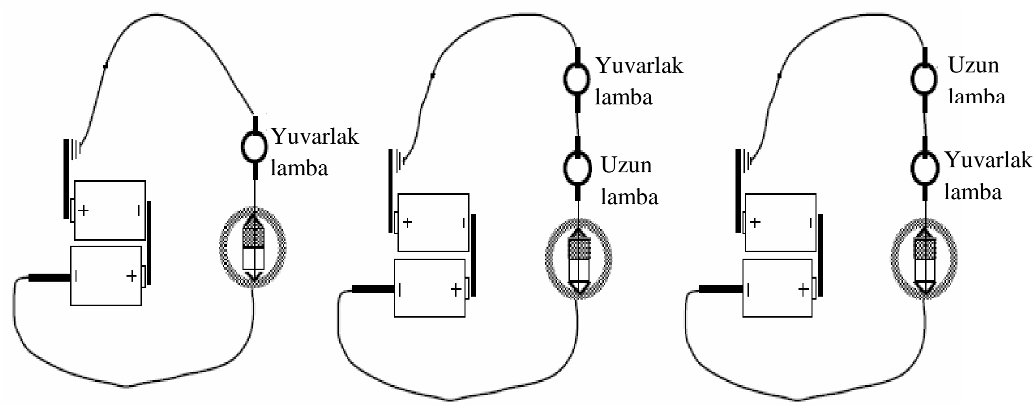
Bunu bir ırmaktaki suyun akışına benzetelim. Eğer ırmağa akan herhangi bir dere veya çay yoksa ya da ırmağın üzerinde kurulmuş herhangi bir baraj veya yapılmış herhangi bir drenaj çalışması da yoksa ırmaktaki su düz bir ırmak boyunca her yerde aynı akış yoğunluğuna sahiptir. Fakat ırmağın daraldığı yerlerde su damlaları ırmak boyunca aynı akış yoğunluğunu tutturabilmek için daha hızlı hareket ederler.

İşte pusula üzerine yerleştirilen kabloda hareket eden yük yoğunluğunu tespit eder, yoksa küçük bir yük miktarının hareket hızını değil. Aşağıdaki olaylar buna kanıt teşkil eder:

- Pusuladaki sapma miktarı lambaların parlaklığıyla birlikte artar ya da azalır.
- Lambanın yanması lambanın içindeki flamandan geçen bütün yüklerce sağlanır.

## İNCELEME 2: LAMBALARIN VE DİRENÇLERİN REZİSTANSLARINI KARŞILAŞTIRMA

### ETKİNLİK 2.5 FARKLI LAMBALARIN ETKİLERİNİ KARŞILAŞTIRMA




Şekil 2.5a Şekil 2.5b Şekil 2.5c

Şekil 2.5a, 2.5b, ve 2.5c'deki devreleri kuralım. Her bir lambanın parlaklığını ve pusuladaki sapma miktarını not edelim. Lambaları ve pusulayı değişik sıralamalarla yerleştirip tekrar edelim.

1. Devre şemalarına lambaların parlaklığını kıyaslayarak ışınlar çizelim.

2. Şekil 2.5b ve 2.5c'deki yuvarlak lambalar yanmıyormuş gibi görünüyor. Yuvarlak lambalardan yük akışı olduğuna dair bir kanıt var mı? Eldeki kanıtlara dayanarak üç devre şemasına oklar çizelim.

3. Daha önceki 2.2 etkinliğindeki devrelerle şimdiki 2.5 etkinliğindeki devreleri karşılaştıralım. Gözlemlerimize dayanarak, sizce uzun lamba yuvarlak lambadan yüksek, düşük ya da onunla aynı rezistansa mı sahiptir?

**ETKİNLİK 2.6 FLAMANLARI BÜYÜTEÇ ALTINDA İNCELEMEK**

Devredeki diğer iletken kablolarla karşılaştırıldığında, lambalardaki flamanlar çok ince bir telden yapılmıştır. Bu etkinlikte, yuvarlak ve uzun lambaların içindeki flamanların, destek tellerinin ve devredeki bağlantı kablolarının kalınlıklarının karşılaştırılmasını inceleyeceğiz.

Yuvarlak ve uzun lambalardaki flamanların kalınlığını incelemek için öğretmenimizden bir büyüteç alalım. Bu Flamanların kalınlığını onlara tutturulmuş destek tellerinin kalınlığıyla karşılaştıralım. Ayrıca bu iki telin kalınlıklarını, devre elemanlarını bağlamakta kullandığımız bağlantı kablolarının kalınlıklarıyla karşılaştıralım.

1. Flamanlar, destek telleri ve bağlantı kablolarıyla karşılaştırıldığında nasıldılar?

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2. Uzun ve yuvarlak kablolardaki Flamanların kalınlıklarını karşılaştıralım.

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3. Şimdiye kadar yuvarlak ve uzun lambalardaki Flamanları, destek kablolarını ve bağlantı kablolarını inceledik. Bunları en kalından en inceye doğru sıralayalım.

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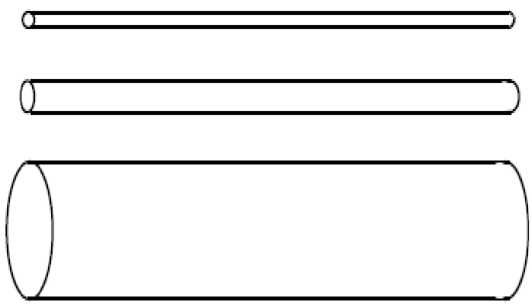
4. Hangi kablo yüklerin geçişi için en zor yolmuş gibi görünüyor? Hangisi en kolay yolmuş gibi görünüyor? Cevabımızı açıklayalım.

## ETKİNLİK 2.7 PİPETLERİN (ÇUBUKLARIN) HAVA AKIMINA KARŞI DİRENÇLERİNİ BULMAK



İki tane aynı boyda fakat farklı kalınlıklarda pipet elde edelim. Derin bir nefes alalım ve nefesimizi çubuklardan dışarı verelim. Dar çubuktan tüm nefesimizi geri verelim ve bunun için geçen süreyi not edelim. Aynı işlemi daha kalın çubuk için tekrarlayalım.

**Şekil 2.7 Üç tane birbirinden farklı kalınlıkta fakat birbiriyle aynı boyda çubuk**

1. Dar ve kalın çubuktan nefesimizi tamamen geri verene kadar geçen süreyi karşılaştıralım.

2. Bir çubuktan diğerine göre fazla mı nefes verdik?

3. Her bir çubukla etkinliği bir kez daha yapalım, yalnız bu sefer üflediğimiz hava avucumuza gelecek şekilde dışarı nefesimizi verelim. Elimizde ne hissettik?

4. Sonra bir kâğıt havlunun boş karton rulosunu alalım ve daha önceki çubuklarımızla aynı boya getirelim. Yine, ciğerlerimizin olanca gücüyle, dışarı nefes verelim. Rulonun kalınlığı, nefes verme süremizi ve ciğerlerimizden geçen hava akımının yoğunluğunu nasıl etkiledi?

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5. Ciğerlerimizi yeniden şarj etmemiz için değişik kalınlıklardaki borulardan aldığımız nefesin süresini karşılaştıralım.

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6. Lamba flamanlarının çaplarının üzerlerinden geçen akım yoğunluğuna etkisiyle boruların çaplarının içlerinden geçen hava akımının yoğunluğuna etkisini karşılaştıralım.

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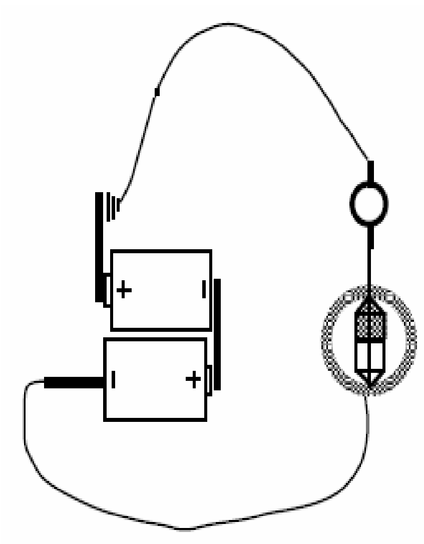
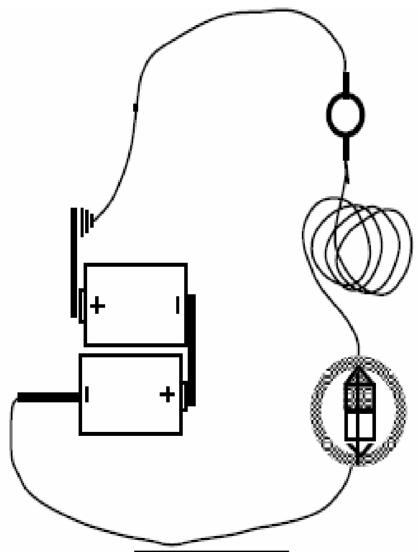
**ETKİNLİK 2.8 TELİN REZİSTANSI İLE BİR LAMBANIN FLAMANINKİNİ KARŞILAŞTIRMAK**



Şekil 2.8a



Şekil 2.8b

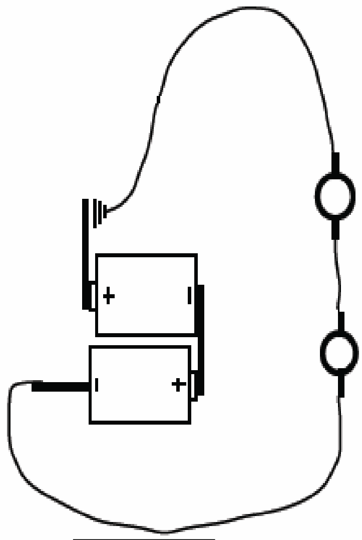
1. Bir yuvarlak lamba ve iki pilden oluşan devreyi kuralım. Daha sonra bu devreyi açalım ve öğretmenimizden alacağımız uzun bir tel sarımını devreye ekleyim. Teli eklemeden önce aşağıdaki sorulara dair tahminlerde bulunalım.

Pusula iğnesindeki sapma miktarı nasıl olur?

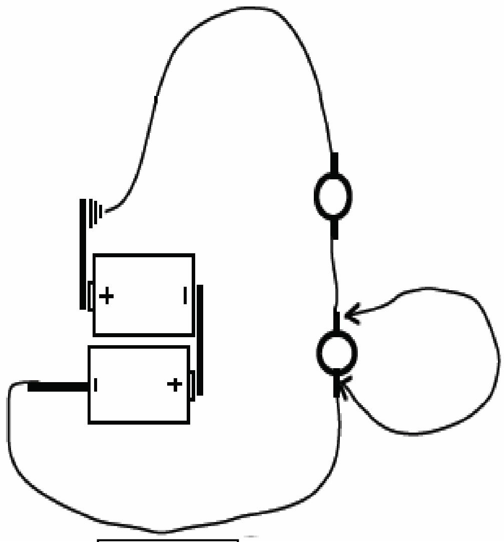
Yuvarlak lambanın parlaklığı nasıl olur?

2. Uzun tel sarımını devreye ekleyelim. Lambanın parlaklığı ile pusula iğnesinin üzerindeki etkiyi gözlemleyelim. Bu etkinlikte kullandığımız tel sarımının rezistansı ile ilgili hangi sonuçlara ulaşabiliriz?

**ETKİNLİK 2.9 BAĞLANTI KABLOSUNUN REZİSTANSINI DOĞRULAMAK**



Şekil 2.9a



Şekil 2.9b

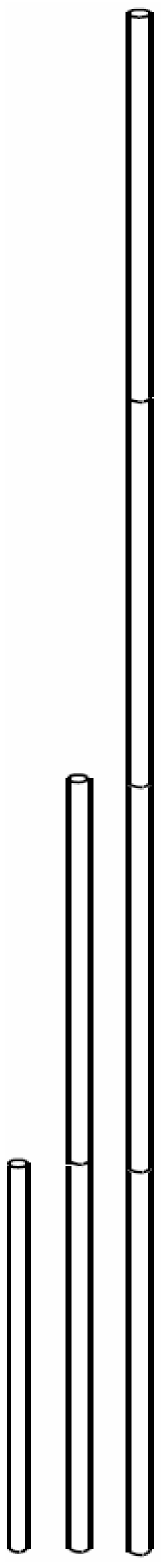
1. Şekil 2.9a'daki devreyi kuralım. Daha sonra başka bir bağlantı kablosuyla bir lambanın etrafından ikinci bir ilmek oluşturalım. Yalnız bunu yapmadan önce aşağıdaki soruya ilişkin bir tahminde bulunalım.

Tahmin: Ne olacağını düşünüyorsunuz? Neler gözlemleyebiliriz? Neden?

2. Timsah ağızlı bağlantı kablolarından bir tanesinin bir ucunu lambanın yuvasının bir ucuna bağlayalım. Kablonun boşta kalan ucunu yuvanın diğer ucuna kısa bir süre için dokunduralım ve neler olduğunu gözlemleyelim. Bu gözlemlerimize dayanarak, sonradan eklediğimiz bağlantı kablosunun ne işe yaradığını düşünüyorsunuz? Sizce, bu bağlantı kablosu ne yapıyor?

## İNCELEME 3: LAMBA KOMBİNASYONLARININ DİRENÇLERİ

### ETKİNLİK 2.10 SERİ HALDEKİ PİPETLER



Öğretmenimiz şimdi bize 4 tane ince pipet ve bant verecek. İki pipeti uç uca bantlayarak ilk pipetin iki katı uzunluğunda bir pipet elde edelim. Pipetlerin bantladığımız uçlarının açık kalmasına ve hiç hava kaçırmamasına dikkat edelim. Bu parçayı ayrı bir yere koyalım.

1. Derin bir nefes alıp, nefesimizi bir pipete üfleyerek verelim. Bütün nefesimizi dışarı verene kadar geçen süreyi not edelim.

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2. Derin bir nefes alıp, bu sefer nefesimizi demin oluşturduğumuz pipet çiftinden üfleyerek verelim. Bütün nefesimizi verene kadar geçen süreyi not edelim.

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**ETKİNLİK 2.11 PARALEL HALDEKİ PİPETLER**

Dört tane ince pipet alalım. Ölçü olarak, derin bir nefes alıp bir pipetin içinden verelim. Bütün nefesimizi dışarı vermek için gereken zamanı not edelim. Sonra, iki pipeti birbirine paralel olacak şekilde tutup nefesimizi verelim.

1. Bir pipetten mi yoksa iki pipetten mi nefesimizi dışarı vermek daha kolaydır?

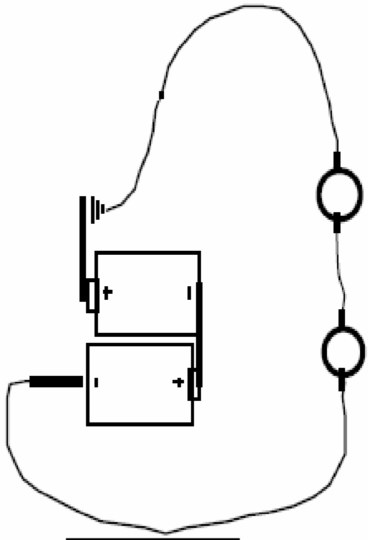
2.

Şekil 2.11

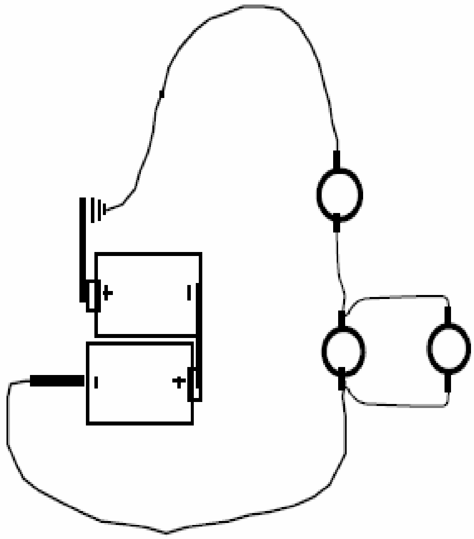
Daha sonra dört tane pipeti bir tutam yapıp nefesimizi verelim. Bu tutamdan nefes vermekle kalın bir pipetten nefes vermeyi karşılaştıralım.

3. Eğer bütün gün dört pipetten dışarı nefes vermeye zorlansaydınız, bu pipetleri nasıl yerleştirsek daha iyi olur? Sebebimizi açıklayalım.

**ETKİNLİK 2.12 PARALEL BAĞLI LAMBALARDAN OLUŞAN BİR ELEKTRİK DEVRESİ**



Şekil 2.12a

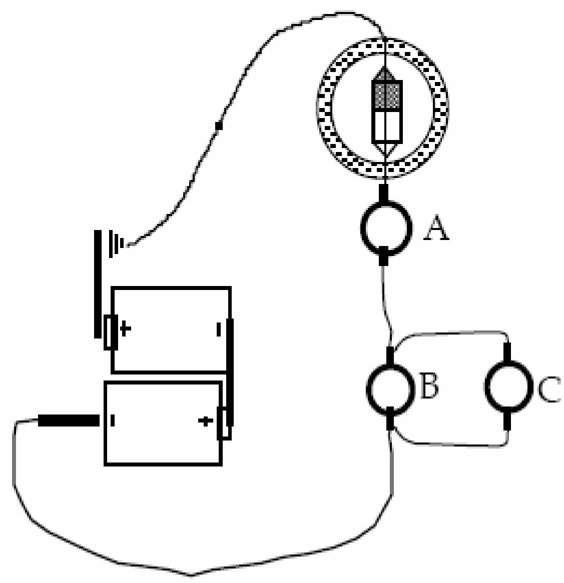


Şekil 2.12b

1. Şekil 2.12a'da gösterilen devreyi kuralım. Şekil 2.12b'de gösterildiği gibi bir yuvarlak lambayı daha devreye bağlarsak neler olacağını tahmin edelim.

**Tahminimiz:**

2.




Şekil 2.12c

Şekil 2.12c'deki gibi üçüncü bir lambayı lambalardan birine paralel olacak şekilde devreye bağlayalım. Ne gözlemledik?

C lambası devreye şekildeki bağlandığı zaman A lambasından geçen akım yoğunluğunun değişimini tespit etmek için bir pusula kullanalım. Neler gözledik?

## AÇIKLAMA 2.13 SERİ VE PARALEL BAĞLI DEVRELERDE EŞDEĞER DİRENÇ

Devreye seri olarak daha çok direnç bağlamak sanki daha uzun tek bir direnç bağlamak gibidir. Bu durum direnç gruplarından yük akımına karşı daha fazla toplam direnç gösterilmesine yol açar.

Aksine, devreye paralel olarak daha fazla direnç bağlamak, devreye tek bir kalın direnç bağlamakla aynı etkiyi gösterir. Bu durum direnç gruplarından yük geçişine karşı daha az toplam direnç gösterilmesine neden olur.

Seri ve paralel bağlanma arasındaki farkı anlamak için aşağıdaki gibi düşünmek işimizi kolaylaştırır.

- Seri bağlı devrelerde, yüklerin hepsi her bir dirençten teker teker geçer. Yükler bir dirençten geçerken hepsi bir karşı koymayla karşılaşır.

- Paralel bağlı devrelerde, yükler parçalara ayrılır. Bu parçalardan her biri sadece bir direncin üzerinden geçer ve sadece bir kez karşı koymaya maruz kalır.

Özet olarak, son dört etkinlik, birden fazla direncin yük akımını -hava akımında olduğu gibi- aşağıdaki gibi etkilediğini gösterir.

Seri bağlı daha fazla direnç → Daha uzun tek bir direnç gibi davranır. → Akım geçişini zorlaştırır.

Paralel bağlı daha fazla direnç → Daha kalın tek bir direnç gibi davranır. → Akım geçişini kolaylaştırır

**ÖZET ALIŞTIRMASI**

1. Bir elektrik lambası dirençlere hangi yönlerden benzer?

2. Yüksek rezistanslı lambanın mı yoksa düşük rezistanslı lambanın mı daha kalın flamanı vardır?

3. Akım yoğunluğunu göstermek için kullanılabilecek iki gözlem türü hangileridir?

4. Devreye daha fazla direnç bağlandığında, sonuç her zaman daha fazla toplam rezistans mıdır? Açıklayalım.

5. Hangi deneyler kabloların sıfır dirence sahip olduğunu gösterir?

## BÖLÜM 3 DEVRE DEĞİŞKENLERİ NASIL ÖLÇÜLÜR?

### GİRİŞ

Elektrik devrelerini uygulama amaçlı kullanan insanlar genellikle devredeki basınç (potansiyel) farklarını ve yüklerin akım yoğunluğunu (akımı) belirlermek için nicel ölçümler yaparlar. Bu ölçümleri kullanmak için “voltmetre” ve “ampermatre” adı verilen araçları kullanırlar. Bu bölümde bu araçların davranışlarını inceleyeceğiz. Daha sonra bu araçlarla yaptığımız ölçümleri kullanarak devre elemanlarının eşdeğer dirençlerini hesaplayacağız.

### AÇIKLAMA 3.1


Voltmetre

Ampermetre

Öğretemenimiz bize birer tane voltmetre ve ampermetre sağlayacak. Voltmetrenin devrenin sembolik gösteriminde kullanılan sembolü bir kutu içindeki V harfidir. Ampermetre ise yine bir kutu içine yazılmış A harfi ile gösterilir. Bir ampermetreyi yalnız başına bir üretece ya da pile bağlamak genellikle o ampermetreye zarar verir. Lütfen bize yapılan uyarıları dikkatlice takip edelim.

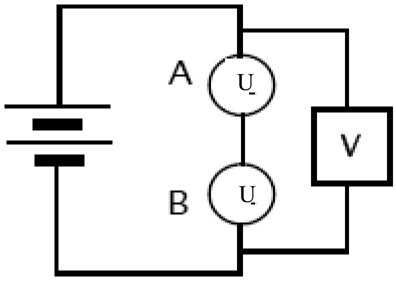
**Herhangi bir ampermetreyi öğretmenimiz bize nasıl olacağını göstermeden devreye bağlamayalım.**

### İNCELEME 1: ”VOLTMETRE” NE İŞ YAPAR?

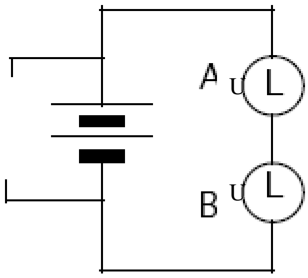
Voltmetre bize devredeki iki nokta arasındaki potansiyel farkı ölçerken yardım eder. Voltmetrenin uçlarını potansiyel farklarını öğrenmek istediğimiz iki noktaya bağlarız. Bu bölümde voltmerenin çalışma prensibini inceleyeceğiz.

**Etkinlik 6.2 Voltmetreyi nitel olarak test etmek**

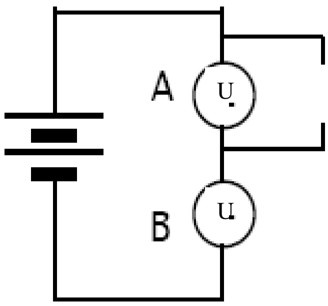
Aşağıdaki şemalardaki her devre iki noktasında boş kablolar varken çizilmiştir. Bu boş noktalara voltmetre bağlanacaktır. Şimdilik devreleri kurmayalım, sadece inceleyelim.




**Şekil 3.2a** Bir çift lambanın iki ucuna bağlanmış bir voltmetre

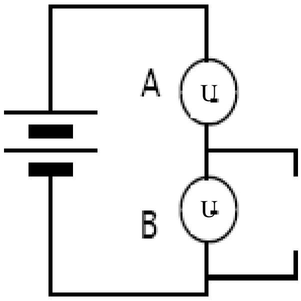



**Şekil 3.2b** Pillerin iki ucuna bağlanmış ekstra kablolar




**Şekil 3.2c** Üstteki lambanın iki ucuna bağlanmış ekstra kablolar

1. Her bir devredeki noktaları harflendirelim.
2. Bu harflendirmeye göre Şekil 3.2a'daki voltmetrenin iki ucu arasında bir potansiyel fark var mıdır? Bir fark varsa, bu fark Şekil 3.2b'deki iki lambanın ucundaki potansiyel farka eşit midir değil midir? Neden?
3. Aşağıda belirtilen noktalar arasındaki potansiyel farkları karşılaştıralım. Bu karşılaştırmaya dair tahminlerimizi not edelim.
   a. A lambasının uçları arasındaki potansiyel farkla (Şekil 3.2c) pillerin uçları arasındaki potansiyel farkı (Şekil 3.2b) karşılaştıralım.
   b. B lambasının uçları arasındaki potansiyel farkla (Şekil 3.2d) pillerin uçları arasındaki potansiyel farkı (Şekil 3.2b) karşılaştıralım.




**Şekil 3.2d** Alttaki lambanın iki ucuna bağlanmış ekstra kablolar

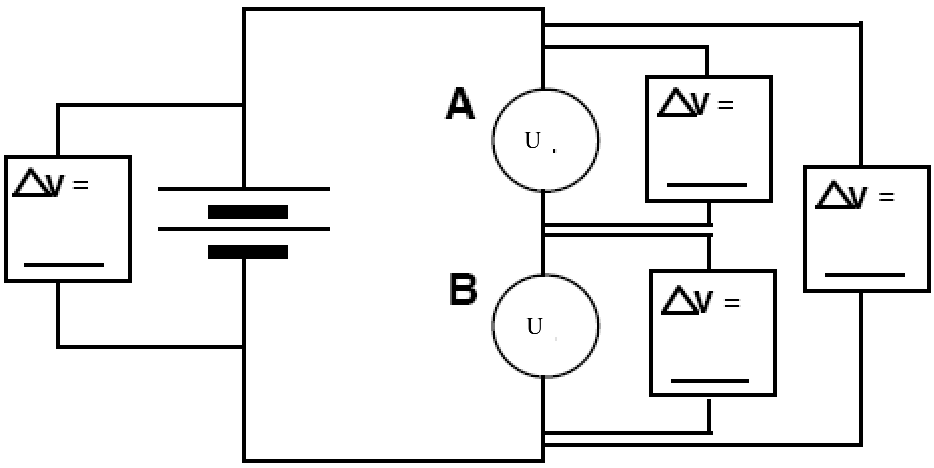
c. A lambasının uçları arasındaki potansiyel farkla (Şekil 3.2c) B lambasının uçları arasındaki potansiyel farkı (Şekil 3.2d) karşılaştıralım.

## AÇIKLAMA 3.3

Elektrik potansiyelinin sayısal değerinin sembolü “V” dir. İki noktanın elektrik potansiyelleri arasındaki farkı göstermek için ise “ΔV” sembolü kullanılır. Elektrik potansiyelinini ve elektrik potansiyel farkının birimi “Volt”tur. Potansiyel farkının değerleri voltmetre denilen cihazlaölçülür ve “Volt” cinsinden ifade edilir.

**Etkinlik 3.4 Voltmetreyi nicel olarak test etmek**

1. Aşağıdaki devre şemasında gerekli harflendirmeleri yapalım. Fakat henüz voltmetreyi bağlamayalım.

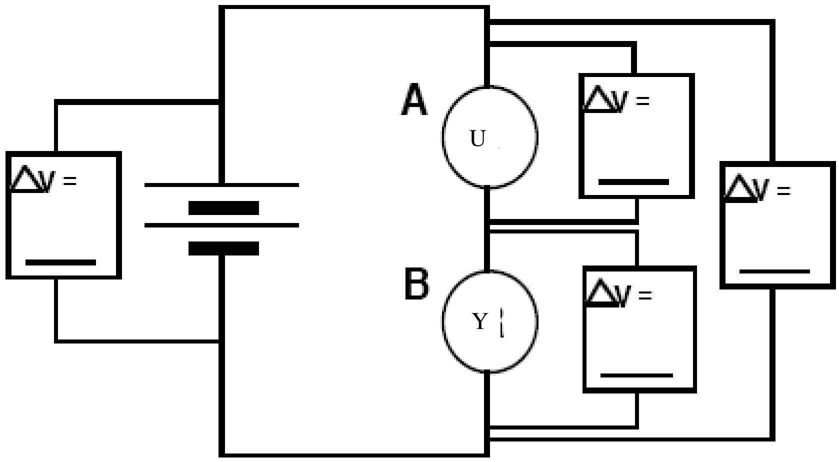



**Şekil 3.4a** Voltmetrede okunan değerler

2. Pillerin iki ucu arasındaki potansiyel farkın kaç volt olacağını tahmin edelim.

3. Öğretmenimizden bir voltmetre alalım. Voltmetreyi Şekil 3.4a'da gösterilen yerlere şekildeki gibi bağlayalım. Voltmetrede okuduğumuz değerleri şekilde ayrılan yerlere yazalım.

4. Şimdi aşağıdaki devrede harflendirme yapalım.




**Şekil 3.4b** İki farklı lambanın bulunduğu devrede voltmetrede okunan değerler

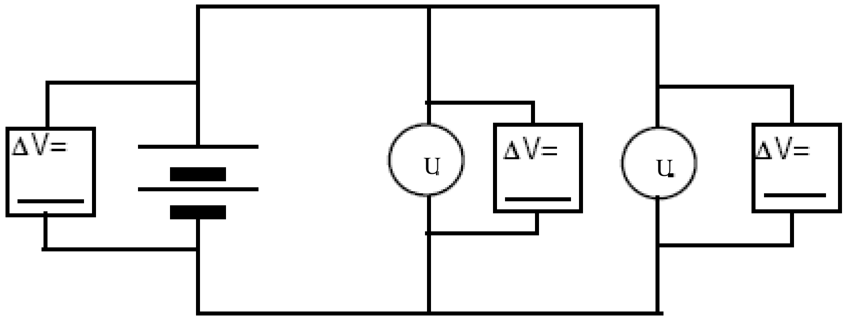
5. Daha önce yaptığımız ölçümlere, ve yuvarlak ve uzun lambalara ilişkin daha önceki deneyimlerimize dayanarak, lambaların ucundaki voltmetrelerde okuyacağımız değerleri tahmin edelim.

| | | |
|---|---|---|
| Tahminimiz: | Uzun:_______ | Yuvarlak:_____ |

6. Şekil 3.4b'deki devreyi kuralım. Şekilde belirtilen yerlere voltmetre bağlayıp, ölçtüğümüz değerleri ayrılan yerlere yazalım.

7. Voltmetrede okuduğumuz değerler tahminlerimizi destekledi mi? Aynı zamanda lambaların parlaklıkları da tahminlerimizi destekledi mi? Açıklayalım.

8. Şekil 3.4c'deki devreyi kuralım fakat ölçüm yapmadan önce voltmetrede okunan değerlerde ve lambaların parlaklıklarında neler gözlemleyeceğimize dair tahminde bulunalım.



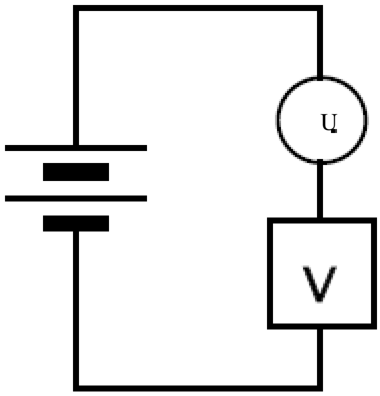

**Şekil 3.4c** Paralel kollardaki voltmetrelerde okunan değerler

Tahminimiz:

Şekil 3.4c'deki devreyi kuralım ve şekilde gösterilen yerlerdeki potansiyel fark değerlerini ölçüp belirtilen yerlere yazalım.

9. Voltmetrede okuduğumuz üç değeri karşılaştıralım. Piller ve iki lamba seri bağlanmış olsaydı bu üç değer nasıl olurdu?

**Etkinlik 3.5 Voltmetrenin direncini incelemek**




**Şekil 3.5a** Devreye seri bağlanmış voltmetre

1. Şekil 3.5a'da gösterilen devreyi kuralım. Lambanın ve voltmetrenin nasıl davrandığına dair gözlemlerimizi yazalım.

2. Bu gözlemlerimizden voltmetrenin direncine dair ne gibi çıkarımlar yapabiliriz?

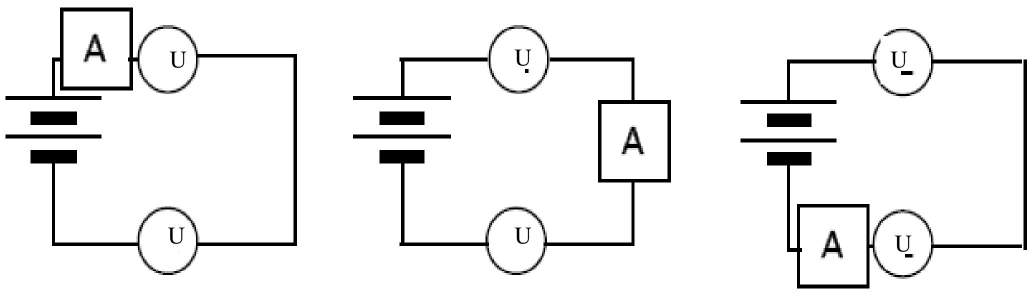
3. Voltmetrenin hangi amaçla böyle bir dirence sahip olacak şekilde tasarlandığını açıklayalım.

4. Niçin bir voltmetrede Şekil 3.5a'da gösterildiği gibi devreye seri bağlanmıyor? Açıklayaım.

## İNCELEME 2: "AMPERMETRE" NE İŞ YAPAR?

**<u>BU İNCELEMEYE ÖĞRETMENİMİZ BİZE AMPERMETREYİ BOZMADAN NASIL KULLANACAĞIMIZI ÖĞRETMEDEN BAŞLAMAYALIM.</u>**

### Etkinlik 3.6 Seri Bağlı Devrelerde Ampermetreyi Test Etmek



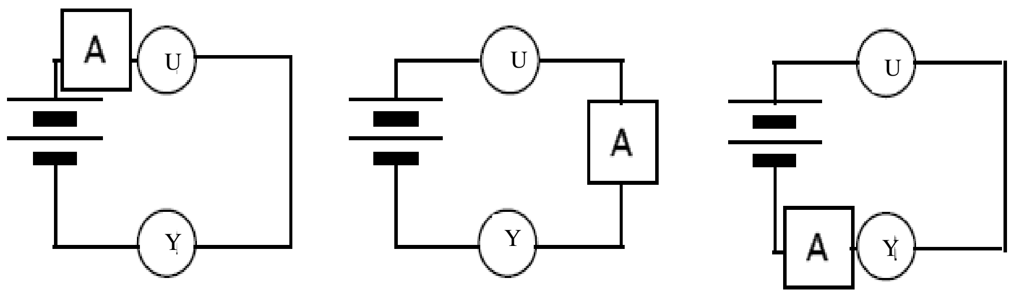

**Şekil 3.6a** **Şekil 3.6b** **Şekil 3.6c**

İçinde ampermetre bulununan seri bağlı devreler

1. Şekil 6.6'da gösterilen üç devreyi teker teker kuralım. Ampermetrede okunan değerleri kaydedelim, bu üç değeri karşılaştıralım.

A: B: C:

Şimdi devredeki bir uzun lambayı yuvarlak lambayla değiştirelim ve bir önceki adımda olduğu gibi ampermetreyi devrede dolaştıralım.




**Şekil 3.6d** **Şekil 3.6e** **Şekil 3.6f**

İki tür lamba ve ampermetreden oluşan devre

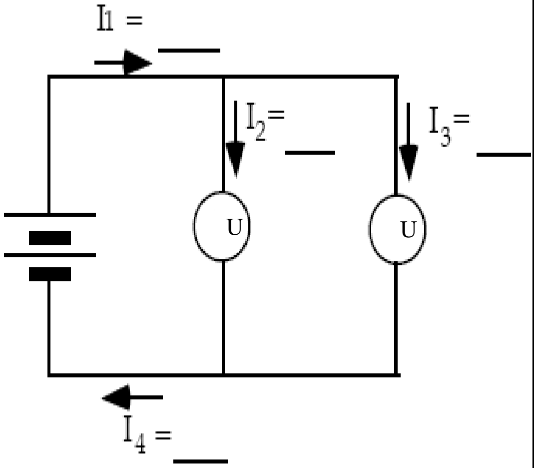
2. Ampermetrede okuduğumuz değerlerin birinci adımda okuduğumuz değerlerden neden farklı çıktığını açıklayalım.

## AÇIKLAMA 3.7

Akım yoğunluğunun nicel değeri “I” ile gösterilir. Bir devre elemanından geçen akım yoğunluğuna, genellikle o devre elemanından geçen “akım” denir.

Akımın sayısal değerlerini ifade etmek için Fransız fizikçi André Amperé’in soyadından esinlenerek Amper birimi kullanılır. Akım değerleri ampermetre kullanılarak Amper cinsinden ölçülür.

**Etkinlik 3.8: Paralel Bağlı Devrelerde Ampermetreyi Test Etmek**



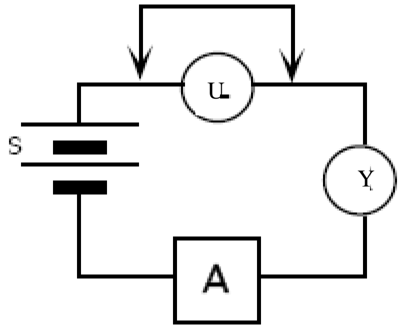

**Şekil 3.8a** Ampermetreyi devrede dört farklı yere bağlamak

Şekil 6.8a'da gösterilen devreyi kuralım.

1. Şekil 6.8a'da "I" sembolü ile gösterilen her yere ampermetreyi bağlayarak ölçüm yapalım. Bu ölçüm değerlerini Şekil 6.8a'da ayrılan yerlere yazalım. ($I_1$ ve $I_4$ devrede ana koldan geçen akımı gösterirken, $I_2$ ve $I_3$ devrede kollardan geçen akımı gösterir.)

2. Ampermetrenin devrede uygun ölçüm yaptığına dair elimizde ne gibi bir kanıt var?

**Etkinlik 3.9: Ampermetrenin Direncini İncelemek**

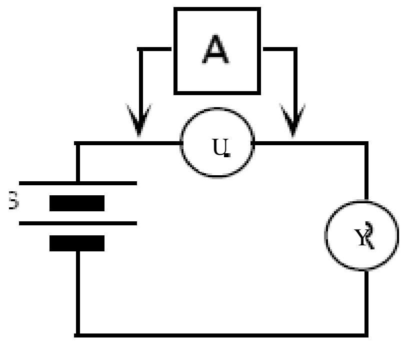



**Şekil 3.9a** Bir lambanın etrafında kısa devre yapmak

1. **Tahmin edelim.** Şekil 6.9a'daki uzun lambanın iki ucuna bir kablo bağlarsak, uzun lambanın etrafında bir kısa devre oluştururuz. Böylece uzun lambanın direnci devre dışı kalmış olur. Bu durumda ampermetrede okuyacağımız değer nasıl değişecektir?

2. Devreyi kuralım ve deneyimizi yapalım. Tahminimiz doğrulandı mı? Neler gözlemledik?

3. Şimdi Şekil 3.9b'deki devreyi kuralım. Şekil 6.9a'daki devrede ampermetrede okuduğumuz değer ile Şekil 3.9b'deki devrede ampermetrede okuduğumuz değeri karşılaştıralım.




**Şekil 3.9b** Uzun lambanın iki ucuna bağlı bir ampermetre

4. Uzun lamba ve kısa lambanın parlaklıklarından yola çıkarak, ampermetre kısa devre gibi davranmıştır diyebilir miyiz?

5. Ampermetrenin direnci hakkında ne söyleyebiliriz? Açıklayalım.

6. Ampermetre niçin böyle bir direnç değeriyle tasarlanmış olabilir? Açıklayalım.

7. Bir ampermetreye hasar vermek niçin kolaydır? Açıklayalım.

## İNCELEME 4: DİRENCİ NASIL ÖLÇERİZ?

Lambaların flamanlarından başka, elektrik akımına karşı koyan fakat ışık yaymayan ve genellikle karbondan yapılan "direnç" adını verdiğimiz devre elemanları da vardır. Dirençlerin rezistans değerleri herhangi bir değerde olabilir. Bu bölümde direnci nasıl ölçeceğimizi öğreneceğiz.

### AÇIKLAMA 3.10

Bir devre elemanının direncinin sayısal değerini belirtmek için "R" sembolü kullanılır. Direncin birimi Ohm'dur (Ω) ve adını Alman fizikçi ve öğretmen Grerg Ohm'dan almıştır.  Devre elemanı olarak direnç yandaki sembolle gösterilir.

**Etkinlik 3.11 Direnci Ölçmek**

Bu etkinlikte direncin sayısal değerini ölçeceğiz. İlk önce bir tahminle başlayalım. Büyük bir devrede bir devre elemanının iki ucu arasında büyük bir potansiyel fark varsa, bu devre elemanının direnci büyük müdür, yoksa küçük müdür?

**Tahminimiz:**

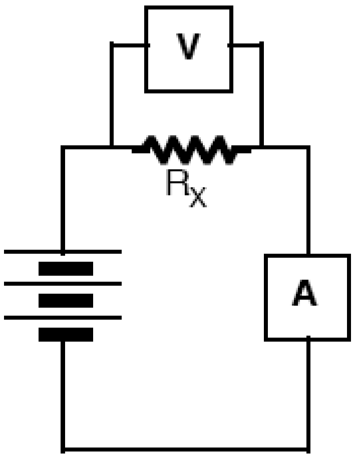
Bir devre elemanının direncini ölçebilmek için hem bir ampermetreye hem de bir voltmetreye ihtiyacımız var. Ölçüm basamakları aşağıdaki gibidir:

1. Direnci pillere bağlayalım.
2. Direncin iki ucu arasındaki potansiyel farkı volt cinsinden bulabilmek için direncin uçlarına bir voltmetre bağlayalım.
3. Dirençten geçen akımı Amper cinsinden ölçebilmek için bir ampermetre kullanalım.

4. y-ekseni Voltajı x-ekseni de Amperi gösterecek şekilde bir grafik hazırlayalım.

5. Doğrunun eğimini hesaplayalım. Bu eğim bize Volt/Amper ya da Ohm cinsinden direnç değerini verecektir.

Öğretmenimiz bize $R_x$ ve $R_y$ olarak göstereceğimiz iki farklı direnç verecek. Şekil 3.11'de gösterilen devreyi $R_x$ direncini kullanarak kuralım. Daha sonra aynı işlemleri $R_y$ direncini kullanarak tekrarlayalım.




**Şekil 3.11** Direnci hesaplamak için kuracağımız devre

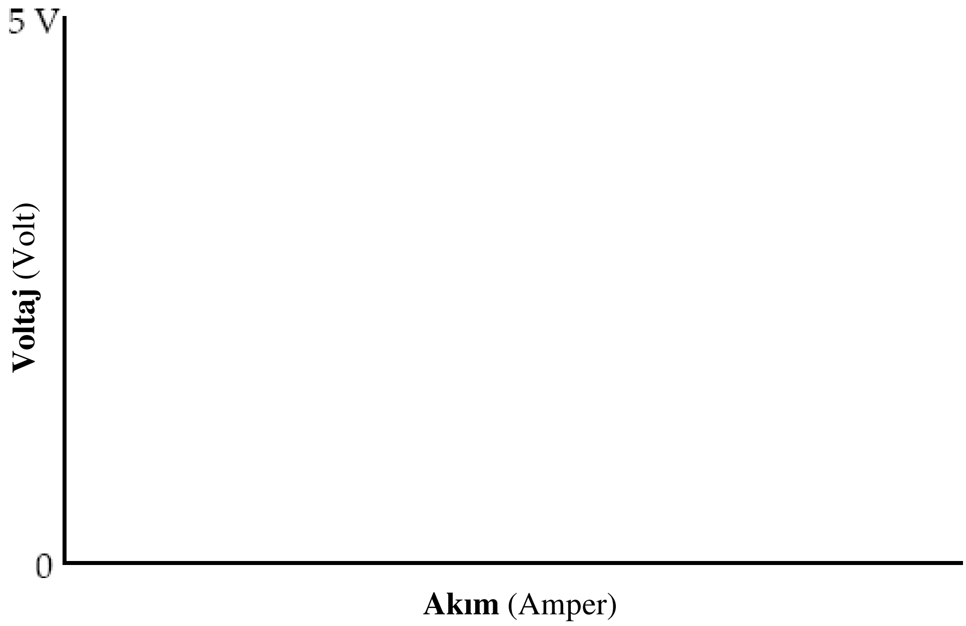
1. Devreyi sırasıyla bir pil, iki pil, ve üç pil kullanarak kuralım. Her üç durumda da direncin iki ucu arasında potansiyel farkını ve dirençten geçen akımı ölçüp not edelim. Daha sonra aynı işlemleri $R_y$ direncini kullanarak tekrarlayalım.

Verilerimizi aşağıdaki tabloya yazalım ve $R_x$ ve $R_y$ dirençleri için çizeceğimiz grafikleri aynı eksenleri kullanarak aşağıdaki grafiğe çizelim. Eğimi hesaplayalım.

| | $R_x$ | | | $R_y$ | | |
|---|---|---|---|---|---|---|
| **Pil** | **Potansiyel Fark** (Volt) | **Akım** (Amper) | **Eğim** (Volt/Amp, ohm) | **Potansiyel Fark** (Volt) | **Akım** (Amper) | **Eğim** (Volt/Amp, ohm) |
| 1 | | | | | | |
| 2 | | | | | | |
| 3 | | | | | | |

**Tablo 3.11**

**İki Direnç için Voltaj-Akım Grafiği**




2. Her üç voltaj değerini kullanarak çizdiğimiz $R_x$ ve $R_y$ grafiklerinin eğimlerini karşılaştıralım. İki direncin sayısal direnç değerleri için ne söyleyebiliriz?

Bu hesaplama aşağıda gösterilen önemli formül kullanarak yapılabilir:

$$Direnç = \frac{Po \tan siyelFark}{Ak\imath k} \quad \text{ya da sembollerle} \quad R = \frac{\Delta V}{I}$$

Bu formül bize bir direncin iki ucu arasındaki potansiyel farkın (ΔV) üzerinden geçen akıma (I) oranının o direncin direncinin sayısal değerine (R) eşit olduğunu söyler. Buna göre, direnç değeri bir direncin üzerinden I akımı geçirebilmek için o direncin uçları arasına uygulanması gereken potansiyel fark miktarıdır. Bu anlamlıdır çünkü, büyük dirence sahip devre elemanlarının üzerinden belli bir büyüklükte akım geçirebilmek için yine büyük bir potansiyel farka ihtiyaç duyarız.

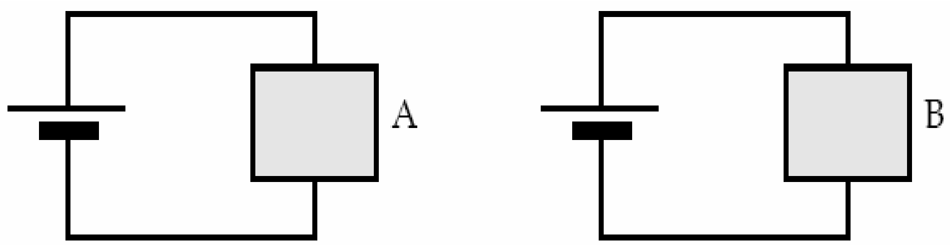
Bu formul bir Ohm'un bir Volt/Amper'e eşit olduğunu da gösterir. Fakat bu denklemdeki hiç bir şey bu direnç değerinin sabşt olduğunu göstermez. Nitekim, bir devre elemanının direnci yüksek potansiyelde farklı, düşük potansiyelde farklı değerler alabilir.

**UYARI**

**Eğer bir direnç farklı voltaj değerleri altında aynı direnç değerine sahipse, o direnç Ohm Yasası'na uyuyor deriz.**

4. $R_x$ ve $R_y$ dirençleri Ohm Yasası'na uyuyorlar mı?

## AÇIKLAMA 3.12 "EŞDEĞER DİRENÇ" KAVRAMI



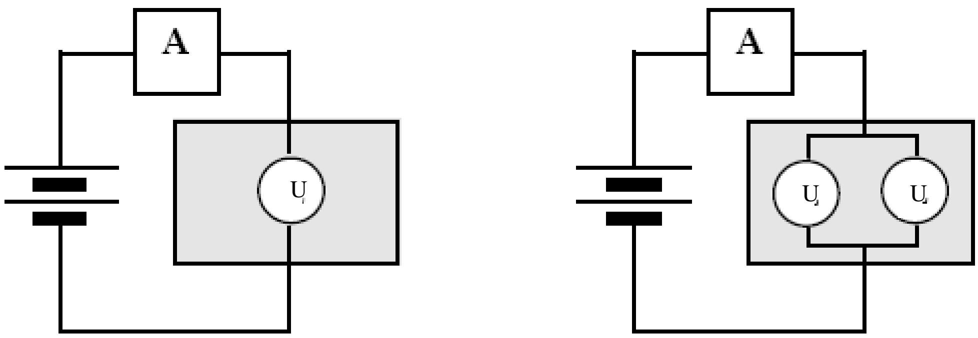

**Şekil 3.12a** **Şekil 3.12b**

Eşdeğer dirençli devreler

Elimizde içinde değişik kombinasyonlarda lambaların bağlı olduğu iki ucunu pillere bağladağımız kutularımız olduğunu varsayalım. Her bir kutu bir eşdeğer direnç gibi davranacaktır ve bu kutuların dirençlerine içindeki lambaların "eşdeğer direnç"leri denilecektir.

Şekil 3.12a ve Şekil 3.12b'dw gösterilen taralı alanlar bunun gibi kutuları temsil etmektedir. Bu kutuların eşdeğer dirençleri onları aynı voltaja bağlayıp devreden çektikleri akımın değeri ölçülerek karşılaştırılabilir.

## Etkinlik 3.13 Seri ve Paralel Bağlı Dirençlerin Eşdeğer Dirençleri




**Şekil 3.13a** **Şekil 3.13b**

Eşdeğer dirençleri karşılaştırmak

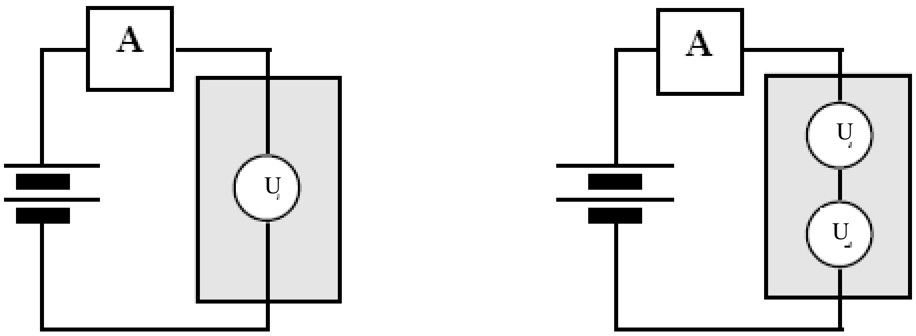
Şekil 3.13a ve Şekil 3.13b'deki taralı alanlar bize paralel bağlı iki uzun lamba ile bir uzun lambanın eşdeğer direncini karşılaştıracağımızı belirtiyor. 1. ve 2. soruları cevaplamadan şekillerde gösterilen devreleri kurmayalım.

1. İki lambanın eşdeğer direncinin bir lambanınkinden büyük veya küçük veya bir lambanın direncine eşit olduğuna karar vermek için ampermetreden okuduğumuz değerleri nasıl kullanabiliriz?

2. Önsezilerimize dayanarak cevaplayacak olursak paralel bağlı iki lambanın eşdeğer direnci için tek bir lambanın eşdeer direncine kıyasla ne diyebiliriz?

3. Şimdi Şekil 3.13a'daki ve Şekil 3.13b'deki devreleri kuralım. Paralel bağlı iki lambanın eşdeğer direncini tek bir lambanın direnciyle karşılaştırırsak ne diyebiliriz? Kanıtlayalım.

Şimdi lamba çiftlerini birbirinden ayıralım ve daha sonra onları Şekil 3.13c'deki gibi seri bağlayalım. Şekil 3.13a'daki devrenin eşdeğer direnci ile Şekil 3.13c'deki devrenin eşdeğer direncini karşılaştıralım.

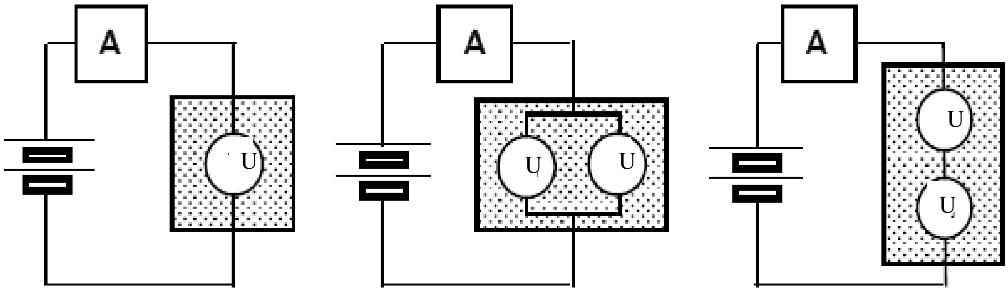



**Şekil 3.13a** **Şekil 3.13c**

Eşdeğer dirençleri karşılaştırmak

4. Şekil 3.13c’deki seri bağlı iki lambanın eşdeğer direnci ile Şekil 3.13a’daki tek lambanın direncini karşılaştıralım. Nasıl ispatlayabiliriz?

5. Şekil 3.13a, Şekil 3.13b ve Şekil 3.13c’deki devrelerde okuduğumuz ampermetre değerlerini açıklamak için harflendirme metodunu kullanalım.

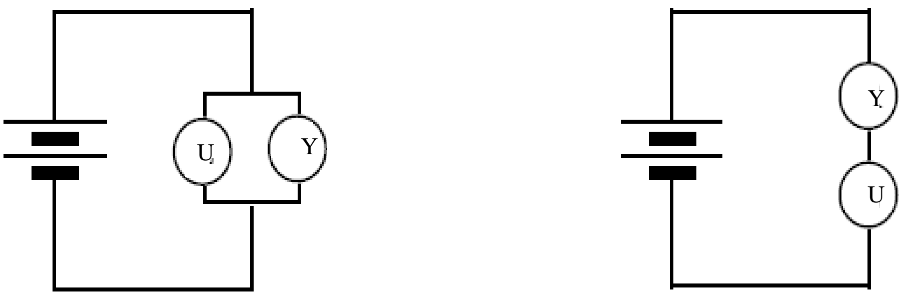



**Şekil 3.13a** **Şekil 3.13b** **Şekil 3.13c**

## İNCELEME 5: ENERJİ TRANSFERİNİ NASIL ÖLÇERİZ?

### Etkinlik 3.14: Enerji Transferini Belirleyen Değişkenler Nelerdir?

Şekil 3.14a ve daha sonra Şekil 3.14b’deki devreleri kuralım. Bu devredeki lambalar devredeki pillerden enerji almaktadırlar. Lambaları pile bağladığımızda çevreye ışık yaymaları bunun bir kanıtı sayılabilir.




**Şekil 3.14a** **Şekil 3.14b**

1. Şekil 3.14a’daki lambalardan hangisi daha fazla enerji almaktadır? İspatlayalım.

2. Şekil 3.14a'daki lambalardan bir tanesi diğerine göre pilden bir saniyede daha fazla enerji almaktadır. Bunun nedeni bu lambanın üzerinden diğerine göre daha fazla akım geçmesi mi yoksa bu lambanın uçları arasında daha fazla potansiyel fark olması mıdır?

3. Şekil 3.14b'deki lambalardan hangisi daha fazla enerji almaktadır? İspatlayalım.

4. Şekil 3.14b'deki lambalardan bir tanesi diğerine göre pilden bir saniyede daha fazla enerji almaktadır. Bunun nedeni bu lambanın üzerinden diğerine göre daha fazla akım geçmesi mi yoksa bu lambanın uçları arasında daha fazla potansiyel fark olması mıdır?

## AÇIKLAMA 3.15 "GÜÇ" NEDİR? BİR "WATT" NE DEMEKTİR?

Yukarıdaki Etkinlik 3.14 bize pillerden lambaya olan enerji transfer oranının iki değişkene bağlı olduğunu gösterdi.

(1) AKIM: Lambanın üzerinden geçen yüklerin akım yoğunluğu

(2) VOLTAJ: Akımı tetikleyen potansiyel farkı

Her iki değişkenin birleşerek enerji transfer oranını nasıl belirlediğini açıklamak isteriz. Enerji transfer oranını ifade etmek için GÜÇ terimini kullanırız.

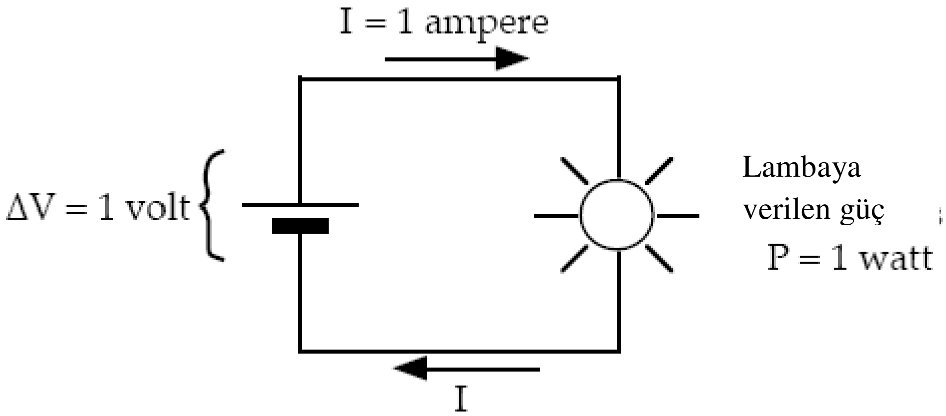
**GÜÇ BİR SANİYEDE AKTARILAN ENERJİ MİKTARIDIR.**

Bir lambaya aktarılan enerji bir pilden ya da başka bir enerji kaynağından gelir. Devrenin bir parçasından diğer parçasına aktarılan enerji transferini ifade etmek için GÜÇ GİRDİsi ve GÜÇ ÇIKTIsı terimlerini kullanacağız.

Güç birimi WATT'tır. Bir WATT'ın büyüklüğü aşağıdaki gibi tanımlanabilir.

**Bir VOLT potansiyel fark altında bir lambadan bir AMPERlik akım geçtiği zaman lambaya olan enerji aktarım hızına bir WATTlık GÜÇ denir.**

Şekil 3.15'te bir "birim" lamba bir "birim" pile bağlanmıştır. Bu sanal pilin içindeki kimyasal aktivite onun uçları arasında 1 Volt'lık bir gerilim oluştururken, lambanın direnci de lambadan 1Amper'lik akım geçmesine neden olur. Güç girdisi için P sembolü kullanılır. Sonuç olarak Şekil 3.15'teki gibi bir birim lambanın bir birim pil tarafından yakılabilmesi için gereken güç miktarı P=1 watt'dır.




**Şekil 3.15** Bir Watt'lık gücü sanal bir lambaya verilen güç olarak tanımlamak

Bu birim lambalar ve birim piller dükkanlardan satın alınamazlar fakat devre şemalarını incelemeyi çok kolay bir hale getirirler. Bu da bize dirençlere verilen gücü belirlerken voltaj ve akımın birlikte nasıl hesaba katılacaklarını anlamamızda yardımcı olur.

### Etkinlik 3.16 Voltaj ve Akım Güç Transferini Birlikte Nasıl Belirler?

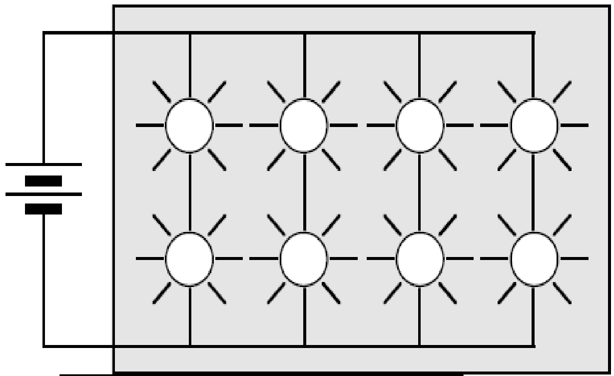
Bir kutunun içinde değişik kombinasyonlarda yerleştirilmiş birim lambalara verilen gücü hesaplamak iiçin Şekil 3.15'te verilen güç tanımını kullanabiliriz. Şekil 3.16a ve Şekil 3.16b'ye bakarak seri bağlanmış birim pillerin her bir birim lambanın iki ucu arasında nasıl 1 Volt'luk potansiyel farkı oluşturduğunu anlayabiliriz. Bu devrelerde farklı pil potansiyelleri kutulardan farklı büyüklükte akım geçmesine neden olmasına rağmen her bir lambaya 1 wattlık güç sağlar.

Şekil 3.16a ve Şekil 3.16b'deki taralı alanlarla gösterilen kutularda farklı kombinasyonlardaki lambaların yerleştirildiğini göstermektedir. Aşağıdaki yönergeleri kullanarak devredeki değişkenleri hesaplayabiliriz.

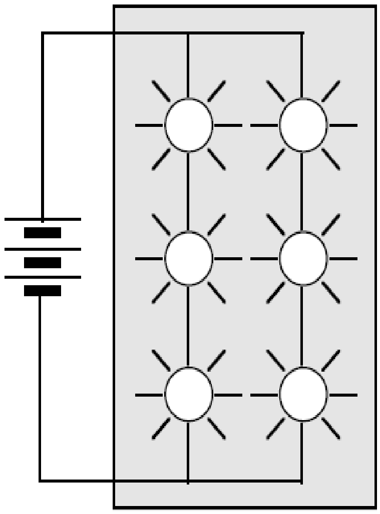
Bir kutuya verilen toplam **GÜÇ** kutulardaki **birim lambaların sayısı**na eşittir.

Bir kutudan geçen **AKIM** kutulardaki **paralel kolların sayısı**na eşittir.

Akıma yol açan **VOLTAJ** seri bağlanmış **birim pillerin sayısı**na eşittir.



**Şekil 3.16a** 8 birim lambadan oluşan kutu



**Şekil 3.16b** 6 birim lambadan oluşan kutu

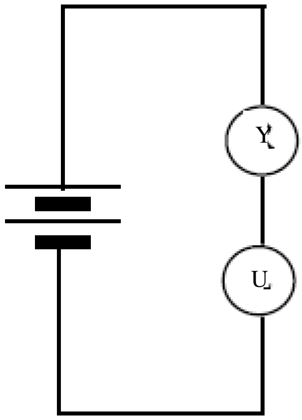
1. Her bir şekil için P=?, I=?, ve ΔV=? değerlerini üstte verilen yönergelere göre hesaplayalım.

P=________ I=_________ ΔV=_______ (Şekil 3.16a)

P=________ I=_________ ΔV=_______ (Şekil 3.16b)

2. Yukarda yazdığımız rakanlara bakarak bu değişkenler arasındaki ilişkiyi ortaya koyan bir denklem yazalım.

### Etkinlik 3.17: Giriş Gücü – Çıkış Gücü




**Şekil 3.17**

Güç tenferi denklemi olan **P=ΔV. I**, özdeş parlaklıklarda yanan özdeş lambaların giriç gücü için geçerlidir. Acaba aynı ilişki bütün lamba kombinasyonları için de geçerli midir? Aynı şekilde, acaba bu ilişki lambaların giriş gücü gibi pillerin çıkış gücünü açıklarken de geçerli midir?

Şekil 3.17 farklı iki lambanın seri bağlandığı bir devre göstermektedir.

1. Ölçüm araçlarını kullanarak aşağıdaki Tablo 3.17'yi dolduracak verileri toplayalım.
2. Bu tablodaki giriş gücü çıkış gücüne eşit midir? Yorumlayalım.

**Tablo 3.17**

| Devre Elemanları | ΔV | I | Pilden çıkış gücü | Her lamba için giriş gücü |
|---|---|---|---|---|
| Pil | | | | |
| Yuvarlak Lamba | | | | |
| Uzun Lamba | | | | |
| | | Toplam | | |

### Etkinlik 3.18: Birden fazla pilin olduğu devreler

Şekil 3.18b ve Şekil 3.18c'deki devreler Şekil 3.18a'da olmayan üçüncü bir pile daha sahiptirler. Şekil 3.18c'deki pil Şekil 3.18b'deki pile göre ters

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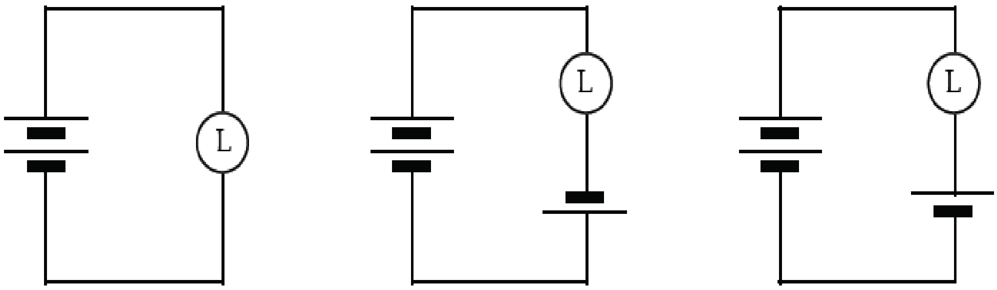
bağlanmıştır. Çünkü onun yönü devredeki diğer pillere terstir.




1. Şekil 3.18b'deki bütün piller lambaya enerji veriyorlar mı? İspatlayalım.

2. Şekil 3.18c'deki bütün piller lambaya enerji veriyorlar mı? İspatlayalım.

3. Şekil 3.18c'deki tekli pil daha güçlü olan diğer pil çiftinden enerji alıyor mudur? Cevabımızı açıklayalım.

Ölçüm araçlarını kullanarak sadece Şekil 3.18c'deki devre için gerekli ölçümleri yaparak aşağıdaki Tablo 3.18'i dolduralım.

**Tablo 3.18**

| Devre Elemanları | ΔV | I | Verilen Güç | Alınan Güç |
|---|---|---|---|---|
| 2 Pil | | | | |
| Tek Pil | | | | |
| Lamba | | | | |
| | | Toplam | | |

4. Bu devrede giriş gücü ile çıkış gücü birbirine eşit midir? Açıklayalım.

5. Şekil 3.18c'deki pil çifti diğer pile enerji veriyor mudur? Açıklayalım.

# APPENDIX K

## INSTRUCTIONAL GUIDE

## SORGULAMA TEMELLİ ÖĞRETİM
## ÖĞRETMEN KILAVUZU

Uygulayacağımız öğretim yönteminin etkililiğini arttırmak için lütfen aşağıdaki önerileri göz önünde bulundurunuz.

- İlk olarak, yöntemimiz dört bölümde toplanmış sıralı aktiviteler içermektedir. Bu aktiviteler oluşturulurken öğrencilerin bilimsel yöntem sürecini doğru ve etkin biçimde işleterek kendi öğrenme süreçlerini yönlendirebilmeleri hedeflenmiştir. Öğrencilerin gruplar halinde çalışması ve her aktivitenin iki ders saati içinde tamamlanması beklenmektedir.

- Araştırmalar, öğrencilerin elektrik konusunda sahip oldukları kavramların pek azının bilimsel geçerliliği bulunduğunu göstermektedir. Bu çalışmada temel hedefimiz, öğrencilerin deneyimsel model inşa yaklaşımı yoluyla doğru kavramları edinebilmelerini sağlamaktır. Bu süreçte, öğrencilerin taze bir başlangıç yapabilmeleri çok önemlidir. Bu nedenle, çalışmaya başlarken öğrencilerden elektrik konusunda bildikleri ya da bildiklerini sandıkları her şeyi unutmaları istenmelidir.

- Konuyla ilgili teknik terimler (devre, akım, akım şiddeti, güç gibi) gözlem ve analizler sonucunda tanımlanmalıdır. Öğrenciler bu kavramları doğru kullanma becerisini, onları devreye uygulayabildiklerinde kazanırlar. Bu kavramlar işlevsel olarak tanımlanıncaya kadar onların yerine öğrencilerin içini kolayca doldurabilecekleri terimler (ilmek, yük yoğunluğu, akış oranı, enerji transfer oranı gibi) kullanılmalıdır.

- Her bir öğrencinin öğrenim sürecine etkin katılımı, önemli bir başarı ve güven kazanımına neden olur. Onları kendilerine yöneltilen sorulara yanıt aramaya, fikirlerini tartışmaya, tahminlerini dile getirmeye ve araştırmalarda laboratuar ortaklarıyla işbirliği içinde çalışmaya teşvik edin.

- "Tahmin et, gözlemle, açıkla" yaklaşımı başlangıçta pek çok öğrenci için rahatsız edicidir. Tahmin etmelerini istediğinizde hiçbir fikirleri olmadığını söyleyebilirler. Onları risk almaya, ortaklarıyla olası fikirleri tartışmaya, hipotezlerini paylaşmaya ve tahminlerini yazmaya teşvik edin. Her birinin kendi hipotezini kurması, araştırmanın etkin bir parçası olma isteklerini arttıracaktır.

- Fikir uyuşmazlıkları da dâhil, öğrencileri kendi aralarında tartışmaya teşvik edin. Sorular sorun, onları düşünmeye zorlayan problem durumları oluşturun. Geçerli modelleri kendileri deneyerek oluşturabilirler. Dikkatli gözlemler konusunda deneyim edinmek, kendilerine güvenlerini ve bilim üretmek konusundaki olumlu tutumlarını besleyen başarılı tahminler yürütmelerine olanak tanıyacaktır.

- Size sunulan öğrenci kılavuzunun tüm bölümlerini kopyalayıp her öğrenci için spiral cilt yaptırabilirsiniz. Bu, özellikle öğrencilerin tamamlayacağı etkinlikleri bir arada tutmak için yararlı olacaktır.

- Bölüm sonlarında düzenlenecek sınıf tartışmalarını yönetirken, o bölümün hedeflenen kazanımları göz önünde bulundurulmalıdır. Hem bu takibi kolaylaştırmak için, hem de genel tekrar amacıyla öğrencilere ilgili bölümün kazanım listesini vermenizi öneririz. Bu kazanımları size verilen "Kazanım-Etkinlik Tablosu"nda bulabilirsiniz.

# APPENDIX L

## OBJECTIVE - ACTIVITY TABLE

| Activity / Objective | A.1 | A.2 | A.3 | A.4 |
|---|---|---|---|---|
| 1 | * | | | |
| 2 | | * | | |
| 3 | | | | |
| 4 | * | * | * | * |
| 5 | | * | * | * |
| 6 | | * | | |
| 7 | | * | | |
| 8 | | | * | |
| 9 | | | | |
| 10 | | | * | |
| 11 | | | * | |
| 12 | | | * | |
| 13 | | | * | |
| 14 | | | | * |
| 15 | | | | * |
| 16 | | | | * |
| 17 | | | | * |
| 18 | | * | | * |
| 19 | | | | * |
| 20 | | * | | |

# APPENDIX M

## PARENT CONSENT FORM

1956

ORTA DOĞU TEKNİK ÜNİVERSİTESİ
MIDDLE EAST TECHNICAL UNIVERSITY
06531 ANKARA-TURKEY

Orta Öğretim Fen ve Matematik Alanları Eğitimi Bölümü
Department of Secondary Science and Math Education

Tel: 90 (312) 210 36 86
Faks: 90 (312) 210 79 71

*Sayın Veliler, Sevgili Anne-Babalar,*

Orta Doğu Teknik Üniversitesi Orta Öğretim Fen ve Matematik Alanları Eğitimi Bölümü'nde yapmakta olduğum doktora çalışmamın bir parçası olarak DPT tarafından Öğretim Görevlisi Yetiştirme Projesi kapsamında desteklenmekte olan *BAP*-08-11-DPT2002K120510 No'lu "Bir Öğrenci Özellikleri-Uygulama Etkileşimi Çalışması: Öğrenci-Merkezli ve Öğretmen Merkezli Öğretimin Lise Öğrencilerinin Fizik Başarısı Üzerindeki Etkisi" başlıklı araştırma projesini yürütmekteyiz. Araştırmamızın amacı farklı öğretim metodlarının (tümevarım ve tümdengelim) ve bu metodların öğrencilerin bilişsel stilleriyle (alandan bağımsız ve alana bağımlı) etkileşiminin 11. sınıf öğrencilerinin elektrik devreleri konusundaki başarılarına ve bu konuya karşı tutumlarına etkisini araştırmaktır. Bu amacı gerçekleştirebilmek için uygulama kapsamında, elektrik devreleri konusu iki farklı yöntemle işlenecek, bu yöntemlerin ve bu yöntemlerin öğrencilerin bilişsel stilleriyle (alandan bağımsız ve alana bağımlı) etkileşiminin 11. sınıf öğrencilerin elektrik devreleri konusundaki başarılarına ve bu konuya karşı tutumlarına etkileri araştırılacaktır.

Katılmasına izin verdiğiniz takdirde, araştırma kapsamında, çocuklarınızdan kimlik belirleyici hiçbir bilgi istenmeyecektir. Öğrencilerin cevapları tamamiyle gizli tutulacak ve sadece araştırmacılar tarafından değerlendirilecektir; elde edilecek bilgiler bilimsel yayınlarda kullanılacaktır.

Uygulamada cevaplanmasını istediğimiz testler, kişisel rahatsızlık verecek soruları içermemektedir ve yöntemler öğrencinin konuyu öğrenmesinde bir aksaklık meydana getirmeyecektir. Ancak, katılım sırasında sorulardan ya da herhangi başka bir nedenden ötürü çocuğunuz kendisini rahatsız hissederse çalışmayı yarıda bırakıp çıkmakta serbesttir. Böyle bir durumda çocuğunuzun araştırmacıya, çalışmayı tamamlamayacağını söylemesi yeterli olacaktır. Uygulama sonunda, bu çalışmayla ilgili sorularınız cevaplanacaktır ve araştırma sonuçlarının özeti tarafımızdan okullara ulaştırılacaktır. Araştırmaya katılarak bize sağladığınız bilgiler Fizik derslerinin öğrencilerin kişisel özelliklerine daha uygun işlenmesi ve bu şekilde başarının attırılması konusunda önemli bir katkıda bulunacaktır. Bu çalışmaya katıldığınız için şimdiden teşekkür ederiz.

Araştırma hakkında daha fazla bilgi almak için Orta Doğu Teknik Üniversitesi Orta Öğretim Fen ve Matematik Alanları Eğitimi Bölümü araştırma görevlilerinden Hanife Can ŞEN (Oda: 204; Tel: 210 3686; e-posta: hsen@metu.edu.tr) ile iletişim kurabilirsiniz.

Saygılarımızla,

Araş. Gör. Hanife Can ŞEN

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Orta Doğu Teknik Üniversitesi, Ankara
Tel: (0312) 210 3686
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*Lütfen bu araştırmaya katılmak konusundaki tercihinizi aşağıdaki seçeneklerden size en uygun gelenin altına imzanızı atarak belirtiniz ve bu formu çocuğunuzla okula geri gönderiniz.*

**A)** Bu araştırmaya tamamen gönüllü olarak katılıyorum ve çocuğum ......................................'nın da katılımcı olmasına izin veriyorum. Çalışmayı istediğim zaman yarıda kesip bırakabileceğimi biliyorum ve verdiğim bilgilerin bilimsel amaçlı olarak kullanılmasını kabul ediyorum.

Baba Adı-Soyadı.................................... Anne Adı-Soyadı.......................................

İmza ...................................................... İmza .........................................................

**B)** Bu çalışmaya katılmayı kabul etmiyorum ve çocuğumun........................................'nın da katılımcı olmasına izin vermiyorum.

Baba Adı-Soyadı.................................... Anne Adı-Soyadı.......................................

İmza ...................................................... Imza ………………………………………………

# APPENDIX N

## PERMISSION CERTICIFATE FOR THE IMPLEMENTATION

ÖĞRENCİ İŞLERİ
DAİRESİ BAŞKANLIĞI
Ev. Arş. Md. Saat :

T.C.
AYDIN VALİLİĞİ
İl Milli Eğitim Müdürlüğü

SAYI : B.08.4.MEM.4.09.00.06/ 14.10.2008* 34536 AYDIN

KONU : İzin

ORTADOĞU TEKNİK ÜNİVERSİTESİ REKTÖRLÜĞÜNE

ANKARA

İlgi : 30/07/2008 tarihli 5669 sayılı yazınız

Üniversitenin Ortaöğretim Fen ve Matematik Alanları Eğitimi Anabilim Dalı Doktora Programı öğrencilerinden Hanife Can ŞEN 'in, 15 Eylül 2008- 02 Ocak 2009 tarihleri arasında "Bir Öğrenci Özellikleri-Uygulama Etkileşimi Çalışması:Öğrenci Merkezli ve Öğretimin Lise Öğrencilerinin Fizik Başarısı Üzerindeki Etkisi" başlıklı tez çalışmasına ilişkin olarak Aydın Lisesi, Fen Lisesi, Emel Mustafa Uşaklı And. Lis. Cumhuriyet Lisesi, Efeler Lisesi, S.DEMİREL Anadolu Lisesi, Adnan Menderes Anadolu Lisesinde uygulama çalışması yapmasını uygun gören Valilik Makamının onayı ekte gönderilmiştir.

Bilgilerinizi ve Araştırma bitiminde sonuç raporunun bir örneğinin Müdürlüğümüz Kültür Hizmetleri Şubesine gönderilmesi hususunda gereğini rica ederim.

Alp ASLANARGUN
Vali a.
Vali Yardımcısı

EK :
1)Valilik Oluru(1 adet)
2)Anket
3)Düzgün Dairesel Hareket Konusuna İlişkin Tutum Ölçeği
4)Düzgün Dairesel Hareket Başarı Testi
5)Gizlenmiş Figürler Grup Testi

20.10.08 016055

# CURRICULUM VITAE

## PERSONAL INFORMATION

Surname, Name: Şen, Hanife Can

Nationality: Turkish (TC)

Date and Place of Birth: 10 January 1980, Aydın

Marital Status: Single

Phone: +90 312 242 13 92

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## EDUCATION

| **Degree** | **Institution** | **Year of Graduation** |
|---|---|---|
| M.Sc. | METU Secondary Science and Math. Ed. | 2003 |
| High School | Aydın Adnan Menderes Anadolu Lisesi | 1998 |

## WORK EXPERIENCE

| **Year** | **Place** | **Enrollment** |
|---|---|---|
| 2005-Present | METU Dept. of Secondary Science and Math. Ed. | Research Assistant |
| 2003-2004 | TED Ankara Koleji | Part-time Teacher |

## HOBBIES

Dancing, Traveling, Reading, Photography