THE ROLES OF GENDER AND LEARNING STYLES ON TENTH GRADE STUDENTS' KINEMATICS GRAPHING SKILLS

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I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Science.

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ABSTRACT

THE ROLES OF GENDER AND LEARNING STYLES ON TENTH GRADE STUDENTS' KINEMATICS GRAPHING SKILLS

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This study was designed to investigate the roles of gender and learning styles on tenth grade students' kinematics graphing skills. In this study Test of Understanding Graphs-Kinematics and Learning Style Inventory were used as measuring tools. Test of Understanding Graphs-Kinematics was translated into Turkish and pilot tested with 60 tenth grade students from a representative school.

The main study was conducted in 14 representative cities throughout seven different geographical regions over Turkey with a total of 989 tenth grade students in last four weeks of the spring semester of 2002-2003 school year.

The data obtained from the administration of the measuring instruments were analyzed by using both descriptive and inferential statistics. Findings of the kinematics graphing skills test indicated that general performances of the students were very low and many students have difficulties in interpreting kinematics graphs.

When the data were analyzed using Analysis of Covariance (ANCOVA), while controlling the effects of students' age, previous physics course grades and previous mathematics course grades, the results indicate that there was no significant difference among the kinematics graphing skills test scores of students having different learning styles. Similarly, no significant difference was found between the kinematics graphing skills test scores of female and male students. On the other hand, a significant interaction was observed between gender and learning styles on students' kinematics graphing skills test scores. The most common learning style type was assimilator for the participants of this study. Accommodator female students' kinematics graphing skills test scores were higher than that of female students having other learning styles and converger male students' kinematics graphing skills test scores were higher than that of male students having other learning styles on kinematics graphing skills test. Bivariate correlations revealed significant positive correlations between students previous physics course grades, previous mathematics course grades, and age and their kinematics graphing skills test scores.

Keywords: Physics Education, Kinematics Graphing Skills, Learning Style

ÖZ

CINSIYETIN VE ÖGRENME STILLERININ ONUNCU SINIF ÖGRENCILERININ KINEMATIK GRAFIK BECERILERINDEKI ROLÜ

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Yüksek Lisans, Orta Ögretim Fen ve Matematik Alanlari Egitimi Bölümü

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Bu çalisma, onuncu sinif ögrencilerinin cinsiyetlerinin ve ögrenme stillerinin kinematik grafik becerilerindeki rolünü arastirmak için tasarlanmistir. Bu çalismada, ölçüm araçlari olarak Grafikleri Anlama Sinavi-Kinematik ve Ögrenme Stilleri Envanteri kullanilmistir. Grafikleri Anlama Sinavi-Kinematik Türkçe ye çevrilmis ve 60 onuncu sinif ögrencisinin katilimiyla pilot çalismasi gerçeklestirilmistir.

Esas çalisma, 2002-2003 ögretim yilinin bahar döneminin son dört haftasinda Türkiye'nin yedi cografi bölgesindeki 14 ilden toplam 989 onuncu sinif ögrencisine uygulanmistir.

Elde edilen veriler, betimsel ve kestirisel istatistik teknikleri kullanilarak degerlendirilmistir. Kinematik grafik becerisi testinin bulgulari ögrencilerin genel performanslarinin düsük oldugunu ve ögrencilerin çogunun kinematik grafiklerini yorumlamada güçlük çektiklerini göstermistir. Ögrencilerin önceki fizik ve matematik ders notlari ile yaslari kontrol edilerek veriler Kovaryans Analizi

(ANCOVA) kullanilarak analiz edildiginde, sonuçlar, farkli ögrenme stillerine sahip ögrencilerin kinematik grafik becerisi puanlari arasinda anlamli bir fark olmadigini göstermistir. Benzer sekilde, kiz ve erkek ögrencilerin kinematik grafik becerisi testi puanlari arasinda da anlamli bir fark bulunmamistir. Öte yandan, ögrencilerin kinematik becerisi testi puanlarinda, cinsiyet ve ögrenme stilleri arasinda anlamli bir etkilesim oldugu gözlenmistir. Çalismaya katilan ögrenciler arasinda özümseyen ögrenme stilinin son derece yaygin oldugu görülmüstür.Yerlestiren ögrenme stiline sahip kiz ögrencilerin kinematik grafik becerisi testi puanlarinin, diger ögrenme stillerine sahip kiz ögrencilerin puanlarindan; ayrica ayristiran ögrenme stiline sahip erkek ögrencilerin kinematik grafik becerisi testi puanlarinin diger ögrenme becerilerine sahip erkek ögrencilerin puanlarindan daha yüksek oldugu saptanmistir. Basit iliski analizleri, ögrencilerin önceki fizik ve matematik ders notlari ve yaslari ile kinematik grafik becerileri arasinda pozitif iliski oldugunu göstermistir.

Anahtar Kelimeler: Fizik Egitimi, Kinematik Grafik Becerisi, Ögrenme Stili

To my father and my son

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SYMBOLS

TUG-K	: Test of Understanding of Graphs-Kinematics
LSI	: Learning Style Inventory
PPCG	: Previous Physics Course Grades
PMCG	: Previous Mathematics Course Grades
KGST	: Kinematics Graphing Skills Test Scores
LS	: Learning Style
DV	: Dependent Variable
IV	: Independent Variable
ANCOVA	: Analysis of Covariance
df	: Degrees of Freedom
N	: Sample Size
a	: Significance Level

CHAPTER 1

INTRODUCTION

The rapid increase in developments on science and technology influences education systems of nations besides lives of many people. As transmitting the knowledge has been accelerated the importance of science has been enhanced. Thus, there have been fundamental changes in traditional transmitting of knowledge due to changes in socioeconomic, technological and educational conditions. The science education has become very important because nations have need qualified stuff, especially engineers and researchers who are the outputs of their education systems.

Since 1950's, almost all of the researches on science education have been trying to find out and evaluate the effect or contribution of factors that affecting achievement in science courses. Many factors, such as socio-economic status, anxiety, critical thinking, language skills, problem solving, logical thinking...etc. have been studied. In the attempts to develop science education, the physicists, psychologists and science educators have focused their attentions to the problems of teaching physics. They have also been conducting research that has yielded detailed information about how students learn physics (McDermott, 1984). For some investigators, primary emphasis has been on conceptual understanding in a particular area of physics such as mechanics, electricity, heat or optics. Moreover, McDermott (1984) says that "the results indicate that similar difficulties occur among students of different ages and ability, often in spite of formal study in physics. The persistence of these difficulties suggests that they are not easily overcome, and need to be addressed explicitly during instruction.”(p.24)

More specifically, in order to mention about teaching and learning physics it has to mention about introductory physics. Mechanics comprises a major part of the content of virtually every introductory physics course in both high school and collage. So, the concepts of motion deserve special attention. In here kinematics as a common subject is indicated. A considerable effort has been made to examine what physics students learn from their introductory classes dealing with kinematics- the motion of objects. This one area of physics instruction has received more attention than others because researchers have recognized the importance of this topic as a “building block” upon which other concepts are based (Beichner, 1994). With respect to kinematical aspects of motion, researchers indicates that the most common and critical problem is a failure to discriminate among the various kinematical quantities (Halloun & Hestenes, 1985).

“Teaching a traditional introductory physics course introducing motion, which includes concepts of position, velocity and acceleration without using graphs is not possible if one wants to explain the essence of these concepts” (Zajkov & Jonoska, 2003). Graphs are extensively used by scientists because of their abilities to visualize a complex and large set of data and in that way offer a valuable alternative to verbal and algebraic description and summarize a functional relationship (Zajkov & Jonoska, 2003; Berg & Phillips, 1994; Mokros & Tinker, 1987; Brasel, 1987b; Nachmias & Linn, 1987; McDermott, Rosenquist & van Zee, 1987). A depicting a physical event allows a looking of trends which can not easily be recognized in another way. Graphs summarize large amounts of information while still allowing details to be resolved for that reason the ability to understand and use of graphs may be an important step toward expertise in problem solving. Graphs are such efficient packages of data; they are used almost as a language by physics teachers but unfortunately not by students efficiently (Beichner, 1994). The students often misunderstand graphs. Some students do not like graphs since interpreting them require understanding physics i.e. require conceptual knowledge.

Some researchers have found out and categorized the difficulties related with graphs (Goldberg & Anderson, 1989; Svec, 1995; Berg & Philips, 1994; Mokros & Tinker, 1987; Brasel, 1987b; Nachmias & Linn, 1987; McDermott, Rosenquist & van Zee, 1987). Others have studied on overcoming these problems and improving graphing skills of students (Nachmias & Linn, 1987; Mokros & Tinker, 1987; Brasel, 1987; Thornton & Sokolof, 1990; Svec, 1995; Beichner, 1990; Brungardt & Zollman, 1995; Hale, 2000).

The common aim of these studies is trying to find out the answer of the question "How students learn better kinematics graphs?" If it would be reached the reasons beneath the problems that students have related with graphing and the process of teaching would be planned in that direction then it can overcome the failure of students at the beginning. The answer of the question above can be concealed in the nature of the "learning".

Individuals have learning skills when he was born. They improve these skills as an instinct for saving their life with a continuous interaction of their environment. On the contrary that it can be defined in vary, many of the psychologists indicate that learning happens with the interaction of environment and it causes a change in the life of individual (Fidan & Erden, 1993). We are often confronted with new experiences or learning situations in life, in careers or on the job. Different person gives different reaction and learns different from each other. Each individual develops a preferred and consistent set of behaviors or approaches to learning. "The way each learner begins to concentrate, process and retain new and difficult information" is called learning style (Dunn, 1990, cited in Larkin-Hein, 2000, p. 2). Learning style is facilitated by the individual's perceptual and sensory strengths and is not, in itself, ability, but rather a preference (Taylor, 1997). As noted by Sims and Sims (1995, cited in Farquharson & Bernatte, 2003), knowledge of learning styles can be used in many ways to assist the instructor in developing strategies to enhance learning in the classroom.

With respect to learning styles, research has shown that what students learn is significantly influenced by their individual differences such as pre-existing knowledge, age and gender. McDermott (1984) states that students of different ages and educational backgrounds often begin their study of physics with very similar ideas, many of which are in conflict with the concepts of physics. For the last two decades, science educators have evidenced the gender differences in science, such as achievement, attitude, motivation, interest, and performance behaviors. Although girls notice the significance and importance of scientific knowledge for future events to a much smaller extend than boys, the requirements in mathematics and science are normally considered higher by them than by boys (Schwedes, 2003). Murphy (1996 cited in Hsiung, Hsiung & Lin, 2003) pointed out that gender difference in science, in favor of boys. According to Hsiung, Hsiung and Lin (2003), the boys and girls use different ways to solve problems or to do experiments in science classes. Most girls like to follow teacher's instruction or textbook's step to solve problems or to do experiments. Boys on the other hand, like to use their ways to solve problem or to do experiments in general. Similarly girls do reading textbook more than boys this way the girls are more influenced by all which is positive as well as negative of the curricula, which are implemented in the textbook.

In Turkey, students firstly meet concept of graph at the 7th level. The unit of 'statistics and graphs' is the last chapter of their mathematics textbook. For several reasons, this chapter can not be studied. So, students couldn't understand the essence of graphs and couldn't have basic graphing skills (Isik, 2003). There is no more research on specifically on understanding of kinematics graphs in Turkey. For the reasons have already discussed, we can confirm that there is an urgent necessity of specifying determinants of kinematics graphing skills in our schools. Since students' learning styles and gender was found as important determinants of school performance by previous research and there isn't any study on factors influence kinematics graphing skills in our schools, this study attempts to investigate the relationship between tenth grade students' learning styles and the kinematics graphing skills.

1.1 Main Problem and Sub-problems

1.1.1 The Main Problem

The main problem of this study is stated as;

Do students' learning style and gender have significant effects on the kinematics graphing skills of the tenth grade students?

1.1.2 The Sub-problems

1) What is the effect of learning styles on tenth grade students' kinematics graphing skills test scores when the effects of students' age, previous physics course grades and previous mathematics course grades are controlled?

2) What is the effect of gender on tenth grade students' kinematics graphing skills test scores when the effects of students' age, previous physics course grades and previous mathematics course grades are controlled?

3) Is there a significant interaction between gender and learning styles on tenth grade students' kinematics graphing skills test scores when the effects of students' age, previous physics course grades and previous mathematics course grades are controlled?

4) Is there a significant relation between tenth grade students' age and their kinematics graphing skills test scores?

5) Is there a significant relation between tenth grade students' previous physics course grades and their kinematics graphing skills test scores?

6) Is there a significant relation between tenth grade students' previous mathematics course grades and their kinematics graphing skills test scores?

1.2 Hypotheses

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

Null Hypothesis 1: There will be no significant main effect of learning styles on the population means of the kinematics graphing skills test scores when the effects of students' age, previous physics course grades and previous mathematics course grades are controlled.

Null Hypothesis 2: There will be no significant main effect of gender on the population means of the kinematics graphing skills test scores when the effects of students' age, previous physics course grades and previous mathematics course grades are controlled.

Null Hypothesis 3: There will be no significant interaction between gender and learning styles on the population means of the kinematics graphing skills test scores when the effects of students' age, previous physics course grades and previous mathematics course grades are controlled.

Null Hypothesis 4: There will be no significant relation between tenth grade students' age and the population means of the kinematics graphing skills test scores.

Null Hypothesis 5: There will be no significant relation between tenth grade students' previous physics course grades and population means of the kinematics graphing skills test scores.

Null Hypothesis 6: There will be no significant relation between tenth grade students' previous mathematics course grades and population means of the kinematics graphing skills test scores.

1.3 Definition of Important Terms

Students' learning styles (LS), gender, previous physics course grades (PPCG), previous mathematics course grades (PMCG) and age are the independent variables (IVs) of this study. Students' kinematics graphing skills test scores (KGST) is dependent variable (DV). Following terms are necessary in understanding this study.

Students' gender: It is the fact of being male or female.

Students' age: The ages of students in years, participated in the study were taken at the time of testing. It was used as a covariate in the statistical analysis.

Learning Style (LS): The interaction of cognitive, affective and physiological behaviors as the learner perceives, interacts with, and responds to the learning environment. As identified by Kolb in his Learning Style Inventory, learning style is a measure of an individual's relative emphasis on the four learning modes (Concrete Experience-CE; Reflective Observation-RO; Abstract Conceptualization-AC and Active Experimentation-AE). It was measured by Learning Style Inventory (LSI).

PPCG: Students' physics course grades in the previous semester. It was used as a covariate in the statistical analyses.

PMCG: Students' mathematics course grades in the previous semester. It was used as a covariate in the statistical analyses.

Kinematics Graphing Skills: Understanding, using and interpreting a graph. It was measured by Test of Understanding Graphs-Kinematics (TUG-K).

1.4 Significance of the Study

In modern societies, individuals don't be rest, themselves; they are educated in an educational system in order to benefits of that society and individual. In that way, education becomes a public service. In general, in order to obtain learning outputs, all of the performances that are planned and organized with determined goals are instruction (Fidan & Erden, 1993).

One of the major priorities of science educators should be to help all students improve their science learning. At the beginning of the instructional process, it is very important that knowing the students' efficiency and skills. The entry characteristics of the students are the indicators that what they are able to learn or what they are not able to learn. One of the most important entry characteristic is learning styles. Before the learning process, knowing those students' learning styles-their strength and weaknesses-is very useful for design teaching strategies in terms of their active involvement in the process.

Designing science education in the level of secondary school is not so easy for the educators. From the childhood to the adolescence, individuals have to relate new information and scientific concepts with the old ones; and assimilate them. These learning concepts go through from general to specific and from simple to complex.

Depends on some researches, it is obvious that the study of graphs can lead to deeper understanding of physical concepts (Özgün-Koca, 2001; Mokros & Tinker, 1987; Brasel, 1987b; Nachmias & Linn, 1987; McDermott, Rosenquist & van Zee, 1987). However, there are many problems that students have related with graphing and modeling (Goldberg & Anderson, 1989; Svec, 1995). As mentioned above there are so many studies all over the world about students' difficulties in kinematics graphs and improving graphing skills but it has not been performed a similar study in Turkey, yet. According to the above supplied knowledge, it is seen worthwhile to state that, investigating students' individual differences such as learning styles, gender and age and seeking their relationship with the kinematics graphing skills, seems to shed light to teaching-learning of the introductory physics. Therefore, the present study is designed to:

1. find out, to what extend there is a relationship between students learning styles and kinematics graphing skills.
2. explore implications and make recommendations for establishment of a more effective instruction for better understanding in physics courses and to guide instructors in predicting students' performance.

CHAPTER 2

REVIEW OF RELATED LITERATURE

There has been a steadily increasing amount of research on the learning and teaching of physics during the past two decades. The results indicate that the difference between what is taught and what is learned is much grater than realized especially at the introductory level (McDermott, 1991). An important outcome has been the identification and analysis of student difficulties. Reports on the nature and prevalence of these difficulties constitute a rich source of documented information that physics instructors can use as resource. To bring about an increase in student learning, however, research must include a second and a third component: the development of instructional strategies and materials and the examination of their effect on student learning.

One of the most important topics of introductory physics is kinematics. Researchers have emphasized on how effective kinematics concepts are taught and which factors role on the effectiveness of the instruction. Some researchers have studied on the conceptual understanding of kinematics; others have studied on student difficulties in connecting graphs and kinematics. However there must be some other factors that influence the instruction of kinematics. These are individual differences, such as learning styles and gender of the students.

This review starts by conceptual and functional understanding of kinematics learning and then continues with graphic understanding of students and finally the students' preferred learning styles.

2.1 Conceptual and Functional Understanding of Kinematics

Kinematics is the branch of mechanics that deals with pure motion, without reference to the masses or forces involved in it. Researchers think that kinematics is the most difficult topic in elementary mechanics (Hesteness & Wells, 1992). When one searches for sources of the difficulty that students encounter in kinematics, one can identify many contributing factors such as abstractness of the material, degree of logical precision required in problem solving and so on (Clement,1982). McDermott (1994) says that "The criterion most often used in introductory physics as a measure of mastery of the subject is performance on standard quantitative problems" (p. 46). Students completing traditional courses can usually perform complex calculations and solve the problems required to achieve a high grade, but are incapable of displaying an understanding of the concepts underlying the problems' solutions (Mestre, 1991). As a result, these students do not develop a functional understanding of physics that is the ability to do the reasoning needed to apply relevant concepts in situations not previously encountered.

Even for successful physics students there seems to be a lack of basic conceptual understanding. In order to mention about conceptual understanding of kinematics subject, it has to be mentioned about another source of difficulty: students' existing knowledge prior to instruction. The students' prior knowledge provides an indication of the misconceptions as well as the scientific conceptions possessed by the students (Hewson & Hewson, 1983).

2.1.1 Misconceptions

Brown (1992) used the term *misconception* to refer to “student's ideas which are incompatible with currently accepted scientific knowledge” (p.18). Other researchers used descriptions such as *alternative conceptions* (Hewson & Hewson, 1983); *preconceptions* (Clement, 1982) and *commonsense concepts* (Halloun & Hestenes, 1985). It was preferred to use “misconception” because “The commonsense alternatives to Newtonian concepts are commonly labeled as *misconceptions*” (Hestenes, Wells & Swackhamer, 1992, p. 1056). Physics students bring many misconceptions to the classroom. Certainly it must be the major determinant of what the student learns in the course (Halloun & Hesteness, 1985).

2.1.2 Misconceptions about Kinematics

Halloun and Hesteness (1985) have surveyed and analyzed the commonsense beliefs of collage students about motion. According to them every one of the misconceptions about motion common among students today was seriously advocated by leading intellectuals in pre-Newtonian times. To survey concepts about motion held by collage students enrolled in physics course, they used a multiple-choice mechanics diagnostic test and conducted interviews. After that they have summarized the characteristic of commonsense kinematical concepts related with *description of motion*. These were:

a. The concepts of "time interval" and "instant of time" are not differentiated. An "instant" is regarded as a very short time interval.

b. Velocity is *defined* as distance divided by time. Thus average velocity is not differentiated from instantaneous velocity.

c. Concepts of distance, velocity, and acceleration are not well differentiated (p.1063).

Whereas, Hesteness, Wells and Swackhamer (1992), have stated commonsense beliefs play a dominant role in introductory physics, but in kinematics it is not really appropriate to speak of commonsense misconceptions. Rather, the typical commonsense concept of motion is vague and undifferentiated. Thus we preferred to use "difficulty" rather than commonsense concept (or misconception).

One goal of physics instruction is developing curricula that will overcome commonly recognizable difficulties in students' understanding of physical phenomenon. One problem is that students do not connect the physics of motion with their everyday experiences. For example, students have cognitive difficulty with the physics concept of negative velocity, in part because a car only gives them a positive sense of velocity. "When the physics teacher says that 20 m/s east is a positive velocity and 20 m/s west is a negative velocity, the students become confused" (Brungardt & Zollman, 1995, p.856), because Goldberg and Anderson (1989) reported that students believe that negative means "a lesser quantity" or "losing something".

One of the early researches in this area is an empirical study performed by Trowbridge and McDermott in 1980. They have investigated systematically student understanding of the concept of velocity in one dimension. The criterion selected for assessing understanding of a kinematical concept was the ability to apply it successfully in interpreting simple motions of real objects. Instructors generally assume that good performance on course examinations indicates that conceptual understanding is achieved. However, they have found that many students who can do well on conventional test questions cannot correctly apply the kinematical concepts to interpretation of notions observed in the laboratory or in everyday life. "The principal conceptual difficulty demonstrated by students participating in the study was an inability to discriminate between position and velocity" (p. 1028). Another result of the study was that students frequently do not relate their intuition of how fast an object is going to the ratio of the distance traveled to the elapsed time or to the idea of velocity *at* an instant.

In another study Trowbridge and McDermott (1981) have systematically investigated the understanding of the concept of acceleration among students. The criterion for assessing understanding of a kinematical concept was the same with their previous study. The main trust of that study has been on the qualitative understanding of acceleration as the ratio ?*v*/ ?*t*. The results shown that introductory physics students frequently fail to a qualitative understanding of the concept of acceleration as the ratio of ?*v*/ ?*t;* additionally, they do not understand clearly the distinction between instantaneous and average velocity.

2.2 Kinematics Graphs

The methods of displaying trends and relationships between variables are important. MacDonald-Ross (1977, cited in McKenzie et al., 1986) states: "… every discipline in the social, biological, and physical sciences, all applied sciences and every instrument of social and governmental policy depends upon the appropriate use of quantitative data" (p. 571). One type of presenting quantitative data is the line graph. Line graphs show the relationship between two continuous variables in pictorial form. "A graph is depicting a physical event allows a glimpse of trends which cannot easily be recognized in a table of the same data" (Beichner, 1994, p. 750). Mokros and Thinker note that a graph allows scientists to use their powerful visual pattern recognition facilities to see trends and spot subtle differences in shape (1987).

Graph construction and interpretation have been identified as important skills to common to both science and mathematics education (Gallagher, 1979, cited in McKenzie et al., 1986). According to McKenzie and Padilla (1986), in science, more than in any other subject, students should be involved in predicting relationships between variables and attempting to qualify these relationships. Therefore, it has been argued that there is no other statistical tool as powerful for facilitating pattern recognition in complex data (Beichner, 1994). Study of graphs can lead to deeper understanding of physical concepts (Berg & Phillips, 1994; Mokros & Tinker, 1987; Brasel, 1987b; Nachmias & Linn, 1987; McDermott, Rosenquist & van Zee, 1987). Therefore, line graph construction and interpretation are very important to science instruction because they are an integral part of experimentation. However research indicates many students have not acquired these skills, especially in kinematics (Beichner, 1994, McDermott, Rosenquist & van Zee, 1987, McKenzie & Padilla, 1986).

Mckenzie and Padilla (1986) studied on a project; object of which was to develop a multiple choice Test of Graphing Skills in Science (TOGS) appropriate for science students from grades seven through twelve. Skills associated with the construction and interpretation of line graphs were delineated, and some objectives encompassing those skills were developed. In order to measure them, twenty-six items were constructed. The subject of the study is 377 7th to 12th grade students. The reliability (KR-20) was 0.83 for all subjects; Point biserial correlations showed 24 of the 26 items above 0.30 with an average value of 0.43. From this and other data, it was concluded that Test of Graphing in Science (TOGS) was valid and reliable instrument for measuring graphing abilities. Although there have been such studies given below in order to construct an assessment tool on line graphs, researchers have need to develop some instruments in order to assess students' performances and/or difficulties on kinematics graphing skills specifically. It will be mentioned about such an instrument later.

Kinematics graphs have position, velocity or acceleration as the ordinate and time as the abscissa. Because of their wide-spread use as a teaching tool, there have been a great number of studies on students' ability to interpret kinematics graphs.

2.2.1 Students' Difficulties in Kinematics Graphing Skills

McDermott, Rosenquist and Van Zee (1987) studied on difficulty in connecting graphs to physical concepts, and difficulty in connecting graphs to the real world. Those are taken from the results of a descriptive study extending over a period of several years and involved several hundred collage students who were enrolled in a Laboratory-based preparatory physics course. It has seen that from the results, the graphing errors made by that group of students were not common, but were found in different populations and across different levels of sophistication. Specific difficulties in each category were discussed in terms of student performance on written problems and laboratory experiments. The study took time over a period of several years end it involved several hundred-university students who were enrolled in a laboratory-based preparatory physics course. Based on student pencil and paper constructed graphs, and from narrative information, McDermott et al. (1987) categorized 10 difficulties students had in the graphing of kinematics data under two main categories:

1. Difficulties in connecting graphs to physical concepts:
    - Discriminating between the slope and height of a graph
    - Interpreting changes in height and changes in slope
    - Relating one type of graph to another
    - Matching narrative information with relevant features of a graph
    - Interpreting the area under a graph
2. Difficulties in connecting graphs to the real world:
    - Representing continuous motion by a continuous line

- Separating the shape of a graph from the path of the motion
- Representing a negative velocity on a *v* vs. *t* graph
- Representing constant acceleration on an *a* vs. *t* graph
- Distinguishing among different types of motion graphs

Other difficulties were noted (Mokros & Tinker, 1987; McDermott, Rosenquist &van Zee, 1987; Goldberg & Anderson, 1989; Nachmias & Linn, 1987) that contribute to difficulties referred to in the above categories. These include;

- Graph as a picture
- Slope/Height confusion
- Graph Shape and Path of motion confusion.

If graphs are to be valuable tool for students, then we have to determine the level of the students' graphing ability (Svec, 1995). In order to do this Svec (1995) has developed a Graphing Interpretation Skills Test (GIST) about motion. He has adapted three of the questions from TOGS (by Mckenzie & Padilla, 1986). And he has written the remaining items by himself. Distracters were developed and were based on previously identified misconceptions and difficulties. Graphing Interpretation Skills Te st (GIST) had a KR-20 reliability of .97.

Beichner (1994) studied on the process of developing and analyzing a test in order to report student problems with interpreting kinematics graphs. For this study data from 895 students at the high school and collage level was collected and analyzed. The development and analysis of the Test of Understanding Graphs in Kinematics (TUG-K) was described in the study .The results indicate that this test would help teachers modify their instruction to better address student difficulties with kinematics graphs. In addition to this result, Beichner summarized 6 common student difficulties with kinematics graphs. These difficulties are given below:

1) Graph as Picture Errors

The graph is considered to be like a photograph of the situation. It is not seen to be an abstract mathematical representation, but rather a concrete duplication of the motion event.

2) Slope/ Height Confusion

Students often read values off the axes and directly assign them to the slope.

3) Variable Confusion

Students do not distinguish between distance, velocity, and acceleration. They often believe that graphs of these variables should be identical and appear to readily switch axis labels from one variable to another without recognizing that the graphed line should also changed.

4) Nonorigin Slope Errors

Students successfully find the slope of lines which pass through the origin. However, they have find difficulty determining the slope of a line (or the appropriate tangent line) if it does not go through zero.

5) Area Ignorance

Students do not recognize the meaning of areas under kinematics graph curves.

6) Area/ Slope/ Height Confusion

Students often perform slope calculations or inappropriately use axis values when area calculations are required (p. 755).

As a result, students have many difficulties in interpreting and analyzing kinematics graphs and variables. The common aim of these studies is trying the find out the answer of this question: "How students learn better kinematics concepts?" If it would be reached the reasons beneath the problems that students have related with graphing then the process of learning would be planned in that direction and it can overcome the failure of students at the beginning. The answer of the question above it can be concealed in the nature of the "learning".

2.3 Learning Styles

As is evidenced by attendance at the many educational process conferences, educators are increasingly concerned about the efficacy of their instruction. One approach that has been utilized is to study the process by which students learn. Learning is the process whereby knowledge is created through the transformation of experience (Kolb, 1984). A growing body of research on adult learners suggests that increased learning gains can be achieved when instruction is designed with students' learning styles in mind (Dunn, Bruno, Sklar, & Beaudry, 1990; Larkin-Hein, 2000).

Additionally, several researchers within the domain of physics education have noted the importance of teaching with learning styles in mind.

What exactly is a learning style? There are several definitions of learning style currently exist. Keefe (1987, cited in Larkin-Hein, 2000) described learning style as being characteristic of the cognitive, affective, and physiological behaviors that serve as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment. Learning style also represents both inherited characteristics and environmental influences.

Dunn (1990) defined learning style as "... the way each learner begins to concentrate, process, and retain new and difficult information" (p. 224). She noted that this interaction is different for everyone. Dunn also highlighted that "To identify and assess a person's learning style it is important to examine each individual's multidimensional characteristics in order to determine what will most likely trigger each student's concentration, maintain it, respond to his or her natural processing style, *and* cause long-term memory" (p. 224). She also noted that the uniqueness of individual learning styles could be thought of as a fingerprint. She said "Everyone has a learning style, but each person's is different - like our fingerprints which come from each person's five fingers and look similar in many ways" (p. 27). Felder (1996) also have a similar opinion, according to him students have different learning styles-characteristic strengths and preferences in the ways they take in and process information. Some students tend to focus on facts, data, and algorithms; others are more comfortable with theories and mathematical models. Some respond strongly to visual forms of information, like pictures, diagrams, and schematics; others get more from verbal forms-written and spoken explanations. Some prefer to learn actively and interactively; others function more introspectively and individually. Functioning effectively in any professional capacity, however, requires working well in all learning style modes. Dunn further noted that an individual's learning style can change over time as a result of maturation. Kolb (1984, cited in Larkin-Hein, 2000) has suggested that

> "As a result of our hereditary equipment, most people develop learning styles that emphasize some learning abilities over others. Through socialization experiences in family, school, and work, we come to resolve the conflicts between being active and reflective and between being immediate and analytical in characteristic ways, thus lending to reliance on one of the four basic forms of knowing" (p. 76 – 77).

The fact that individuals perceive and process knowledge differently leads to the approach defined as 'Learning Styles Theory'. According to learning style theory, instruction must be presented in different ways related to these differences. In other words, the instructor should ask "how can this learner achieve more?" rather than "why is this learner not a high achiever?"

2.3.1 Kolb's Model for Learning Style and Experiential Learning Theory

David Kolb, developed the Learning Style Inventory (LSI) in 1976 (Larkin-Hein, 2000), and revised by he and other associates in order to improve and refine its psychometric properties (Atkinson, 1991). The LSI was a 12-item self-report questionnaire in which four words describing one's style were rank-ordered. One word in each item was used to correspond to one of four learning modes. Within the Kolb Learning Style Model four learning modes are identified: (1) *Concrete Experience* (CE), (2) *Reflective Observation* (RO), (3) *Abstract Conceptualization* (AC), and (4) *Active Experimentation* (AE).

The CE mode describes people who feel more than they think. An individual in this mode tends to be very good at relating to others and tends to be an intuitive decision-maker.

The RO mode describes people who would rather watch and observe others rather than be active participants. An individual in this mode tends to appreciate exposure to differing points of view.

The AC mode describes people who think more than they feel. Such a person tends to have a scientific approach to problem solving as opposed to a more artistic approach.

The AE mode describes individual who takes an active role in influencing others as well as situations. This individual welcomes practical applications rather than reflective understanding as well as actively participating rather than observing.

According to Sims and Sims (1995, p. 18, 19), effective learning is promoted if the learner goes through four stages. Figure 2.1 shows cycle of learning.

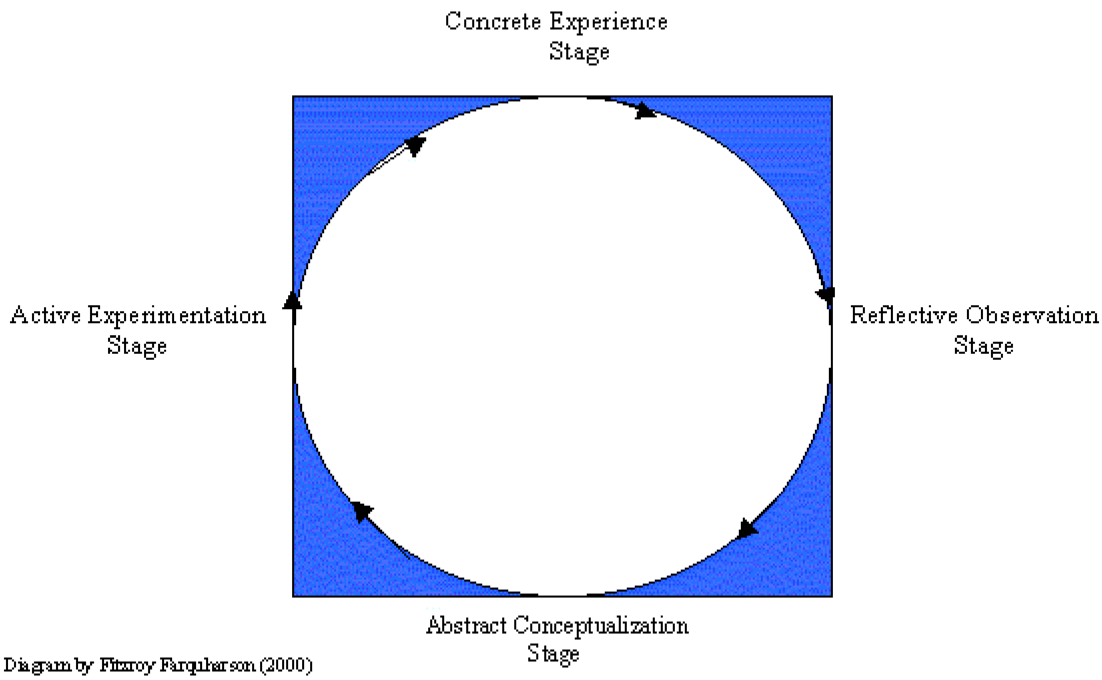

Figure 2.1 Kolb's Experiential Learning Cycle

The theory of Kolb describes, therefore, the process through which the four systems or modes of human experience are engaged at various levels of complexity to create more complete levels of the understanding. A person can try to solve a problem analyzing it exclusively under its personal perspective or considering similar problems; while other try to solve it reflecting about it and elaborating a resolution plan or testing several application manners to arrive to the resolution. The base of the theory of Kolb is, therefore, the balance and the experience in all the four learning types. The favorite learning style of any student can be identified using the Learning Style Inventory. This inventory is a test of preferences selection that requests identification with the several descriptions of the four learning abilities. With the application of that test in thousands of students, Kolb discovered that the students themselves are declared as belonging to one of the four types.

In his work Kolb identified four statistically prevalent learning styles. These styles are referred to as the *Diverger*, the *Assimilator*, the *Converger*, and the *Accommodator*. Felder describes these styles as Type I, Type II, Type III, and Type IV respectively (Felder, 1996). As shown in Figure 2.2, these styles (or types) can be graphed on a coordinated grid illustrating the bipolar dimensions of *doing* (AE) versus *watching* (RO) on the x-coordinate, and *feeling* (CE) versus *thinking* (AC) on the y-coordinate.

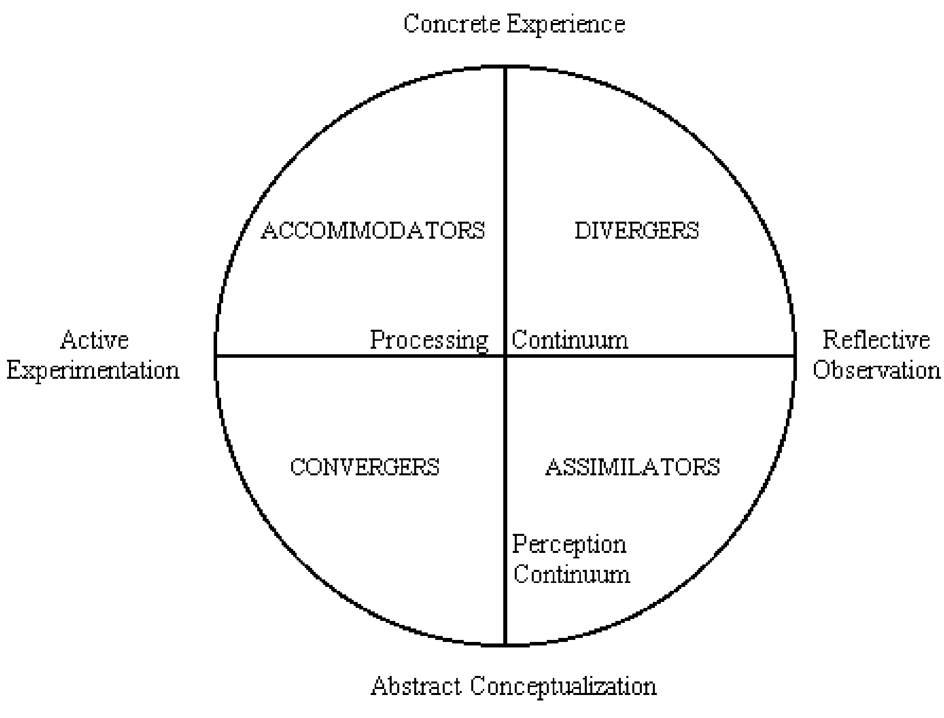

Figure 2.2 Kolb's Experiential Learning Cycle and Basic Learning Styles

According to Kolb (1984) students develop a preference for learning in a particular way. The preferred style reflects a tendency rather than an absolute and students may adopt different learning styles in different situations, but they tend to favor some learning behaviors in preference to others. He identifies four learning styles each of which is associated with a different way of solving problems:

Divergers prefer to learn from the concrete experience (CE) and reflective observation (RO). In this type learners are creative, efficient to generate alternatives, to identify problems and to understand people. Those that are essentially of this type can be too much involved with the alternatives, finding difficulties to take decisions. If this feature is no strong, they can have difficulties to generate ideas and recognize problems and opportunities. Divergers try to know the value of what they will learn and their favorite subject is the question “Why?” (“Why is important to know this concept?”)

Assimilators learn through the reflective observation (RO) and abstract conceptualization (AC). They work with a great variety of information, placing them in logical order very well. They are generally more interested in the logic of an idea than in its practical value. If they are strongly assimilators, they can build “castles in the air”, becoming unable to apply their knowledge in practical situations. If they are less assimilator, they don't take profit of their own mistakes, lacking their basis and systematization in the work that they do. Assimilator’s favorite subject is the question “What?” (“What do I need to know to solve this problem?)

Convergers like to learn through abstract conceptualization (AC) and active experimentation (AE). They appreciate to do practical applications of ideas and theories, they have good acting in the conventional tests, they use the deductive reasoning and they are good to identify and solve problems and to take decisions. If they are strongly convergent, they can mistake in the solution of problems because of their precipitate decisions. Those that are less convergent can lose central axis of the work, becoming disperse. Converger's favorite subject is the question "How?"("How can I solve this problem?")

Accommodators prefer to learn from active experimentation (AE) and concrete experience (CE). They adapt to immediate circumstances well, they learn placing the "hands on" and facing risks. The strongly adapters tend to use their energy in any activities, independent of its relevance and priority. The less accommodator don't conclude their works in time, they have impracticable plans, lacking their objectivity. The favorite subject Accommodators is the question "What if?" ("What if I do something different to solve this problem?).

2.4 Gender and Kinematics Graphing Skills

One focus of the research on gender inequity in science and mathematics has been the classroom environment. Researches suggest that female students tend to differ from their male cohorts in their receptivity to and participation in science and mathematics education (Foster, 1998). It has also been noted that female students contribute less often to classroom discussion than their male classmates. In fact, the very conversations girls have and the matters they concern themselves with (i.e. interaction) is different from boys (Theberg, 1993, cited in Foster, 1998). A female's perception of science contributes to inequity in achievement. It has been found that female students often feel science is a male dominated field (Shwedes, 2003).

According to the literature on gender difference, kinematics graphing skills and student achievement, there is a correlation between students' gender and their achievements (Hein, 2000; Hsiung, Hsiung & Lin 2003).

Hsiung, Hsiung and Lin (2003) have investigated the graphing skill of first year secondary school students. They used two questions probe the graphing interpretation skills, one question, which was slight transition from graph to graphic interpretation skills, and one pure graphic question. For the first two questions wrong and right answers were evenly distributed. 87% of the answers to the third question were right, which is in accordance with the Graph-As-Picture phenomenon. Hsiung, Hsiung and Lin (2003), also observed that the boys and girls use different ways to solve problems or to do experiments in science class. Most girls like to follow teacher's instruction or textbook's step to solve problems or to do experiments. However, boys like to use their ways to solve problem or to do experiments in general. As a result, girls do reading textbook more than boys this way the girls are more influenced by all which is positive as well as negative of the curricula, which are implemented in the textbook.

2.5 Learning Style, Gender and Kinematics Graphing Skills

Numerous studies have documented students' learning of kinematics concepts in introductory physics classes. The topics covered within a typical unit on kinematics in an introductory college physics course provide a rich base for continued research.

Hein (2000) have conducted a study to incorporate interactive digital video techniques (IDV) into the laboratory portion of an introductory course for non-science majors at American University in Washington, DC. A total of 68 students in four sections of laboratory participated in the study. Two kinematics experiments were designed. Students in two lab sections performed the experiments using IDV techniques. One aspect of the study involved the assessment of student learning styles in an attempt to determine if students with particular learning preferences had higher learning gains when instruction involved IDV techniques versus when it involved more traditional techniques. Student learning gains were assessed, in part, using the Test of Understanding Graphs-Kinematics (TUG-K). The statistical procedures employed involved analysis of covariance techniques (ANCOVA). The independent variables were instructional treatment and gender. Learning styles were covariates. The results of this study suggest that laboratory instructional treatment (interactive digital video versus traditional) was not a significant factor upon students' understanding of kinematics concepts as evidenced by mean scores on the Test of Understanding Graphs-Kinematics. "In addition, learning style differences among students cannot be used to explain statistically differences in student understanding of kinematics concepts. Furthermore, gender was a significant factor in students understanding of kinematics concepts as measured by mean scores on the Test of Understanding Graphs-Kinematics" (Hein, 2000, p.6).

2.6 Summary of Literature Review

1. What students learn is significantly influenced by their individual differences such as pre-existing knowledge, age and gender (McDermott, 1984).
2. One of the most common and critical problems in physics education is the failure to discriminate among the various kinematical quantities (Halloun & Hestenes, 1985).
3. Graph construction and interpretation have been identified as important skills to common to both science and mathematics education (Gallagher, 1979, cited in McKenzie et al., 1986).
4. In science, more than in any other subject, students should be involved in predicting relationships between variables and attempting to qualify these relationships (McKenzie & Padilla, 1986).
5. Study of graphs can lead to deeper understanding of physical concepts (Berg & Phillips, 1994; Mokros & Tinker, 1987; Brasel, 1987; Nachmias & Linn, 1987; McDermott, Rosenquist & van Zee, 1987).
6. The students often misunderstand graphs (Goldberg & Anderson, 1989; Svec, 1995; Berg & Philips, 1994; Mokros & Tinker, 1987; Brasel, 1987; Nachmias & Linn, 1987; McDermott, Rosenquist & van Zee, 1987, Beichner, 1994).

7. The graphing errors made by students are not common; they are different for populations and across different levels of sophistication (McDermott, Rosenquist & van Zee, 1987).
8. Students have different learning styles-characteristic strengths and preferences in the ways they take in and process information (Dunn, Bruno, Sklar, & Beaudry, 1990, Kolb, 1984, Felder, 1996).
9. Increased learning gains can be achieved when instruction is designed with students’ learning styles in mind (Dunn, Bruno, Sklar, & Beaudry, 1990; Larkin-Hein, 2000).
10. Female students tend to differ from their male cohorts in their receptivity to and participation in science and mathematics education (Foster, 1998).
11. The boys and girls use different ways to solve problems or to do experiments in science class (Hsiung, Hsiung & Lin 2003)
12. Girls like to follow teacher’s instruction or textbook’s step to solve problems or to do experiments. However, boys like to use their ways to solve problem or to do experiments in general (Hsiung, Hsiung & Lin 2003).
13. Gender is a significant factor in students’ understanding of kinematics (Hein, 2000; Hsiung, Hsiung & Lin 2003).
14. But learning styles by themselves have no effect on students’ understanding of kinematics (Hein, 2000).

These results of the literature propose that, there is a need for research to attain a goal. This goal is: to test the effects of learning style and gender on students’ kinematics graphing skills. This study primarily achieves this goal.

CHAPTER 3

METHOD

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

3.1 Population and Sample

The target population of the study was tenth grade high school students attending science classrooms in general public high schools in city centers in seven geographic regions (Marmara, Aegean, Mediterranean, Central Anatolia, East Anatolia, South-Eastern Anatolia and Black Sea) of Turkey. According to the data obtained from Turkish Ministry of National Education (2002) there were a total of 1.417.814 students in 2.173 Public High Schools in 2002-2003 school year. Assuming that 1/3 of all students are attending the 10^{th} grade, it was obtained that the total number of students in the population were about 472.600. To determine the convenient sample size for the study, Çingi's Table of Sample Sizes for Different Populations and Confidence Intervals was used (Çingi, 1994). It was assumed to have a turn back ratio of 95% for each measuring instrument from each city. As given in the Table 3.1, for a tolerance level of ± 0.03 and a confidence interval of 95 %, the sample size of the study was determined as 1065 students (Çingi, 1994).

Table 3.1- Çingi's Table of Sample Sizes for Different Populations and Confidence Intervals

POPULATION SIZE 'N'	SAMPLE SIZE
10.000	964
20.000	1013
30.000	1031
40.000	1039
50.000	1045
100.000	1056
500.000	**1065**

While choosing the sample, two units of scale, the geographical regions and the cities in which there are students were considered differently. First, the population was divided to seven regions. Then, number of schools and number of students in each city was determined. For each region, two cities were selected that represent that region in terms of their development levels and schooling rates. Using the data obtained from the Head Office of Local Development and Structural Accommodation (1996) two cities were chosen so that the development indexes and schooling rates were parallel (about same values) with the geographical region they represented. There are totally 223.662 students approximately in the accessible population. This is the population for which the results of this study are generalized. Table 3.2 indicates the number of students in sample related with cities.

Table 3.2- The Number of 10th Grade Students Related with Cities in the Sample

REGIONS	CITIES	NUMBER OF STUDENTS IN CITY	NUMBER OF STUDENTS IN SAMPLE
Marmara	Istanbul	66.828	318
	Balikesir	8296	39
Aegean	Izmir	25949	124
	Kütahya	3755	18
Mediterranean	Adana	17743	85
	Içel	14144	67
South-Eastern Anatolia	Gaziantep	9981	48
	Sanliurfa	5628	27
East Anatolia	Elazig	5766	27
	Van	2075	10
Central Anatolia	Ankara	39110	186
	Kayseri	9773	47
Black Sea	Zonguldak	5331	25
	Samsun	9283	44
Total	14 cities	223.662	1065

In order to minimize the different characteristics of the students, such as socio-economic status, motivation, location…etc. it was planned to survey was distributed only for central district of the cities. The survey was distributed to the selected cities' 10th grade general high school students over Turkey by Education Research and Development Office of the Turkish Ministry of National Education (ERDD).

All of 1065 participants (100% of the sample) answered the survey. Because of faulty answers and missing data the results of 76 students were eliminated from the analysis, yielding a final sample size of 989 students. 530 of these students (53. 6%) were male and 459 of them (46. 4%) were female. 41 (4.1%) of the participants didn't answer the question about age. The ages of the students range from 14 to 21 and the average age is 16.7. Distribution of ages of the students who answered the survey with respect to gender is given by Table 3.3. As seen in Table 3.3, the numbers of male students are slightly greater than that of female students.

Table 3.3- Characteristics of the Sample

	Gender		
Age	Male	Female	Total
14	1	0	1
15	6	14	20
16	160	170	330
17	274	229	503
18	51	28	79
19	11	1	12
20	2	0	2
21	1	0	1
Missing	24	17	41
All	506	442	989

3.2 The Variables

There are six variables involved in this study, which were categorized as dependent variables (DVs) and independent variables (IVs). One variable is dependent and the other variables are independent. IVs are divided in two groups as covariates and group membership. Table 3.4 indicates all the characteristics of these variables.

Table 3.4- Identification of the Variables

TYPE OF VARIABLE	NAME	TYPE OF VALUE	TYPE OF SCALE
DV	KGST	Continuous	Interval
IV	LS	Discrete	Nominal
IV	Gender	Discrete	Nominal
IV	PPCG	Continuous	Interval
IV	PMCG	Continuous	Interval
IV	Age	Continuous	Interval

3.2.1 Dependent Variable

The DV is Students' kinematics graphing skills test scores (KGST) as measured by TUG-K. The KGST is a continuous variable and measured on interval scales. Students' possible minimum and maximum scores range from 0 to 21 for the KGST.

3.2.2 Independent Variables

The IVs included in the present study are collected in two groups; Block A and Block B. Students' Previous Physics Course Grades (PPCG), Previous Mathematics Course Grades (PMCG), and age are considered within Block A as covariates to match two groups statistically. Students' Learning Styles (LS) and gender are included in Block B as group membership. In Block A, students' PMCG, PPCG and age, are considered as continuous variables and measured on interval scales. In Block B, the students' gender and LS are determined as discrete variables and measured on nominal scale. The Students' LSs are measured by Learning Style Inventory (LSI).

The students' gender was coded with female as 2 and male as 1. Similarly, LS was coded with accommodator as 1; diverger as 2; converger as 3; assimilator as 4, respectively. The students' possible minimum and maximum scores range from 0 to 5 for the PPCG and PMCG, and 14 to 21 for age, respectively.

3.3 Measuring Tools

For this study, three measuring tools were used. These are Test of Understanding Graphs-Kinematics (TUG-K) (See Appendix-A), Learning Style Inventory (LSI) (See Appendix-C) and Student Information Form (See Appendix-B).

3.3.1 Test of Understanding Graphs-Kinematics (TUG-K)

The Test of Understanding Graphs-Kinematics was administered to the whole students after they have studied the unit of kinematics to assess students' kinematics graphing skills focusing on graph interpretation. The instrument TUG-K was developed by Beichner in 1993 and revised in 1996. A rough flowchart of the steps involved in developing the test is shown in Appendix-D. The content of kinematics graphing skills uncovers a consistent set of student difficulties with graphs of position, velocity, and acceleration versus time. These include misinterpreting graphs as pictures, slope/height confusion, problems finding the slopes of lines not passing through the origin, and inability to interpret the meaning of the area under various graph curves. The test covers seven objectives on kinematics graph interpretation skills. The objectives are listed in Table 3.5. In 1993, Beichner constructed three items for each written objective, producing a test of 21 multiple-choice questions. However he changed one of the items that corresponds another objective in 1996. This item was the first item of the test and it was constructed for the 4^{th} objective before.

Table 3.5- Objectives of the Test of Understanding Graphs-Kinematics (Beichner, 1996).

Given	**The student will**	**Question Number**
1. Position-Time Graph	Determine Velocity	5, 13, 17
2. Velocity-Time Graph	Determine Acceleration	2, 6, 7
3. Velocity-Time Graph	Determine Displacement	1, 4, 18, 20
4. Acceleration-Time Graph	Determine Change in Velocity	10, 16
5. A Kinematics Graph	Select Another Corresponding Graph	11, 14, 15
6. A Kinematics Graph	Select Textual Description	3, 8, 21
7. Textual Motion Description	Select Corresponding Graph	9, 12, 19

After taken permission to use TUG-K for this study, the items of the TUG-K were translated into Turkish. The translation was done by the researcher. The Turkish version of the test was investigated by one subject expert and one physics teachers for interpretation and translation errors. According to the feedback of the investigators, corrections and changes were made before the test was implemented.

3.3.2 Learning Style Inventory (LSI)

The Learning Style Inventory (Kolb, 1985) was administered to students at the same time with TUG-K in order to classify the students according to their learning characteristics. This inventory was originally developed by Kolb and translated into Turkish and standardized by Askar and Akkoyunlu (1993). There were a total of 12 questions in the inventory. These items consist of short statements concerning learning situations. Students ranked four different statements and each statement corresponds to the four learning modes. For the whole inventory, all of the first statements correspond to Concrete Experience (CE); all of the second statements correspond to Reflective Observation (RO); all of the third statements correspond to Abstract Conceptualization (AC); and all of the fourth statements correspond to Active Experimentation (AE), respectively. The raw scores of the four learning modes range from 12 to 48. Higher scores indicate more emphasis on a particular learning mode. In order to determine the learning style of an individual, the scores from four learning modes are combined. The score of (AC-CE) reflects tendency abstractness over concreteness. Similarly, the score of (AE-RO) shows the tendency action over reflection. These two scores of AC-CE and AE-RO are then plotted on the learning style grid to determine the individual's dominant learning style as accommodator; diverger; converger or assimilator.

3.3.3 Student Information Form

The Student Information Form (See Appendix-B) was prepared by the researcher in order to obtain some characteristics of students. It was aimed to collect data about students' gender, age, previous mathematics and physics course grades and some other demographic information that might affect the study and that would be hard to obtain after the data gathering process. It consists of 12 items. The student Information form was administered at the same time with TUG-K and LSI.

3.3.4 Validity and Reliability of the Measuring Tools

According to Beichner (1994), the draft version of the TUG-K was administered to 134 collage students who had already been taught kinematics. "The results were used to modify several of the questions. Those revised test were distributed to 15 science educators including high school, community collage, four year collage, and university faculty. They were asked to complete the test, comment on the appropriateness of the objectives, criticize the items and match items to objectives. This was done in an attempt to establish content validity-does the test really measure what it is supposed to?" (p.752). Then the test was given 524 collage and high school students. Statistical results from the final version of the test indicate that 'reliability of the whole test via calculation of the internal consistency of the items (KR-20) was .83; 'reliability of a single test item, defined as the correlation between the item’s correctness and the whole test score (Point-biserial Coefficient) was average .74.

TUG-K was translated and adapted into Turkish by the researcher. To establish content validity, the test was given to one physics teacher from a high school in Ankara, and one instructor from the Department of Secondary School Science and Mathematics Education at METU. For the validity concerns, the translated TUG-K was then investigated by one instructor from the Department of Secondary School Science and Mathematics Education at METU, three physics teachers from Dikmen Anatolian High School, and one specialist from Education Research and Development Office of the Turkish Ministry of National Education (ERDD) regarding the content and format of the instrument. All these people were informed about the study and main purpose of the test. They were asked to check the test in terms of given criteria of appropriateness of items to the grade level, appropriateness of the test format and the appropriateness of the translation.

During the pilot study, the instruments were administered to 60 tenth grade high school students from a high school in Ankara. The data were collected and a reliability analysis was performed. Internal reliability coefficient was obtained .73 by using Cronbach alpha coefficient. For this study, data from 989 students were analyzed. At this time, internal reliability coefficient was obtained .85 by using Cronbach alpha coefficient.

The Learning Style Inventory was developed by Kolb (1984) and translated into Turkish by Askar and Akkoyunlu (1993). The Turkish version was used in its original form in this study. The reliability coefficients for the adapted inventory were calculated separately for four basic learning style types and their combination, and found to be varying between .73 and .88 (n=268) (Askar & Akkoyunlu, 1993).

In the current study the reliability coefficients findings for the Learning style inventory were parallel with those calculated by Askar and Akkoyunlu (1993). The reliability coefficients were found to be varying between .71 and .89 (n=989) for four basic learning style types and their combination.

3.4 Procedure

The study started with defining the research problem specifically. Next, a detailed review of the literature search was carried out. After determining the keyword list, Educational Resources Information Center (ERIC), International Dissertation Abstracts (DAI), Science Direct and Internet (Goggle) were searched systematically. Previous studies made in Turkey were also searched from the YOK, Education Research and Development Office of the Turkish Ministry of National Education (ERDD), Egitim ve Bilim and Çagdas Egitim Dergisi. Photocopies of obtainable documents were taken from METU library. All of the papers were read; results of the studies were compared with each other. In case of new recent articles on this topic, the researcher continuously checked and followed the literature.

After that, the researcher determined the measuring instruments Test of Understanding Graphs-Kinematics (TUG-K) and Learning Style Inventory (LSI) as mentioned in section 3.3. It was permitted to use of TUG-K from the developer and translated into Turkish by the researcher and adapted by one physics teacher from a high school in Ankara, and one instructor from the Department of Secondary School Science and Mathematics Education at METU. The instrument was checked by one instructor from the Department of Secondary School Science and Mathematics Education at METU, three physics teachers from Dikmen Anatolian High School, and one specialist from Education Research and Development Office of the Turkish Ministry of National Education (ERDD) according to content and format of the instrument. Necessary changes were done before the study.

In order to understand if one class hour will be adequate to complete TUG-K, LSI and Student Information Form, the instruments were implemented to 60 students in one of the private high schools in Ankara on March 2003. The time was found to be adequate.

After determining, preparing and translating the instruments, available sample size was determined for the study. In order to do this, researcher consulted one specialist from Turkish Ministry of National Education, one specialist from Education Research and Development Office of the Turkish Ministry of National Education (ERDD), one instructor from Department of Educational Sciences of Ankara University and benefited from a book which is related with sampling namely 'Örnekleme Kurami' (Çingi, 1994). All necessary permission has been granted for application of the study by Education Research and Development Office of the Turkish Ministry of National Education (ERDD) from the sample. The data needed for the study were gathered through the administration of the measuring tools TUG-K, LSI and Student Information Form. These three instruments were administered at the same time. As explained in the section 3.1 Population and Sample part, they were distributed to randomly select general high schools at different cities over Turkey by the Education Research and Development Office of the Turkish Ministry of National Education (ERDD) in May 2003. At the beginning of each instrument there was an explanation part which informed the students about that instrument. Instrument were gathered by the Turkish Ministry of National Education in May and June, 2003 and handed over in pieces to the researcher.

3.5 Analyses of Data

Data list, consisting of students' gender, age, PPCG, PMCG, KGST, and LS were prepared by using Excel and SPSS computer programs in which columns showed variables and rows showed the students participating in the study. The statistical analyses were done by using both descriptive statistics and inferential statistics. Although the research was designed as a survey study, to see the whole picture and to understand the interaction between the data presented descriptively, inferential statistics were also performed.

3.5.1 Descriptive Statistics

The mean, median, mode, standard deviation, skewness, kurtosis, frequency tables, and histograms of the variables were presented.

3.5.2 Inferential Statistics

In order to test the null hypotheses, statistical technique named Analysis of Covariance (ANCOVA) and Bivariate Correlations were used.

Table 3.6 summarizes all variables and the variable set entry order that were used in the statistical analyses.

Table 3.6- ANCOVA Variable Set Composition and Statistical Model Entry Order

Variable set	Entry order	Variable name
A (covariates)	1st	X1 = Age X2 = PPCG X3 = PMCG
B (group membership)	2nd	X4 = Gender X5 = LS
A*B (covariates * group interactions)	3rd	X6 = X1*X4 X7 = X2*X4 X8 = X3*X4 X9 = X1*X5 X10 = X2*X5 X11 = X3*X5

As shown in Table 3.6, Block A (covariates) was entered first in the ANCOVA model. Therefore, variance due to students' age, PPCG, and PMCG can be removed before the entry of the treatment variables. Block B (group membership) was entered second in the analysis and Block AxB (covariate*group interactions) was entered third to determine covariate-group membership interactions. Block AxB must be statistically non-significant for ANCOVA model to be valid.

3.6 Power Analysis

This study was conducted with 989 high school students and the number of variables was 6. An essential and primary decision in the power analysis is determination of effect size. Effect size was set to medium in this study (?^{2} = 0.06). During analyses, the probability of rejecting true null hypothesis (probability of making Type 1-error) was set to .05 as a priori to our hypothesis testing because it is mostly used value in educational studies. Power of this study with that sample size and medium effect size was calculated as .99. Therefore, the probability of failing to reject the false null hypothesis (probability of making Type 2-error) was found as .01 (i.e., 1-.99).

3.7 Assumptions and Limitations

There may be several considerations that affect the overall findings, or effective usefulness of the results. The assumptions and the limitations in the study considered by the researcher as follows:

3.7.1 Assumptions of the Study

1. The administration of the instruments was under standard conditions.
2. The subjects of the study answered the items of the tests sincerely, seriously and correctly to the items of the TUG-K and LSI.
3. All students did their tests by themselves.
4. Each student had the same capacity to answer the questions in measuring experiments because they were all tenth grade students.

5. For obtaining a large amount of information quickly and easily, multiple survey method was used. Hence, all information-gathering instruments were administered at the same time.
6. All instructors were expected to be sincerely involved in the study.

3.7.2 Limitations of the Study

The study was subjected to the following limitations.

1. The students' characteristics (e.g., family characteristics, health related factors, financial insecurity etc.) were not considered beyond the determination of the learner's learning style, and kinematics graphing skills.
2. The students' entry behaviors (e.g., motivation, anxiety, and hyperactivity) were not examined. Although these behaviors can play a major role on the learner's achievement, the determination of these behaviors is beyond the scope of the study.
3. During the study, the learning styles of the instructors (i.e. teaching style) were not measured.
4. The students' graph construction skills were not examined.

CHAPTER 4

RESULTS

The results of this study are explained in three sections. Descriptive statistics associated with the data collected from the administration of the measuring tools in the first section. The second section presents the inferential statistical data produced from testing the null hypotheses. Finally, the last section summarizes the findings of the study.

4.1 Descriptive Statistics

4.1.1 Descriptive Statistics of the Test of Understanding Graphs-Kinematics

Descriptive statistics related to students' scores on the Test of Understanding Graphs-Kinematics (TUG-K) were categorized according to students' gender and presented in Table 4.1. Scores could range from 0 to 21 in which higher scores mean greater kinematics interpretation skills achievement. As Table 4.1 indicates, both male and female students had approximately close mean values but scores favor male students more than female students. Male students had a mean of 10.53, while female students had a mean of 10.24, which means that female students had more difficulty in interpreting kinematics graphs. Table 4.1 also represents some other basic descriptive statistics of the sample like, standard deviation, skewness and kurtosis. The values for skewness were -.027 and -.076 for female and male students respectively which could be accepted as approximately normal. When the kurtosis values are taken into account, values for kurtosis were -1.120 and -1.097 for female and male students, respectively. It is stated by George and Mallery (2001) that kurtosis value between ±1.0 is considered as excellent, however, a kurtosis value between ±2.0 is also acceptable for many cases. This situation was discussed with many statisticians and it was decided that it does not damage the validity of the study.

Table 4.1- Descriptive Statistics Related to the Test of Understanding Graphs-Kinematics Scores According to Students Gender and Learning Styles

Gender	N	Mean	S.D	Range	Skewness	S.E.	Kurtosis	S.E.
Scores for All Learning Styles								
Male	530	10.63	5.18	21	-.076	.106	-1.097	.212
Female	459	10.24	4.91	20	-.027	.114	-1.120	.227
Total	989	10.45	5.06	21	-.049	.078	-1.103	.155
Scores for Accommodators								
Male	21	10.95	4.64	17	-.222	.501	-.551	.972
Female	20	10.2	5.75	17	.137	.512	-1.413	.992
Total	41	10.6	5.16	17	-.040	.369	-1.103	.724
Scores for Divergers								
Male	79	9.25	5.27	20	.343	.271	-.924	.535
Female	53	10.11	5.03	18	-.049	.327	-1.160	.644
Total	132	10.00	5.17	20	.185	.211	-1.061	.419
Scores for Convergers								
Male	135	12.45	4.76	19	-.602	.209	-.545	.414
Female	133	10.15	4.84	18	.150	.210	-1.156	.417
Total	268	11.31	4.93	19	-.212	.149	-1.096	.297
Scores for Assimilators								
Male	295	10.13	5.17	20	.061	.142	-1.080	.283
Female	253	10.31	4.88	20	-.130	.153	-1.060	.305
Total	548	10.22	5.03	20	-.022	.104	-1.072	.208

Four histograms with normal curves related to male students' KGST with respect to their LSs were given in Figure 4.1. These are also an evidence for the normal distribution of these four variables.

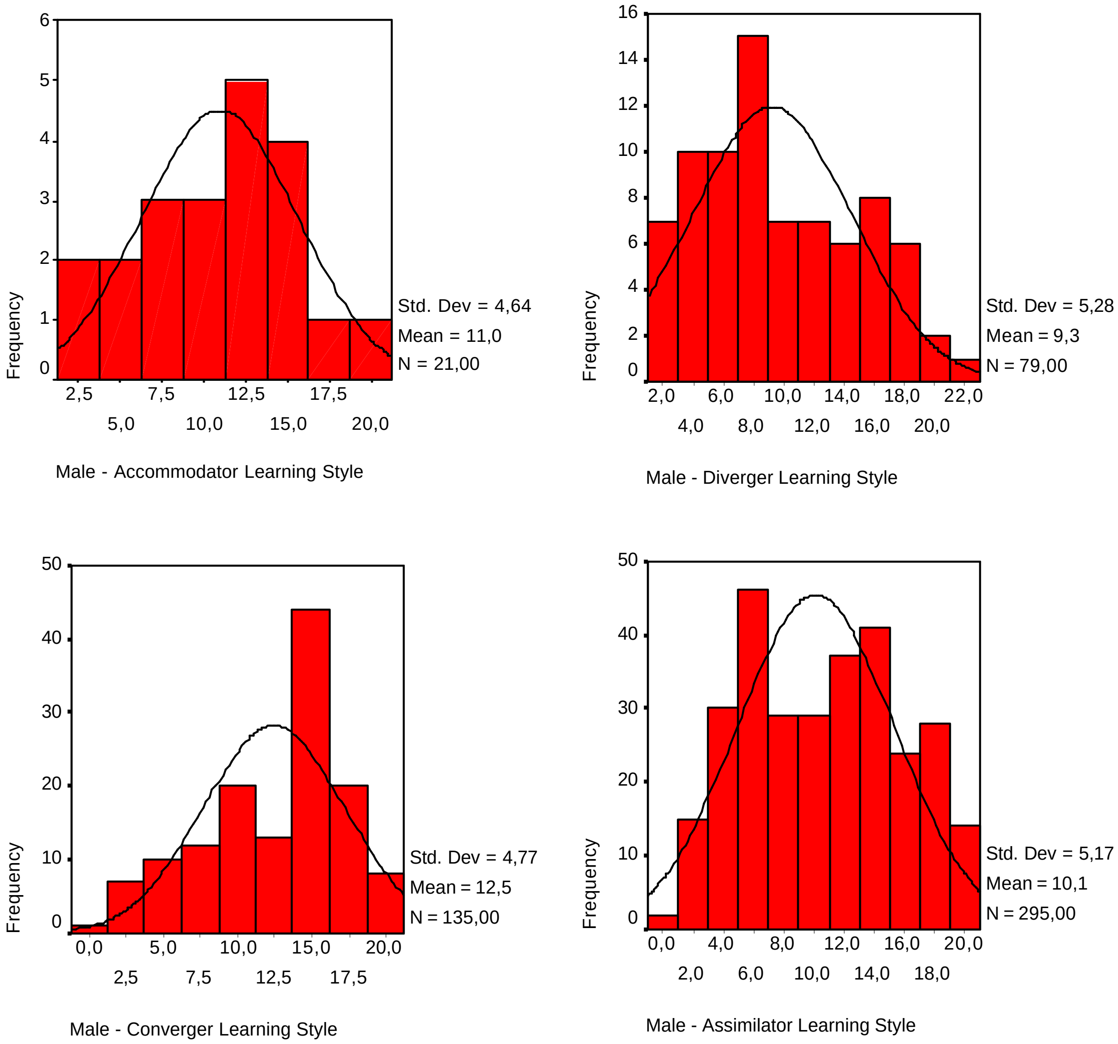

Figure 4.1 Histograms of Male Students' Kinematics Graphing Skills Test Scores with respect to Learning Styles

Figure 4.2 shows the histograms with normal curves related to female students' KGST with respect to their LSs. These are also an evidence for the normal distribution of these variables.

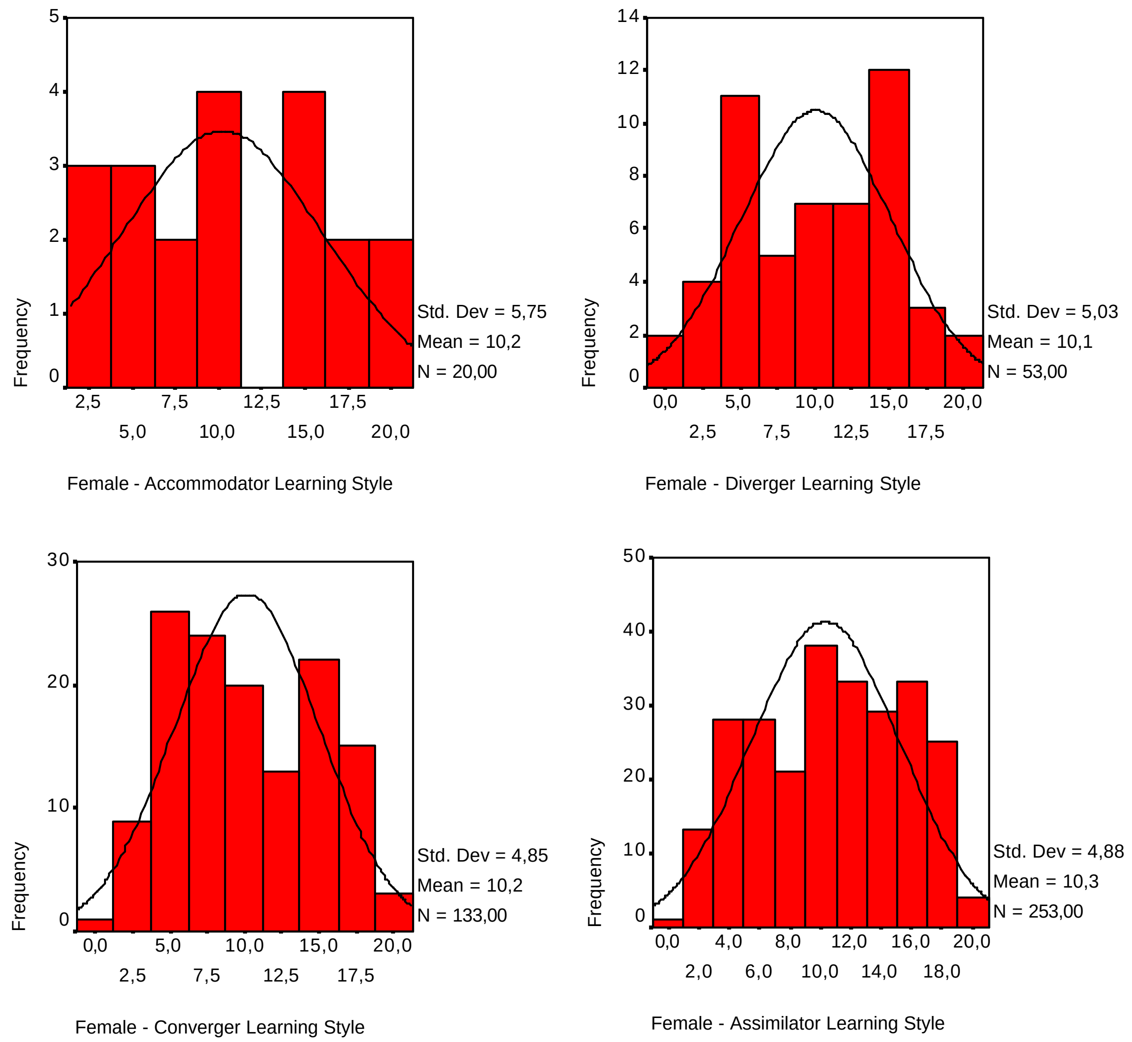

Figure 4.2 Histograms of Female Students' Kinematics Graphing Skills Test Scores with respect to Learning Styles

The frequencies of students' correct and incorrect answers for the questions in Test of Understanding-Kinematics according to specified objectives are given in Table 4.2. The correct answers are indicated as boldface.

Table 4.2- Frequencies of Students Selecting a Particular Choice for Each Test Item.

		Choice					
Item	Objective	A	B	C	D	E	Omit
1	3	147	**[578]**	28	134	92	6
2	2	27	246	249	47	**[386]**	30
3	6	68	11	212	**[577]**	111	6
4	3	32	66	104	**[595]**	172	16
5	1	29	23	**[686]**	167	77	3
6	2	356	**[347]**	56	114	79	33
7	2	**[430]**	204	102	138	76	35
8	6	90	121	215	**[468]**	86	5
9	7	112	334	118	61	**[355]**	5
10	4	**[466]**	71	355	62	26	5
11	5	159	347	87	**[304]**	77	11
12	7	92	**[694]**	77	46	66	10
13	1	91	136	148	**[533]**	63	14
14	5	154	**[630]**	94	59	44	4
15	5	**[323]**	171	66	104	311	10
16	4	32	140	180	**[543]**	60	30
17	1	**[244]**	278	90	189	141	43
18	3	39	**[657]**	111	77	81	20
19	7	161	97	**[530]**	72	120	5
20	3	65	79	83	70	**[673]**	15
21	6	**[297]**	513	66	54	48	11

It can be seen from the Table 4.2 that most of the students selected the incorrect answers for the questions 6, 11, 17, and 21. Additionally, for some questions correct and one of the incorrect answers' frequencies are very close to each other such as questions 9 and 15.

4.1.2 Descriptive Statistics of the Learning Style Inventory

Descriptive statistics related to the types of learning style were categorized according to gender. The distributions of the accommodators, divergers, convergers, and assimilators according to gender were presented in Table 4.3. As shown in the table, most of the female students (N=254) and male students (N=295) were assimilators. The next common learning style type was converger. The numbers of students having converger learning style type were 132 and 135 for female and male students respectively.

Table 4.3- Distributions of Learning Style Types With Respect to Gender

LS	Female	Male	Total
Accommodator	20	21	41
Diverger	53	79	132
Converger	133	135	268
Assimilator	253	295	548
Total	459	530	989

The frequencies and percentages of the accommodators, divergers, convergers, and assimilators were presented in Figure 4.3. Assimilators had the highest frequency (548) and the highest percentage (55.5%) when compared to the other learning style types. Convergers were next common category with a frequency of 268 and a percentage of 27.0%. The lowest frequency (41) and the lowest percentage (4.1%) were belonging to the accommodators in the whole sample.

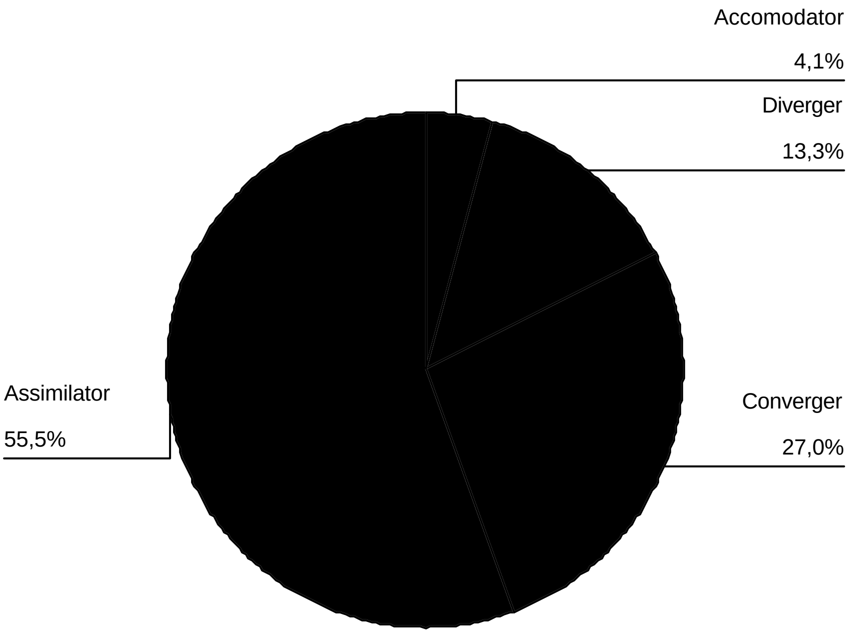

Figure 4.3 Percentages of the Four Learning Style Types

4.1.3 Descriptive Statistics of the TUG-K with respect to LSI and Gender

In Table 4.4, the kinematics graphing skills test mean scores of students with different learning style types were presented. According to the findings of the study, students with converging learning style had the highest mean value (M=11.34), which may be interpreted as converger's kinematics graphing skills test scores were higher than others.

Table 4.4- Kinematics Graphing Skills Test Mean Scores of All Students Having Different Learning Styles

LS	Mean Scores in TUG-K
Accommodator	10.59
Diverger	10.00
Converger	11.31
Assimilator	10.22

4.2 Inferential Statistics

This section deals with the missing data analysis, determination of the covariates, the clarifications of the analysis of covariance (ANCOVA) assumptions, the statistical model of ANCOVA, and the analysis of the hypotheses.

4.2.1 Missing Data Analysis

Before starting the inferential statistics, the missing data analysis was carried out. Firstly, measuring tools were applied to 1065 students. However, 18 of these students answered the Learning Style Inventory with several fault. These faults result in impossible determination of learning style. Additionally, 4 students chosen the same alternative for each question; and 54 students were not answered more than 15% of the questions of the Test of Understanding Graphs- Kinematics (TUG-K). So, the data of these seventy eight students were excluded from the statistical analysis of the study completely.

Missing data in students' age, previous physics course grades, and previous mathematics course grades constitutes a range smaller than 5% of the whole data so they easily replaced with the series mean of the entire subjects. The whole missing values were replaced the mean of the entire subjects (SMEAN) as shown in Table 4.5.

Table 4.5- Missing Data versus Variables

Resultant Variable	Missing Values Replaced	Valid Cases	Missing Percentage	Creating Functions
PPCG	7	989	.7	SMEAN (PPCG)
PMCG	6	989	.6	SMEAN (PMCG)
Age	41	989	4.1	SMEAN (Age)

4.2.2 Dummy Coding of Variables

One of the IVs had more than three categories. This was LS having four categories. In order to avoid some defaults during testing assumptions of the ANCOVA, this variable was recoded by the method of Dummy Coding. Because of LS had four categories, three (number of the category-1) dummy variables were created to represent the variable (For example, in the first dummy variable, 1 was coded for the first category and 0 was coded for all other categories).

4.2.3 Determination of Covariates

Three IVs; students' age, PPCG and PMCG were pre-determined as potential confounding factors of the study. These variables were included in Block A as covariates. All pre-determined IVs in Block A have been correlated with the dependent variable (DV) of KGST. Table 4.6 presents the results of these correlations and their level of significance. All three of the IVs in Block A; PPCG, PMCG, and age have significant correlations with KGST. Hence; PPCG, PMCG, and age were determined as covariates for the following inferential analyses.

Table 4.6- Significance Test of Correlations between the Dependent Variable and the Independent Variables

	Pearson R Correlation Coefficients
Variables	KGST
PPCG	.410*
PMCG	.358*
Age	.135*

Table 4.7 indicates the correlation between covariates. There are significant correlations between PPCG and PMCG, PPCG and age. However, none of the correlation value is greater than 0.80. So no multicollinearity can be detected among covariates.

Table 4.7- Significance Test of Correlations between Covariates

Variables	PPCG	PMCG	Age
PPCG		.587*	.062*
PMCG			.022
Age			

4.2.4 Assumptions of Analysis of Covariance

ANCOVA has four assumptions: Normality, equality of variances, homogeneity of slopes, and independency of scores on the dependent variable.

For normality assumption, skewness and kurtosis values given in descriptive statistics section Table 4.1 were used. The skewness and kurtosis values were in approximately acceptable range for a normal distribution. KGST show normal distribution for all types of learning styles and gender.

Levene's Test of Equality was used to determine the equality of variance assumption. Levene's Test in Table 4.8 shows that error variance of the dependent variable (KGST) is equal across groups since F (7,981) =.693, p=.678.

Table 4.8- Leven's Test of Equality of Error Variances

	F	df1	df2	Sig.
KGST	.693	7	981	.678

The third assumption that was checked before conducting the ANCOVA was homogeneity-of-slopes. Homogeneity-of-slopes assumption should be first tested before proceeding to ANCOVA. This test evaluated if there was an interaction between IVs and CVs. As it can be seen in Table 4.9, the interactions between Gender and PMCG, Gender and PPCG, and Gender and Age were not significant, F (1, 968) =.150, p=.699, F (1, 968) =.495, p=.482, and F (1, 968) =3.118, p=.078, respectively. The interactions between LS and PMCG, LS and PPCG, and LS and

Age were not significant, F (3, 968) =.639, p=.590, F (3, 968) =.352, p=.788, and F (3, 968) =.766, p=.513. Besides, the interactions between Gender, LS and PMCG; Gender, LS and PPCG; and Gender, LS and Age were not significant, F (3, 968) =.875, p=.453, F (3, 968) =.129, p=.943, and F (3, 968) =.612, p=.607. Thus, we can proceed to the ANCOVA assuming homogeneity of regression.

Table 4.9- Results of the Test of Homogeneity of Slopes

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Observed Power
Corrected Model	5623.356	28	200.834	9.802	.000	.232	1.000
Intercept	87.928	1	87.928	4.291	.039	.005	.544
Gender	40.432	1	40.432	1.973	.160	.002	.289
LS	18.244	3	6.081	.297	.828	.001	.108
PMCG	71.973	1	71.973	3.513	.061	.004	.465
PPCG	310.031	1	310.031	15.132	.000	.016	.973
Age	132.690	1	132.690	6.476	.011	.007	.720
Gender*PMCG	3.068	1	3.068	.150	.699	.000	.067
Gender*PPCG	10.144	1	10.144	.495	.482	.001	.108
Gender*Age	63.880	1	63.880	3.118	.078	.003	.422
LS*PMCG	39.259	3	13.086	.639	.590	.002	.185
LS*PPCG	21.613	3	7.204	.352	.788	.001	.119
LS*Age	47.108	3	15.703	.766	.513	.003	.216
Gender* LS*PMCG	53.805	3	17.935	.875	.453	.003	.243
Gender* LS*PPCG	7.906	3	2.635	.129	.943	.000	.074
Gender* LS*Age	37.637	3	12.546	.612	.607	.002	.179
Error	18645.029	968	20.489				
Total	127405.000	978					
Corrected Total	24268.386	989					

For the last assumption, independency of scores was examined. This assumption was met one of the assumptions of the study. It was assumed that all participants did their tests by themselves. However, the researcher could not observe all students participating in the study. Teachers in the classes were requested to observe each student in order to validate this assumption.

4.2.5 Analysis of Covariance Model

The dependent variable of the study is KGST. The variables of the PPCG, PMCG, and age are the covariates of the study. Students' learning styles and gender are the independent variables in the ANCOVA model. Table 4.10 indicates the results of the ANCOVA.

Table 4.10- Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Observed Power
Corrected Model	5212.595	10	521.259	25.385	.000	.215	1.000
Intercept	225.195	1	225.195	10.967	.001	.012	.911
PMCG	447.124	1	447.124	21.775	.000	.023	.997
PPCG	1337.617	1	1337.617	65.141	.000	.066	1.000
Age	293.691	1	293.691	14.302	.000	.015	.965
Gender	1.131	1	1.131	.055	.815	.000	.056
LS	87.957	3	29.319	1.428	.233	.005	.381
Gender*LS	187.289	3	62.430	3.040	.028	.010	.716
Error	19055.791	978	20.534				
Total	127405.000	989					
Corrected Total	24268.386	988					

4.2.6 Null Hypothesis 1

The first null hypothesis was "There will be no significant main effect of learning styles on the population means of the kinematics graphing skills test scores when the effects of students' age, previous physics course grades and previous mathematics course grades are controlled".

ANCOVA was conducted to determine the effect of learning style on the KGST by controlling the effects of students' age, previous physics course grades and previous mathematics course grades. This null hypothesis was failed to be rejected ($F(3,978) = 1.428$, $p = .233$). So, learning style had no significant effect on the KGST when the effects of students' age, previous physics course grades and previous mathematics course grades are controlled. In other words, there was no significant difference among KGST of students having different learning styles when the effects of students' age, previous physics course grades and previous mathematics course grades are controlled.

4.2.7 Null Hypothesis 2

The second null hypothesis was "There will be no significant main effect of gender on the population means of the kinematics graphing skills test scores when the effects of students' age, previous physics course grades and previous mathematics course grades are controlled".

As seen in Table 4.10, the second null hypothesis was failed to be rejected ($F(1,978) = .055$, $p = .815$). Therefore, gender had no significant effect on the KGST when the effects of students' age, previous physics course grades and previous mathematics course grades are controlled. In other words, there was no significant difference between male and female students' KGST when the effects of students' age, previous physics course grades and previous mathematics course grades are controlled.

4.2.8 Null Hypothesis 3

The third hypothesis was "There will be no significant interaction between gender and learning styles on the population means of the kinematics graphing skills test scores when the effects of students' age, previous physics course grades and previous mathematics course grades are controlled".

Table 4.10 indicates that, the third null hypothesis was rejected ($F(3,978) = 3.040$, $p = .028$) which means that interaction is significant between gender and learning styles on the kinematics graphing skills test scores when the effects of students' age, previous physics course grades and previous mathematics course grades are controlled. Figure 4.4 indicates that KGST means of female and male students with respect to LSs.

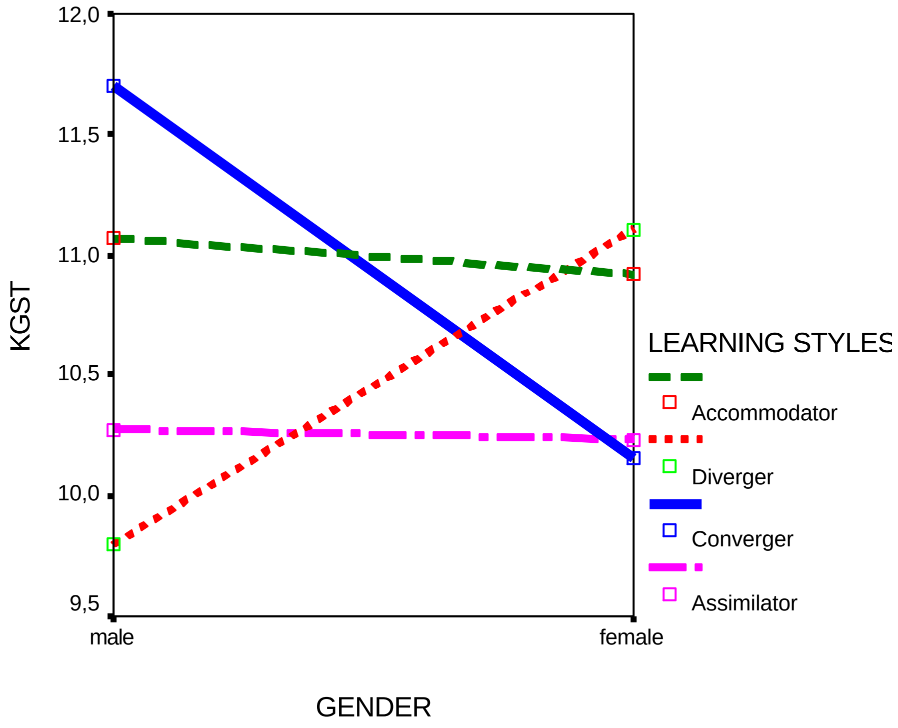

Figure 4.4 Interaction Between Gender and Learning Styles on Kinematics Graphing Skills Test Mean Scores.

The graph indicates that there was a large A X B interaction (A= gender; B= Learning Styles) because lines were not parallel. The difference between female and male students' kinematics graphing skills test mean scores depends on learning styles. Accommodator female students were more successful than converger, diverger, and assimilator female students on kinematics graphing skills test. Similarly, converger male students were more successful than accommodator, diverger, and assimilator male students on kinematics graphing skills test.

4.2.9 Null Hypothesis 4

The fourth null hypothesis was "There will be no significant relation between tenth grade students' age and the population means of the kinematics graphing skills test scores".

As indicated in Table 4.7, this hypothesis was rejected (r = .135) which means there was a significant low positive correlation between students' age and their kinematics graphing skills test scores.

4.2.10 Null Hypothesis 5

The fifth null hypothesis was "There will be no significant relation between tenth grade students' previous physics course grades and population means of the kinematics graphing skills test scores".

As indicated in Table 4.7, this hypothesis was rejected (r = .410) which means there was a significant positive correlation between students' previous physics course grades and their kinematics graphing skills test scores.

4.2.11 Null Hypothesis 6

The last null hypothesis was "there will be no significant relation between students' previous mathematics course grades and the population means of the kinematics graphing skills test scores".

As indicated in Table 4.7, sixth hypothesis was rejected (r = .358) which means there was a significant positive correlation between students' previous mathematics course grades and their kinematics graphing skills test scores.

4.3 Summary of the Results

The results of this study can be summarized as follows:

1. It appears from the mean scores that kinematics graphing skills test, mean score was quite low that the test was taken after the instructions in kinematics.
2. Most of the students selected incorrect choice rather than the correct one for a few of the questions of kinematics graphing skills test.
3. The most common learning style type was assimilator for the subjects of this study. The second highest learning style type observed in this study were converger.
4. Learning style had no significant effect on the KGST when the effects of students' age, previous physics course grades and previous mathematics course grades are controlled.
5. Gender had no significant effect on the KGST when the effects of students' age, previous physics course grades and previous mathematics course grades are controlled
6. There is a significant interaction between gender and learning styles on kinematics graphing skills test mean scores when the effects of students' age,

previous physics course grades and previous mathematics course grades are controlled.

7. Accomodator female students were more successful than converger, diverger, and assimilator female students on kinematics graphing skills test.
8. Converger male students were more successful than accommodator, diverger, and assimilator male students on kinematics graphing skills test.
9. There was a significant low positive correlation between students' age and their kinematics graphing skills test scores.
10. There was a significant positive correlation between students' previous physics course grades and their kinematics graphing skills test scores.
11. There was a significant positive correlation between students' previous mathematics course grades and their kinematics graphing skills test scores.

CHAPTER 5

CONCLUSIONS, DISCUSSION AND IMPLICATIONS

This chapter presents the summary of the research study; conclusions and discussion of the results, internal and external validities of the study, and finally gives the implications of the study and recommendations for further studies.

5.1 Summary of the Research Study

To investigate the purposes of the study, 1065 tenth grade students were randomly selected from 14 different cities over Turkey. The Learning Style Inventory and Test of Understanding Graphs-Kinematics with Student Information Form were administered during the last four weeks of the spring semester of 2002-2003 school year. Correlational and casual comparative research methodologies employed during the study. The accessible population was large randomized and stratified but it was limited. So the conclusions presented below can be applied to defined accessible population.

5.2 Conclusions

It can be said that from the result, kinematics graphing skills test mean score was quite low, and for several questions a great number of students selected incorrect choices rather than the corrects.

It appears that, the most common types of learning style among the subjects of this study were assimilator and converger, as expected. On the other hand students' learning style did not have an effect on kinematics graphing skills.

Although most of the previous research pointed out the fact that gender is a significant factor in students understanding of kinematics concepts, results of this study indicated that gender did not have a main effect on kinematics graphing skills. However, an interesting finding was that there was a significant interaction between gender and learning styles on kinematics skills test scores. Accommodator female students were more successful than converger, diverger, and assimilator female students on kinematics graphing skills test. Whereas, converger male students were more successful than accommodator, diverger, and assimilator male students on kinematics graphing skills test.

The results also emphasized on the relationship of students' age, previous physics and mathematics course grades with students' kinematics graphing skills. It was seen that there was a positive correlation between students' age, previous physics course grades, and previous mathematics grades and their kinematics graphing skills.

5.3 Discussion of the Results

The test mean of 10.45 is quite low considering that the test was taken after the instruction in kinematics. The results are clear, whether the instruction was exemplary or ordinary, the students in this study were not able to fluently interpret kinematics graphs.

An analysis of individual test questions is indicated in Table 4.2. It appears that some of the students are consistently selecting the same incorrect answers. Approximately 25% of the students believed that changing kinematics variables would not change appearance of the graph. Items 11, 14, and 15 detected this. Clearly students who could correctly translate from one kinematics graph to another also had the best overall understanding of kinematics graphs (Beichner, 1994). This could mean that "graph-as-picture" errors (Goldberg & Anderson, 1989; Nachmias & Linn, 1987) are the most critical to address. If the students viewed graphs as the picture of the physical event, although the ordinate variable changed, they would see no reason for changing the appearance of a graph (Beichner, 1994). Although these findings seems reasonable, it can not be shed light on why students answered as they did from this type of assessment. Interviews or open ended questions might be clearer.

As noted by studies earlier, it was found that students have considerable difficulty in determining slopes (Mokros & Tinker, 1987; McDermott, Rosenquist & van Zee, 1987, Beichner, 1994). This study indicates that this is only true for the lines did not pass through the origin. If the line went straight through the origin, 70% of the students were able to correctly determine the slope. Item 5 required this calculation. But, if the tangent line did not pass through the origin as in items 6 and 17, the correct answers dropped to 35% and 25%, respectively. These results are in agreement with the results of Beichner. Items 2, 7, and 17 indicate the previously reported slope/height confusion for approximately 30% of the students taking the test. For the same reason students selected choice B rather than the correct one in item 13. For the same item, 15% of students selected the choice C. The possible explanation for item 13 results could be kinematics variable confusion (Halloun & Hesteness, 1985, McDermott, Rosenquist & van Zee, 1987). This confusion could be seen more precisely in items 9 and 21 where a simple change of the vertical axis label from one kinematics variable to another. A great number of students selected the choice B for item 9 rather than the correct one because they confuse the kinematics variables. Similarly most of the students (52%) selected the incorrect answer B for item 21 because of the same reason.

It appears that students also confused slopes and areas in a graph (Beichner, 1994). Comparing results of item 1 and item 10, it can be said that students consistently selected answers referring to slopes rather than area-related choices. According to Beichner (1994), this might be result in the use of the word "change" in the questions.

McDermott, Rosenquist and van Zee (1987) reported that students have difficulty in finding the area under a graph curve. In this study, students can generally select the correct solution of finding an area when words describing that action are presented as one of the choices as in item 18. However, when they have to actually perform the calculation, they do much worse. Similarly, in item 16, students' tendency is to calculate the slope rather than the area (answer B) or to read a value from the vertical axis (answer C). These results are in agreement with McDermott et al. (1987). But in item 20, most of the students (68%) picked up the correct answer. However, students might notice that the constant velocity. And they were able to use the formula ($x = vt$) then they multiplied that value by the length of the time interval easily rather than finding the area under the curve. This appears obviously from the results of item 4 that, the students actually understood that they were finding the area. Hence more than 60% of the students answered this item correctly.

Reviews of Table 3.5 and 4.2 indicate that determining acceleration using given velocity-time graph was the most difficult objective of this test for the sample of the study. The rest of the objectives are in the 40% to 60% range. This is not encouraging because these are skills teachers expect their students to have after instruction.

Other studies have found that, in general, females do not do as well as males in science and math content areas (Foster, 1998). Similarly, according to the literature on gender difference, kinematics graphing skills and student achievement, there is a correlation between students' gender and their achievements (Hein, 2000; Hsiung, Hsiung & Lin, 2003). But in our study, gender had no significant effect on the kinematics graphing skills of the students ($F (1,978) = .002$, $p = .965$). In other words, gender was not one of the determinants of kinematics graphing skills. Therefore this result was not inconsistent with earlier studies.

As observed from the findings, the most common learning style type was assimilator for the sample of this study. Heinn (2000) stated that learning style differences among students cannot be used to explain statistically differences in student understanding of kinematics concepts. Although the kinematics graphing skills test scores of the convergers were slightly higher than that of assimilators, divergers, and accommodators learning style did not have a significant effect on the kinematics graphing skills of the students ($F(3,978) = 1.37$, $p = .25$). Hence, the findings of the present study support this conclusion of Heinn.

An interesting finding was that there was a significant interaction between gender and learning styles on students' kinematics skills test scores ($F(3,978) = 3.01$, $p = .030$) when the effects of students' age, previous physics course grades and previous mathematics course grades are controlled. According to Hsiung, Hsiung and Lin (2003), the boys and girls use different ways to solve problems or to do experiments in science class. Most girls like to follow teacher's instruction or textbook's step to solve problems or to do experiments. Boys on the other hand, like to use their ways to solve problem or to do experiments in general. As easily seen from Figure 4.4 that, female students and male students learn kinematics graphs in different from each other. More specifically, accommodator female students were more successful than converger, diverger, and assimilator female students on kinematics graphing skills test, whereas converger male students were more successful than accommodator, diverger, and assimilator male students on kinematics graphing skills test. In other words accomodator female students learn better kinematics graphs by hands-on activities, group working, field working and projects.

On the other hand, converger male students learn better this subject by laboratory experiments, simulations, field works, problem solving, and practical applications.

As described in Chapter 3, medium effect size (.06) was expected. The statistical result of the SPSS gave the partial ?² as .009 for the interaction. The effect size measured here matched the small effect size. So, this result was quite smaller than as expected. And power was calculated and set to .99 before the study. The observed power for the interaction was .71. Based on the findings presented the practical significance of this study is low.

5.4 Internal Validity of the Study

Possible threads to internal validity and the methods how to deal with them in this study were discussed in this section. These following possible internal threads were considered to control during this study: the subject characteristics, data collector characteristics, data collector bias, history, location and mortality effect.

In this study since the groups are already formed random assignment of subjects to groups is not possible. Each student in the classes has different characteristics such as gender, age, previous physics course grades, and previous mathematics course grades, and so on. They might affect students' kinematics graphing skills test scores. Hence, variables of the age, previous physics course grades, and previous mathematics course grades were considered as covariates in this study. By the statistical analyses, they were determined as covariates as shown in Table 4.3.

The most important threat to internal validity might be data collector characteristics because measuring tools were administered by different instructors and in different cities. However all of the instruments to all students administered approximately at the same time and in regular class hours. It is also assumed that all schools have the same conditions.

To control mortality thread in the study, missing data analysis was performed. Missing data in students' age, previous physics course grades, and previous mathematics course grades constitutes a range smaller than 5% of the whole data so they easily replaced with the series mean of the entire subjects. The whole missing values were replaced the mean of the entire subjects (SMEAN).

The other internal thread is the confidentiality thread. In this study it would be not a problem because students were informed about their names would be only used for the statistical analyses.

5.5 External Validity of the Study

In this study target population was 10th grade students in general high schools in Turkey. In order to represent the whole population, 14 cities were selected considering their population and development indexes in seven geographical regions. Then for each city, sample of the study were selected randomly. The survey was distributed to the accessible population's 10th grade general high school students over Turkey by Education Research and Development Office of the Turkish Ministry of National Education (ERDD). Hence this study's findings could be generalized defined accessible population without any limitation.

Because testing procedures were conducted in students' ordinary classrooms during the regular class time, there were possibly no remarkable differences among environmental conditions. As a result, it was believed that the external effects were sufficiently controlled in this study.

5.6 Implications of the Study

In the light of the findings of the study and related previous work following suggestions can be offered:

1. Each student learns in different way hence teachers should be aware of the differences that exist among students rather than assuming that everyone learns the same way. These differences should be taken in account when lecturing and assessing students' knowledge.
2. Instruction should ask students to predict graph shapes, collect the relevant data, and then compare results to predictions.
3. Teachers should have students examine motion events where the kinematics graphs do not look like a picture of the motion and the graph lines do not go through the origin.
4. Instruction should require students to go back and forth between the different kinematics graphs, predicting the shape of one from another.
5. Teachers should have students determine slopes and areas under curves and relate those values to specific times during the motion event
6. The successes of the accommodator and converger students change depends on their gender on kinematics graphs. Therefore teachers should try to design

instruction and adapt themselves to females' and males' different learning and expression styles.

7. An ideal classroom should include each of four learning style types. For example the lesson should begins with the student's personal involvement through concrete experience (such as an experiment or a simulation); next the student should reflect on this experience looking for meaning (such as brain storming); then the student should apply this meaning to form a logical conclusion (such as model building); finally, the student should experiment similar problems (such as hands on activities), which result in new concrete experiences.
8. For assimilators, lectures, model buildings, analogies, readings, papers, and projects; for convergers, laboratory experiments, simulations, field works, problem solving, homework, and practical applications; for divergers, cooperative learning, and brain storming, logs and journals; and for accommodators, hands-on activities, group working, field working, and projects may be preferred.

5.7 Recommendations for Further Research

This study has suggested some special topics for future studies. These are as follows:

1. Future research could investigate the role of gender and learning style on students’ achievement and attitude in different physics topics, different science subjects and in different grade levels.
2. Future research could perform a replication of this study for a longer time, which is integrated in the flow of physics course.
3. Future research could perform the role of gender and learning style on students’ kinematics skills, focusing on graph construction.
4. Future research could investigate the causes of students’ difficulties in kinematics graphing skills.

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APPENDIX-A

Grafikleri Anlama Sinavi– Kinematik *sürüm 2.6*

Yönerge

Size baslamaniz söylenene kadar bekleyin, ardindan ilk sayfayi açin ve sorulari cevaplamaya baslayin. Her soruyu ayri ayri ve en iyi biçimde cevaplayin. Her soru için tek dogru cevap seçenegi vardir. Dilerseniz hesap makinesi ve karalama kagidi kullanabilirsiniz.

Cevaplarinizi sinav kagidina **isaretleyin.**

Sinavi tamamlamak için süreniz bir saattir. Daha önce bitirirseniz cevap kagidini ve sinav kitapçigini kontrol edin.

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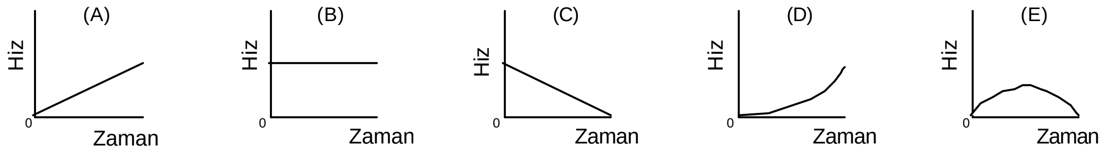
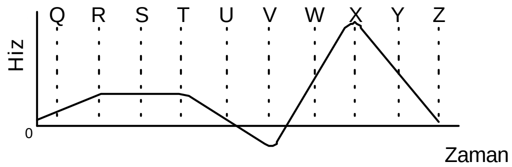
1. Bes cismin hiz-zaman grafikleri asagida verilmistir. Tüm eksenler ayni ölçüye sahiptir. Verilen zaman araliginda en fazla konum degistiren cisim hangisidir?



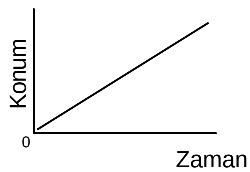
2. Ivme hangi zaman araliginda en negatif degerdedir?

(A) R den T ye
(B) T den V ye
(C) V
(D) X
(E) X den Z ye



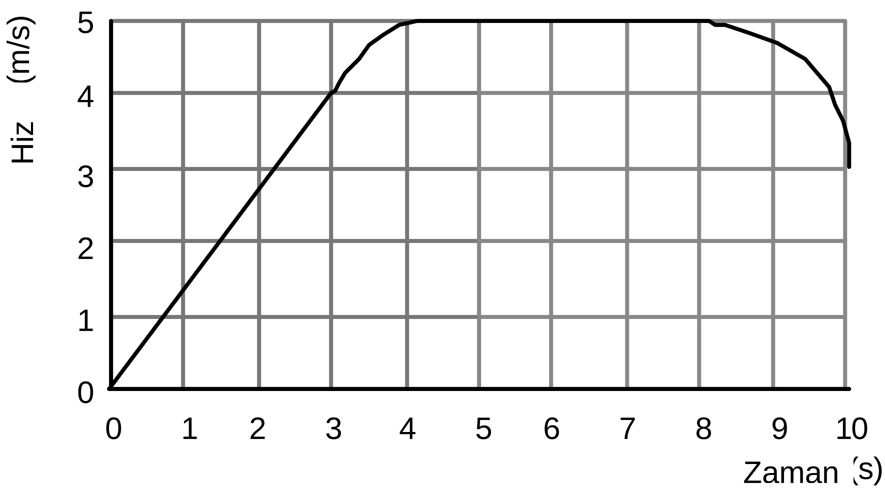
3. Sag tarafta bir cismin hareketinin konum-zaman grafigi verilmistir. Asagidaki cümlelerden hangisi bu cismin hareketini en iyi açiklar.

(A) Cisim sifirdan farkli sabit ivmeyle hareket etmektedir
(B) Cisim hareketsizdir.
(C) Cisim düzgün dogrusal artan hizla hareket etmektedir.
(D) Cisim sabit hizla hareket etmektedir.
(E) Cisim düzgün dogrusal artan ivmeyle hareket etmektedir.



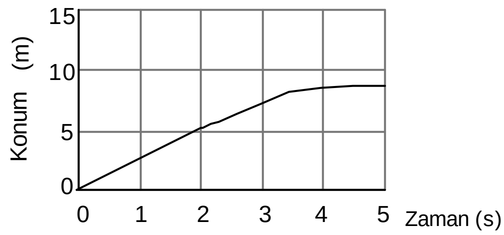
4. Bir binanin asansörü zemin kattan onuncu kata çikmaktadir. Asansörün kütlesi 1000 kg dir ve asagida verilen hiz-zaman grafigindeki gibi hareket etmektedir. Asansör hareketinin ilk üç saniyesinde ne kadar yol almistir?

(A) 0.75 m
(B) 1.33 m
(C) 4.0 m
(D) 6.0 m
(E) 12.0 m



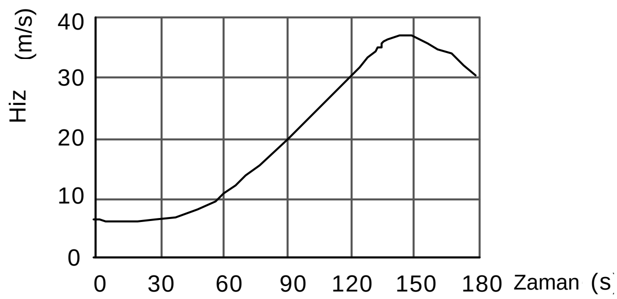
5. Cismin 2. saniyedeki hizi nedir (m/s)?

(A) 0.4
(B) 2.0
(C) 2.5
(D) 5.0
(E)10.0



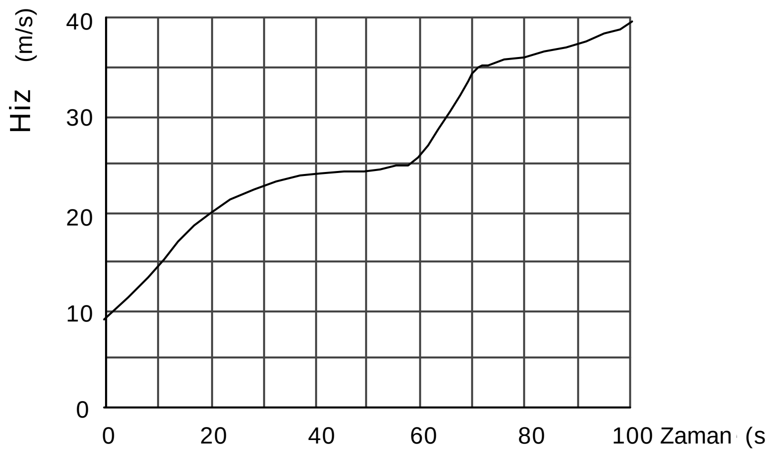
6. Kütlesi 1.5 X103 kg olan bir aracin hiz-zaman grafigi sekildeki gibidir. 90. saniyedeki ivmenin büyüklügü nedir?

(A) 0.22 m/s2
(B) 0.33 m/s2
(C) 1.0 m/s2
(D) 9.8 m/s2
(E) 20 m/s2

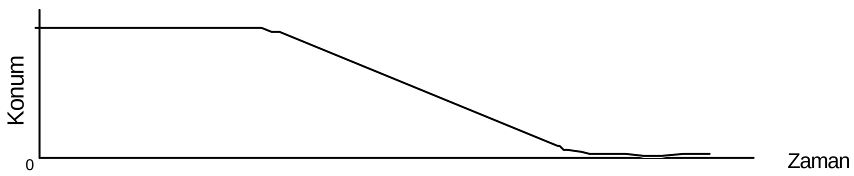


7. Düzgün dogrusal hareket eden bir cismin hiz-zaman grafigi asagida verilmistir. t=65 s deki anlik ivmenin büyüklügü asagidaki degerlerden hangisine en yakindir:

(A) 1 m/s2
(B) 2 m/s2
(C) +9.8 m/s2
(D) +30 m/s2
(E) +34 m/ s2

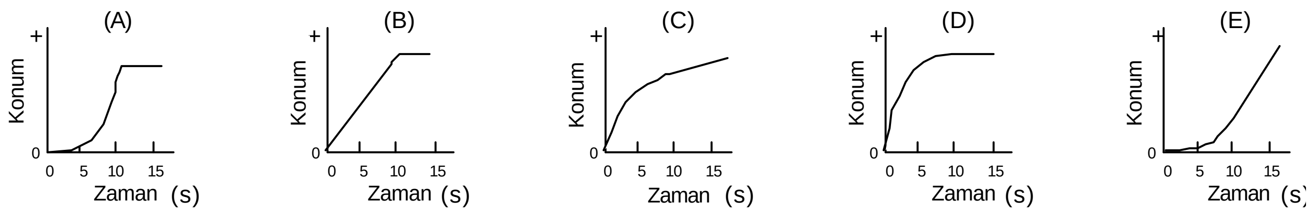


8. Bir cismin hareketinin grafigi asagidaki biçimdedir. Buna göre asagidaki açiklamalardan hangisi dogrudur:

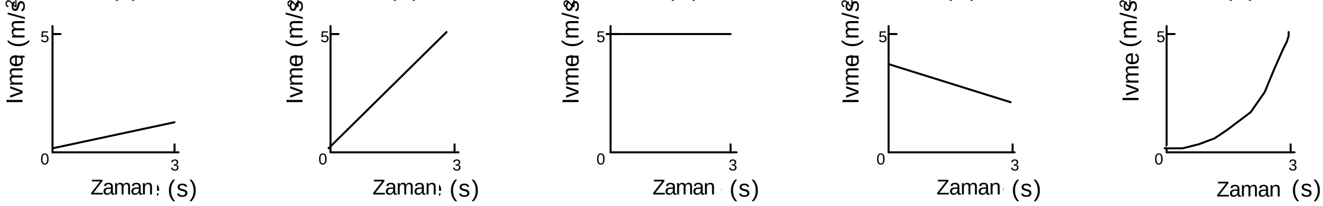


(A) Cisim düz bir yüzey üzerinde yuvarlanir. Daha sonra bir tepeden asagi yuvarlanir ve sonunda durur.
(B) Cisim ilk basta hareketsizdir. Daha sonra bir tepeden asagi yuvarlanir ve sonunda durur.
(C) Cisim sabit hizla hareket eder. Daha sonra yavaslar ve durur.
(D) Cisim ilk basta hareketsizdir. Daha sonra geriye dogru gider ve sonunda durur.
(E) Cisim düz bir yüzeyde hareket eder, daha sonra geriye dogru bir tepeden asagi iner ve ardindan hareketini sürdürür.

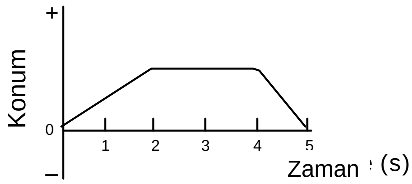
9. Bir cisim durgun halden hareket etmeye baslar ve on saniye sabit pozitif bir ivmeyle gider. Daha sonra sabit hizla hareketini sürdürür. Asagidaki grafiklerden hangisi bu durumu dogru bir sekilde tanimlar?



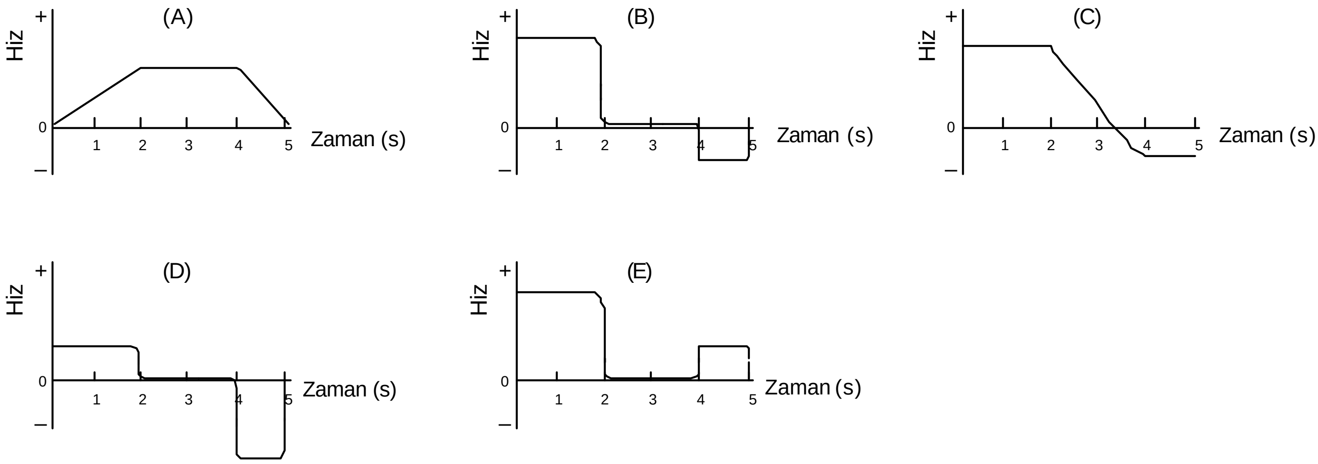
10. Bes cisim asagida verilen ivme zaman grafiklerindeki gibi hareket etmektedir. Üç saniyelik zaman araliginda en az hiz degisimi hangisindedir?



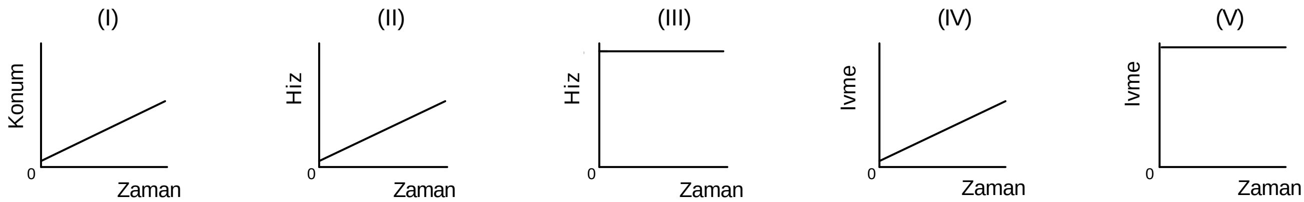
11. Asagida bir cismin 5 saniyelik zaman araligindaki konum-zaman grafigi verilmistir.



Buna göre asagidaki hiz-zaman grafiklerinden hangisi cismin ayni zaman araligindaki hareketini <u>en iyi</u> gösterir?



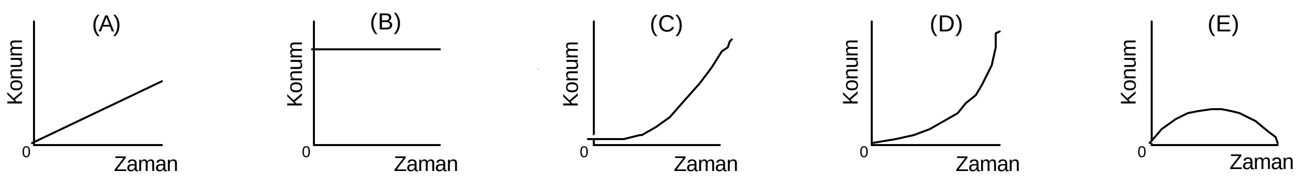
12. Asagidaki grafikleri eksenlerdeki farkliliklari göz önüne alarak inceleyin:



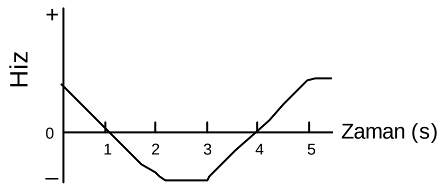
Bunlardan hangisi/hangileri sabit hizla hareketi gösterir?

(A) I, II, ve IV
(B) I ve III
(C) II ve V
(D) yalniz IV
(E) yalniz V

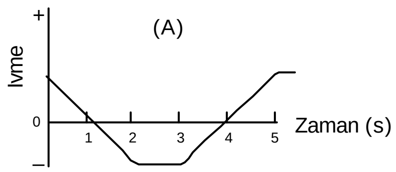
13. Bes cismin konum-zaman grafikleri asagida verilmistir. Tüm eksenler ayni ölçüye sahiptir. Verilen zaman araliginda <u>en yüksek</u> anlik hiza sahip cisim hangisidir?

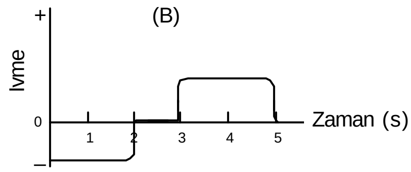


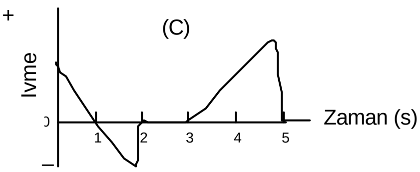
14. Asagida bir cismin 5 saniyelik zaman arligindaki hiz-zaman grafigi verilmistir.

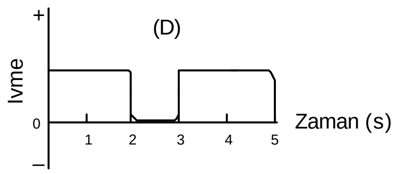


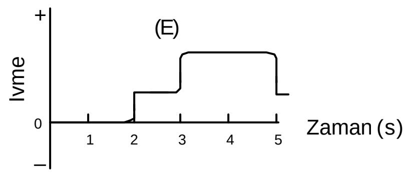
Buna göre ayni zaman araliginda asagidaki ivme-zaman grafiklerinden hangisi cismin hareketini en iyi gösterir?



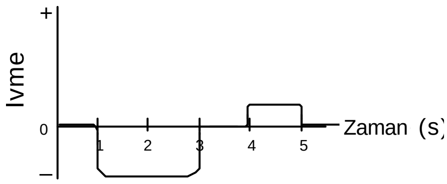




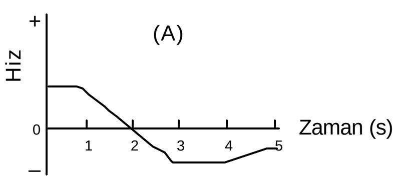


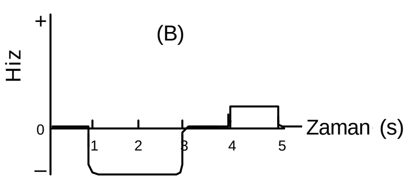


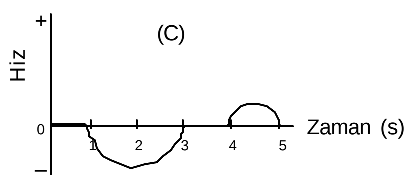
15. Asagida bir cismin 5 saniyelik zaman araligindaki ivme-zaman grafigi verilmistir.

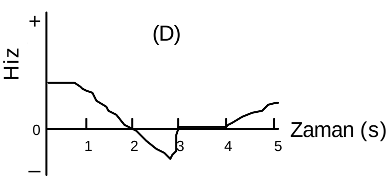


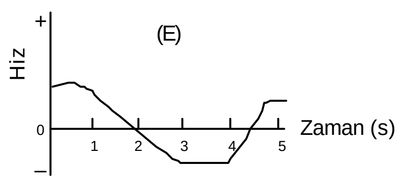
Buna göre asagidaki hiz-zaman grafiklerinden hangisi cismin ayni zaman araligindaki hareketini en iyi gösterir?



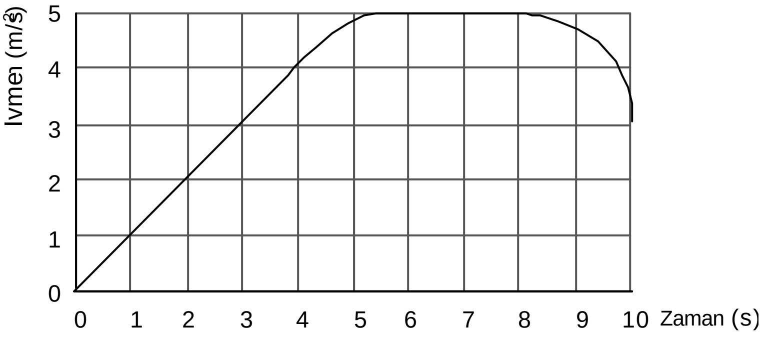








16. Bir cisim asagidaki grafige göre hareket etmektedir:

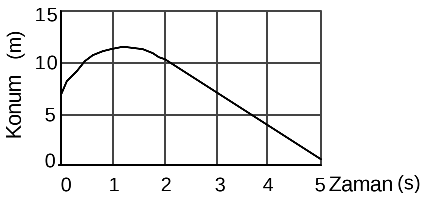


Buna göre, hareketin ilk üç saniyesi boyunca cismin hizindaki degisim ne kadardir?

(A) 0.66 m/s (B) 1.0 m/s (C) 3.0 m/s (D) 4.5 m/s (E) 9.8 m/s

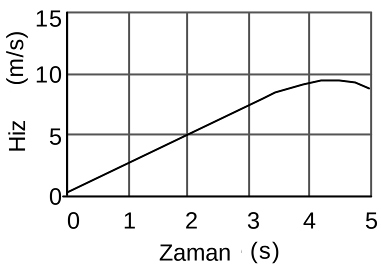
17. 3. saniyedeki hiz yaklasik olarak ne kadardir?

(A) -3.3 m/s
(B) -2.0 m/s
(C) -.67 m/s
(D) 5.0 m/s
(E) 7.0 m/s

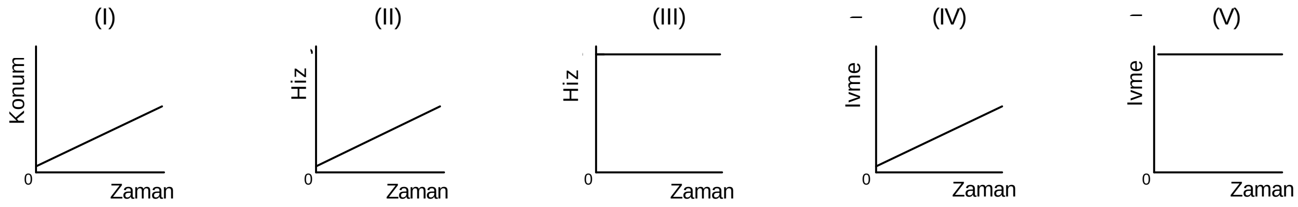


18. Eger t=0 s ile t=2 s zaman araliginda alinan yolu bilmek isteseydiniz, asagidaki grafikten

(A) dogrudan dikey eksenden 5 degerini okurdunuz.
(B) dogru parçasi ve zaman ekseni arasindaki alani (5x2)/2'den hesaplayarak bulurdunuz.
(C) 5'i, 2'ye bölerek dogru parçasinin egimini bulurdunuz.
(D) 15'i, 5'e bölerek dogru parçasinin egimini bulurdunuz.
(E) Cevaplamak için yeterli bilgi yok.



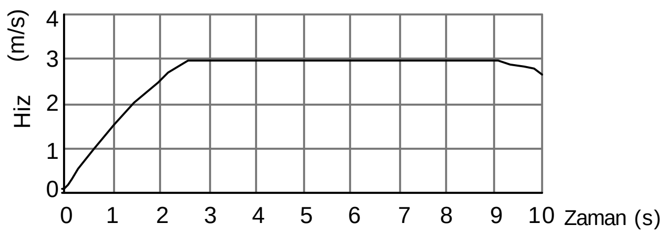
19. Asagidaki grafikleri eksenlerdeki farkliliklari göz önüne alarak inceleyin:



Bunlardan hangisi/hangileri sifirdan farkli sabit ivmeli hareketi gösterir?

(A) I, II, ve IV
(B) I ve III
(C) II ve V
(D) yalniz IV
(E) yalniz V

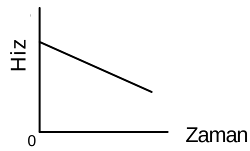
20. Bir cisim asagidaki grafige göre hareket etmektedir:



Buna göre, t=4 s ile t=8 s zaman araliginda cisim ne kadar yer degistirir?

(A) 0.75 m (B) 3.0 m (C) 4.0 m (D) 8.0 m (E) 12.0 m

21. Sag tarafta bir cismin hareketinin grafigi verilmistir. Asagidaki cümlelerden hangisi bu cismin hareketini en iyi açiklar?



(A) Cisim sabit ivmeyle hareket etmektedir.
(B) Cisim düzgün dogrusal azalan ivmeyle hareket etmektedir.
(C) Cisim düzgün dogrusal artan hizla hareket etmektedir.
(D) Cisim sabit hizla hareket etmektedir.
(E) Cisim hareketsizdir.

APPENDIX-B

ÖGRENCI BILGI FORMU

1. Adiniz, Soyadiniz: ________________________________
2. Cinsiyetiniz: E ___ K ___
3. Dogum Tarihiniz: ____/ ____/ _______
4. Okulunuzun adi/ Sinif:_____________________________________/______________

5. Babanizin halen yapmakta oldugu meslegi: __________________________________

6. Babanizin en son mezun oldugu okul: _____ Okur-yazar
_____ Ilkokul
_____ Ortaokul
_____ Lise
_____ Üniversite
_____ Diger (belirtiniz) ___________________

7. Annenizin halen yapmakta oldugu meslegi: __________________________________

8. Annenizin en son mezun oldugu okul: _____ Okur-yazar
_____ Ilkokul
_____ Ortaokul
_____ Lise
_____ Üniversite
_____ Diger (belirtiniz) ___________________

9. Geçen yil matematik ve fizik dersinden aldiginiz yil sonu notu:
Matematik: _____
Fizik: _____

10. Fizik Dersindeki basarinizi artirmak için asagidakilerden hangilerini yapiyorsunuz?
_____ Derslerime düzenli olarak çalisiyorum
_____ Verilen ödevleri yapiyorum
_____ Özel ders aliyorum
_____ Dershaneye gidiyorum
_____ Okul kursuna katiliyorum
_____ Sadece dersi dinliyorum
_____ Diger (belirtiniz) ____

11. Fizik dersini seviyor musunuz? Evet _____ Hayir _____
Nedenini birkaç cümle ile açiklar misiniz?
____
____

12. Fizik dersinde en çok sevdiginiz konuyu belirtiniz:____________________________

APPENDIX-C

ÖGRENME STILI ENVANTERI

Sevgili ögrenci
Asagida her birinde dörder cümle bulunan on iki tane durum verilmektedir. Her durum için size en uygun olan cümleyi 4, ikinci en uygun olani 3, üçüncü uygun olani 2, en az uygun olani ise 1 olarak ilgili cümlenin basinda birakilan bosluga yaziniz. Tesekkür ederiz.
Örnek
Ögrenirken: _4_ mutluyum _1_ hizliyim _2_ mantikliyim _3_ dikkatliyim

Hatirlamaniz için: 4 = en uygun olan
3 = ikinci uygun olan
2 = üçüncü uygun olan
1 = en az uygun olan

Yukardan asagiya dogru degil, soldan saga dogru cevaplayiniz.

1. Ögrenirken	___	duygularimi gözönüne almaktan hoslanirim.	___	izlemekten ve dinlemekten hoslanirim.	___	fkirler üzerine düsünmekten hoslanirim.	___	birseyler yapmaktan hoslanirim.
2. En iyi ....ögrenirim.	___	duygularima ve önsezilerime güvendigimde	___	dikkatlice dinledigim ve izledigimde	___	mantiksal düsünmeyi temel aldigimda	___	birseyler elde etmek için çok çalistigimda
3. Ögrenirken	___	güçlü duygu ve tepkilerle dolu olurum.	___	sessiz ve çekingen olurum.	___	sonuçlari bulmaya yönrlirim.	___	Yapilanlardan sorumlu olurum.
4. .... ögrenirim.	___	Duygularimla	___	Izleyerek	___	Düsünerek	___	Yaparak
5. Ögrenirken	___	yeni deneyimlere açik olurum.	___	konunun her yönüne bakarim.	___	analiz etmekten ve onlari parçalara ayirmaktan hoslanirim.	___	denemekten hoslanirim.
6. Ögrenirken .... biriyim.	___	sezgisel	___	gözleyen	___	mantikli	___	hareketli

7. En iyi ....ögrenirim.	___	kisisel iliskilerden	___	gözlemlerden	___	akilci kuramlardan	___	uygulama ve denemelerden
8. Ögrenirken	___	kisisel olarak o isin bir parçasi olurum.	___	isleri yapmak için acele etmem.	___	kuram ve fikirlerden hoslanirim.	___	çalismamdaki sonuçlari görmekten hoslanirim.
9. En iyi ....ögrenirim.	___	duygularima dayandigim zaman	___	gözlemlerime dayandigim zaman	___	fikirlerime dayandigim zaman	___	ögrendiklerimi uyguladigim zaman
10. Ögrenirken .... biriyim.	___	kabul eden	___	çekingen	___	akilci	___	sorumlu
11. Ögrenirken	___	katilirim.	___	gözlemekten hoslanirim.	___	degerlendiririm.	___	aktif olmaktan hoslanirim.
12. En iyi ....ögrenirim.	___	akilci ve açik fikirli oldugum zaman	___	dikkatli oldugum zaman	___	fikirleri analiz ettigim zaman	___	pratik oldugum zaman

APPENDIX-D

A Flowchart for Test Development Showing Feedback Loops Between Steps

(Beichner, 1994, p. 751)