THE EFFECTS OF CALCULATOR BASED LABORATORIES (CBL) ON GRAPHICAL INTERPRETATION OF KINEMATIC CONCEPTS IN PHYSICS AT METU TEACHER CANDIDATES

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ABSTRACT

THE EFFECTS OF CALCULATOR BASED LABORATORIES (CBL) ON GRAPHICAL INTERPRETATION OF KINEMATIC CONCEPTS IN PHYSICS AT METU TEACHER CANDIDATES

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Science education should teach students to critically evaluate new information. Students have difficulties making connections among graphs of variables, physical concepts and the real world and often perceive graphs as a picture. Calculator Based Laboratories (CBL) provide immediately available calculator drawn graphics of objects in motion. Up to date effectiveness of microcomputers are evaluated but there are few studies on the use of CBL, which are feasible, easy to use, portable and cheap with respect to microcomputers.

In this study we want to find out the effectiveness of CBL method on the graphical interpretation of kinematical concepts in physics at METU teacher candidates. Data will be analyzed with SPSS for Windows program.

The study carried out 2002 – 2003 Spring Semester at Education Faculty in METU. 32 students from two classes were involved in the study. All students administered TUG-K (Test of Understanding Graphs – Kinematics) before and after the CBL activities.

The data obtained from the administration of the pretests and the posttest were analyzed statistical technique of Paired Samples T Test. The statistical analysis failed to show any significant difference in the students' understandings of kinematics graphs.

Keywords: Physics Education, Micro-Computer Based Laboratories, Calculator Based Laboratories.

ÖZ

HESAP MAKİNESİ DESTEKLİ FİZİK EĞİTİMİNİN ODTU ÖĞRETMEN ADAYLARININ KİNEMATİK KAVRAMLARININ GRAFİKSEL YORUMLAMALARI ÜZERİNE ETKİSİ

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Fen eğitimi öğrencilere yeni bilgileri eleştirel gözle değerlendirebilmeyi öğretmelidir. Öğrenciler grafik değişkeleri ile fiziksel kavramları ve gerçek dünyayı ilişkilendirmede sorun yaşamakta ve genellikle grafikleri birer resim olarak algılamaktadırlar. Günümüze kadar bilgisayar destekli laboratuarlar üzerine bir çok araştırmalar yapılmış fakat HeMa Lab üzerine yeterince çalışma yapılmamıştır.Hesap Makineleri Destekli Laboratuarlar (HeMa Lab) hareketli nesnelerin grafiklerini anında verebilmektedirler. HeMa Lab aynı zamanda bilgisayar destekli laboratuarlara göre fiyat olarak uygun, kullanımı kolay ve taşınabilirdirler.

Bu çalışmada biz HeMa Labın ODTÜ öğretmen adaylarının fizikteki kinematik kavramlarının ve grafiklerinin kavranmasındaki etkinliğini bulmaya çalıştık. Bilgiler Windows için SPSS programı ile analiz edilecektir.

Çalışma 2002 – 2003 bahar döneminde ODTÜ Eğitim Fakültesinde yapılmıştır. 2 sınıftan 32 öğrenci çalışmaya katılmıştır. Bütün öğrenciler HeMa Lab aktivitelerinden önce ve sonra TUG – K (Kinematik Grafiklerini Anlama Testi) Testini ön ve son – test olarak almışlardır.

Elde edilen bulgular T – Testi ile analiz edilmiştir. Test sonuçları öğrencilerin kinematik grafiklerini anlamadaki başarı değişikliklerini istatistiksel olarak gösterememiştir.

Anahtar Kelimeler: Fizik Eğitimi, Bilgisayar Destekli Laboratuarlar, Hesap Makineleri Destekli laboratuarlar (HeMa Lab).

To my wife Tuğba and

To my daughter Rana

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ACTSCORE : Students' Scores of CBL Activities

POSTTEST : Students' Scores of TUG – K as Posttest

SCOREDIF : Students' Difference Scores between POSTTEST and PRETEST

PRETEST : Students' Scores of TUG – K as Pretest

PHYS111 : Students' Physics 111 Course Grades

PHYSAT : Students' Scores of Physics Attitude Test

REASON : Students' Reason of Choosing Their Departments

CALAT : Students' Scores of Calculator Attitude Test

CGPA : Students' Cumulative Grade Point Averages

LGPA : Students' Grade Point Averages of the Previous Semester

FGPA : Students' Grade Point Averages When They Had Taken Physics 111

MED : Education Level of Students' Mothers

FED : Education Level of Students' Fathers

CBL : Calculator Based Laboratories

CBR : Calculator Based Ranger

NC : Number of Childs in Students' Family

DV : Dependent Variables

IV : Independent Variables

N : Sample Size

CHAPTER 1

INTRODUCTION

Science education should teach students to critically evaluate new information. This is especially true given the well documented exploration of information. Experts estimate that scientific information doubles every year. As we entered so called “information age” we need to prepare students to assess new things effectively (Nachmias, & Linn, 1987).

Science education contributes to the growth and development of all students, as individuals, as responsible and informed members of society. Science education aims helping students to develop knowledge and a coherent understanding of the living, physical, material, and technological components of their environment, encouraging students to develop skills for investigating the living, physical, material, and technological components of their environment in scientific ways, promoting science as an activity that is carried out by all people as part of their everyday life (The On – Line Teaching Center).

Similarly physics education has similar aims. The most important ones are to find ways to help students learn physics more effectively and efficiently, to understand concepts more deeply (Meltzer, 2003). This may be done with a proper curriculum. There should be connections in the curriculum to everyday life so that the students are trained in the art of finding a physical explanation for what they experience. There should be opportunities to experience the scientific method so that the students can apply it when making critical investigations. The physics education should make a contribution to the development of the student's view of the world, develop scientific literacy, experimental skills, and communication skills and train the student in problem solving with mathematical methods (Olme, 2000).

One of the firs topics taught in a traditional high-school physics course is motion, including the concepts of position, velocity and acceleration. Graph of objects in motion are frequently used since they offer a valuable and alternative to verbal and algebraic descriptions of motion by offering students another way of manipulating the developing concepts (Arons, 1990). Graphs are the best summary of functional relationship. Many teachers consider the use of graphs in a laboratory setting to be critical importance for reinforcing graphing skills and developing an understanding of many topics in physics, especially in motion (Svec, 1999).

If graphs are to be valuable tool for students then we must know the students level of graphing ability. Studies have identified difficulties with such graphic abilities. Students have difficulties making connections among graphs of different variables, physical concepts, and the real world, and they often perceive graphs as just a picture (Linn, Layman & Nachmias, 1987).

From the time when the first calculator invented electronic calculator evolved from a machine that could only carry out simple four – function operations into one that can perform highly technical algebraic and symbolic manipulations instantly and accurately. Calculators are valuable educational tools that allow students to reach a higher level of mathematical power and understanding by reducing time that was spent on learning and performing paper and pencil work. Using calculators allow students and teachers to spend more time on developing understanding of concepts, reasoning and applications. In the past paper and pencil were only tools available but now calculators are available and they are better tools to do most of the computations and manipulations that were done with paper and pencil. Appropriate use of technology and associated pedagogy will get more students to develop useful understanding skills (Pomerantz, 1997).

Calculator Based Laboratory™ (CBL) and Calculator-Based Ranger™ (CBR), which is a data collection device designed to collect and analyze real-world motion data, such as distance, velocity and acceleration, devices are designed to collect data via various probes and then store or feed the data into a computer or calculator. This data can then be analyzed and displayed using many different representations, enabling the student to gather the data and then graph it either at a later time or simultaneously. It seems to be the consensus that the study of graphs can lead to a deeper understanding of physical concepts. However, there are many problems that students have with regard to graphing and modeling (Douglas, 1999).

Laboratory activities which focus on graphing more than traditional labs are valuable in the investigation of students' use of graphs. CBL provide immediately available, calculator drawn graphics of objects in motion. CBL is centered around a sonic ranger, which measures the distance to an object and creates a position versus time graph of the objects motion in real time. Learners can move and see the graph of their motion on the calculator display respond to their motion. The CBL provide an excellent to explore the connection between graphing skills and understanding of motion concepts. Students can connect with concrete, kinesthetic experiences. The ability of calculators to display data graphically is cited as one of the reasons why CBL is effective.

Finally ,with a couple of words, with the CBL the world becomes your laboratory allowing students to collect data anywhere, it is portable and does not need an electrical supply, students learn the reason for graphs and how to interpret them, more time is spent on developing concepts, less time collecting data, during the data analysis there is chance for discussion enabling teachers to gauge the understanding levels of students, activities can be repeated easily with multiple variables, technology can be used successfully with a wide variety of students, students learn to problem solve, data can be collected for various periods of time, multiple probes can be used with the same interface.

In the light of these findings the MBL and CBL studies and its implications are used in most of the developed countries. In Turkey there are only a few researches done on MBL and there is none in CBL usage in physics laboratories. It is important to do similar researches in our country in order to use and develop the CBL activities.

The general purpose of this study is to find out the effectiveness of CBL on understanding and interpreting kinematics graphs.

1.1. The Main Problem

What is the effect of Calculator Based Laboratories (CBL) on students' understandings of kinematics graphs?

1.1.1 The Sub – Problem:

The sub – problems (SP) are:

SP1: Is there a significant effect of CBL on students' understandings of kinematics graphs?

SP2: What are the opinions of the teacher candidates about the treatment and its results?

1.2. Hypothesis

The problem stated above was tested with the following hypothesis that is stated in null form.

Null Hypothesis

H_0: $\mu_2 - \mu_1 = 0$

2: Scores on TUG-K (test of understanding graphs-kinematics) as posttest, 1: Scores on TUG-K (test of understanding graphs-kinematics) as pretest.

There will be no significant effect of CBL on students' means of POSTTEST and PRETEST scores.

1.3. Definition of Important Terms

CBL: Calculator based laboratories where calculators are used to collect data and display them graphically.

CBR: The CBR is a data collection device. Designed for teachers who want their students to collect and analyze real-world motion data, such as distance, velocity and acceleration.

Motion Detector: Motion Detector is a sonic device to collect real-world motion data, such as distance, velocity and acceleration.

Kinematics Graphics: Kinematics graphics are position versus time, velocity versus time, and acceleration versus time graphics.

TUG-K: TUG-K is Test of Understanding Graphs-Kinematics. The test is developed to testing student interpretation of kinematics graphs (Beichner, 1994).

AGE: The age of students in years, participated in the study. This information was taken form the university registration office.

GENDER: It is the fact of being male or female. This information was collected at the time of pretesting.

PRETEST: Students' achievement scores from the TUG – K as a pretest.

POSTTEST: Students' achievement scores from the TUG – K as a posttest.

SCOREDIF: Students' score difference between the POSTTEST and PRETEST scores.

PHYS111: Students' grade of Introduction to Physics I (Phys111) course.

CGPA: Students' cumulative grade point averages.

PHYSAT: Students' physics attitude scores. This information was collected at the time of pretesting.

CALAT: Students' calculator attitude scores. This information was collected at the time of posttesting.

ACTSCORE: Students' scores taken from the CBL activities.

1.4. Significance of the Study

Up to date use of microcomputers are evaluated but there are a few studies on the effectiveness of the use of CBL' s, which are feasible, easy to use, portable and cheap with respect to computers (The price of three computers are equal to 10 calculators with necessary equipments). And also other problem of labs is to find enough space to install computers. However there won't be such problem if we use calculators.

This study will be the first study on Calculator Based Laboratories and Physics in Turkey. The study will help other researches who may work on related topics. Graphic calculators are widely used in other education areas such as mathematics, biology and chemistry. And there are many researches done on this area. There are several studies on CBL and its usage in mathematics education in Turkey. This study aims to show graphic calculators can be also used in Physics Lectures in Turkey.

CHAPTER 2

REVIEW OF RELATED LITERATURE

This chapter devoted to the presentation of theoretical and empirical background for this study.

2.1. Laboratory in Science Teaching

Galileo Galilee established experimentation as a foundation of modern science through the simple act of dropping two iron balls from the Tower of Pisa. Though debatable whether he actually performed that experiment, discussion in his Dialogues Concerning the Two New Sciences shows clearly the power and importance of experimental observations in convincing others of the correctness of a particular scientific theory or hypothesis. The history of science from Galilei on has primarily been the reconciliation of theory with imperfect experimental data (Forinash & Wisman 2001).

Laboratory teaching is one of the hallmarks of education in the sciences (Hegarty, 1987; Tobin, 1990). Laboratory work is seen as an integral part of most science courses and offers an environment different in many ways from that of the "traditional" classroom setting (Henderson, & Fisher 1998).

Science in the laboratory was intended to provide experience in the manipulation of instruments and materials, which was also thought to help students in the development of their conceptual understanding. It is hard to imagine learning to do science, or learning about science in general, without doing laboratory or fieldwork. Since experimentation underlies all scientific knowledge and understanding, laboratories are wonderful settings for teaching and learning science (Trumper, 2002).

2.2. Graphs and Graphing Ability

Fey (as cited in Kwon, 2002) states that there are three mathematical representations of real – world data: (a) tabular representations, (b) algebraic representations, and (c) graphic representations. Tabular representations are useful in showing data with varying parameters. Algebraic representations specify the exact relationship between variables, but neither give a simple example nor a visual image (Goldenberg, 1987). Graphical representations, however, provide an image within the limits of the graph. Graphing representations are frequently used, since they provide a vulnerable alternative to verbal and algebraic description by offering students another way of interpreting data and developing concepts (Padilla, 1995). Graphs provide an invaluable aid in solving arithmetic and algebraic problems and representing relationships among variables. Graphs display mathematical relationships that often can not be easily recognized in numerical form (Arkin & Colton, 1940). Also graphs display trends as geometric patterns that our visual systems encode easily (Pinker, 1983). Graph construction and interpretation skills are obviously important for the development of scientifically literate individuals (Ates & Truman, 2003). McKenzie and Padilla (1986) stated that a graph is an important tool in enabling students to predict relationships between variables and to make the nature of these relationships concrete. Graphs also provide a powerful tool for studying complex relationships, and there are useful means of communicating otherwise difficult to describe information (Norman, 1993).

Kirean (as cited in Kwon, 2002) stated that graphs were rarely taught with purpose of viewing the whole picture; instead, they were often used as another way of representing a relationship that was initially depicted in an algebraic representation in the past. Therefore, most graphical interpretation activities involved the use of point – wise methods applied to basic functions, such as linear, quadratic, and trigonometric equations. Also students mainly learned to construct a graph from a given set of ordered pairs, without reasoning about the physical context in which the number pairs were introduced, and computing function values.

The ability to comfortably work with graphs is a basic skill of the scientist. "Line graph construction and interpretation are very important because they are an integral part of experimentation, the heart of science." A graph depicting a physical event allows a glimpse of trends which cannot easily be recognized in a table of the same data. Mokros and Tinker (1987) note that graphs allow scientists to use their powerful visual pattern recognition facilities to see trends and spot subtle differences in shape. In fact, it has been argued that there is no other statistical tool as powerful for facilitating pattern recognition in complex data. Graphs summarize large amounts of information while still allowing details to be resolved. The ability to use graphs may be an important step toward expertise in problem solving since "the central difference between expert and novice solvers in a scientific domain is that novice solvers have much less ability to construct or use scientific representations". Perhaps the most compelling reason for studying students' ability to interpret kinematics graphs is their widespread use as a teaching tool.

2.2.1. 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. McDermott el 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 the 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 real world:

    - Representing a continuous motion with a continuous line.

- Separating the shape of a graph from the path of the motion.
- Representing a negative velocity on a velocity versus time graph.
- Representing a constant acceleration on acceleration versus time graph.

Some other difficulties were noted (Mokros et al, 1987; Mcdermott, et al., 1987; Goldberg & Anderson, 1989; Nachmias et al., 1987) that students perceive graphs as a picture, they confuse slope with the height of the graph and they also confuse the shape of the graph and the path of the motion.

In addition to above Beichner (1994) studies on the process of developing and analyzing a test in order to report students' problems with interpreting kinematics graphs shown that students also have problems on recognizing the meaning of areas under the kinematics graphs. Students successfully find the slope of lines which pass through the origin but they have difficulties in determining the slope of a line if it does not go through the origin. One another difficulty is distinguishing between distance, velocity and acceleration (variable confusion). They often believe that graphs of these variables should be identical and appear to readily switch axis labels from one variable to another variable without recognizing that the graphed line should also changed.

2.3. Studies on Microcomputer and Calculator Based Laboratories

Physics teachers often report that their students cannot use graphs to represent physical reality. The types of problems physics students have in this area have been carefully examined and categorized. Several of these studies have demonstrated that students entering introductory physics classes understand the basic construction of graphs, but have difficulty applying those skills to the tasks they encounter in the physics laboratory (Beichner, 1994).

In recent years there has been a growing belief that technology should feature in the curriculum of all ages. Pupils should have adequate opportunity to learn about technology and its interaction with the individual, society and environment, and to develop the ability to engage in technological tasks through personal experience (Stewart, 1987). Many pupils have a limited and confused idea of what technology entails (Rennie, 1987; Rennie & Silletto, 1988). Science teachers tend to hold a narrow view that technology is the application of science. The difference between vocational education in the past (which usually was oriented to low achievers) and today's technology education is not always clear. Steps must be taken to present technology in an attractive manner that stimulates interest, motivates students and illustrates various aspects of modem technology (Barak & Eisenberg, 1995).

Svec (1999) studied on the relative effectiveness of traditional lab method and the microcomputer based laboratories (MBL) for engendering conceptual change in students and to investigate students’ ability to interpret and use graphs to help them better learn the kinematics concepts and apply this understanding of those concepts to new non-graphical problems. Subjects were 553 students enrolled in general physics and physics for elementary teachers' courses. The results on the Graphic Interpretation Skills Test and Motion Content Test indicated significant differences between a traditional laboratory and MBL. MBL was more effective at engendering conceptual change in students.

Berg and Philips (1994) investigated relationship between logical thinking structures and the ability to construct and interpret line graphs. Seventy two subjects in 7th, 9th, and 11th graders were administered individual Piagetian tasks to assess five specific mental structures: (a) placement and displacement of objects, (b) one-one multiplication of placement and displacement relations, (c) multiplicative measurements, (d) multiplicative seriation, and (e) proportional reasoning. The results of the study shown that students who had not developed the logical thinking structures in this study were at a severe disadvantage in graphic situations. Mental structures are needed in order to manipulate some forms of content and graphic representations. Without cognitive development students are depending upon their perceptions and low level thinking. Most of the students in elementary grades and many junior high and secondary schools not have mental structures to understand line graphs. Therefore, expecting all students to develop an understanding of graphics is illusory, at least until we facilitate the development of the mental tools needed to grapple with graphs.

Nachmias et al. (1987) studied on the effect of the use of MBL and explicit instruction on students' critical evaluation skills. Subjects were 249 eight-graders in a suburban middle school in California. The Critical Evaluation of Graphs (CEG) instrument was devised to establish how students evaluated MBL generated information is assessed five causes to invalid or unreliable graphs: (a) graph scaling, (b) probe setup, (c) probe calibration, (d) probe sensitivity, (e) experimental variation. Result of the study showed that students unquestioningly accept computer presented data; they only linked this information to their other knowledge of natural world.

Beichner (1990) studied on real time MBL experiments, which allow students to "see" and at least in kinematics exercises, "feel" the connection between a physical event and its graphical representation. Graph production was synchronized with motion reanimation so that students will saw a moving object and its kinematics graph simultaneously. Subjects were 237 students that are 165 high school and 72 were college students. As a result there were no significant difference between students assigned to the different groups but there was significant learning overall.

Redish, Saul, Steinberg (1997) studied on the effectiveness of active engagement of microcomputer based laboratories. Subjects were 470 engineering students. As a result targeted MBL tutorials can be effective in helping students building conceptual understanding, but do not provide complete solution to the problem of building a robust and functional knowledge for many students.

Interpreting graphs is widely recognized as being an important goal of mathematics study. Yet students face many conceptual obstacles in learning to make sense of position-versus-time graphs. A calculator-based motion lab allows students to bring these graphs to life by turning their own motion into a graph that can be analyzed, investigated, and most important, interpreted in terms of how they actually moved. The investigation of motion can become a rich site for building students' intuitions about the concept of rate of change and for developing skills in creating and interpreting graphs. The kinesthetic activity of motion becomes a powerful means for students to understand position-time graphs. The study of changes in motion need not be reserved for students in precalculus or calculus classes. (Doerr & Rieff, 1999).

Dick and Dunham (2000) states that students have trouble with motion graphs even when they understand the mathematical concepts. Students also have trouble discriminating between the slope and the height of a graph, relating one type of graph to another.

Since April, 1996, Kanazawa Technical College has offered a cross-curricular course for first-year and second-year students using a TI-83 (Graphing Calculator) and a Computer Based Laboratory (CBL). The goal of the course is for students to learn about the connection between mathematics and physics through hands-on activities. Students conduct experiments on the motion of a person walking, the dropping of an object, the cooling rate of water, the motion of a swinging pendulum, and sound waves. The following findings were obtained: Most students (a) replaced their naive assumptions regarding the laws of physics with scientific concepts; (b) independently made connections between the results of experiments and their previous mathematical knowledge; (c) reported that their level of interest in physical phenomena and science had either not decreased or had improved, (d) valued mathematics more, and (e) realized the importance of cooperative work. The use of CBL and TI-83s changed not only the authors' teaching style but also students' attitudes. Students had ownership of their experiments, and they engaged in higher-order thinking skills such as making predictions, analyzing data, and modeling data with equations. As a result, students became more interested in learning mathematics and science (Saeiki et al., 2001).

Middle school students can learn to communicate with graphs in the context of appropriate Calculator Based Ranger (CBR) activities. The use of CBR activities developed the three components of students' graphic abilities which are interpreting, modeling and transforming significantly. The study indicates that the CBR activities are pedagogically promising for enhancing graphing ability of physical phenomena (Kwon, 2002).

2.4. Benefits of Calculator Based Laboratories

When students work with graphing calculators, they have the potential to work much more intelligently than they could if they were not using this valuable resource; they form an "intelligent partnership" with the graphing calculator (Jones, 1996). "In almost all cases, students taught with calculators (but tested without technology) had achievement scores for computation as high as or higher than those taught without technology. With calculators, students had higher problem-solving scores, better attitudes toward mathematics, and better self-concepts of their own ability to do mathematics. Recent studies suggest that graphing calculators and computer symbolic algebra systems can be just as beneficial to student learning" (Dunham, 1993).

Dunham's review of research (1993) reports that many students who use graphing technology place at higher levels in hierarchy of graphical understanding; are better able to relate graphs to their equations; can better read and interpret graphical information; obtain more information from graphs; have greater overall achievement on graphing items; are better at "symbolizing", that is, finding an algebraic representation for a graph; better understand global features of functions; increase their "example base" for functions by examining a greater variety of representations; and better understand connections among graphical, numerical, and algebraic representations Moreover, they: had more flexible approaches to problem solving; were more willing to engage in problem solving and stayed with it longer; concentrated on the mathematics of the problem and not on the algebraic manipulation; solved non-routine problems inaccessible by algebraic techniques; and believed calculators improved their ability to solve problems' (Dunham & Dick, 1994).

In studies where graphing technology was in use, students were more active, and they participated in more group work, investigations, problem solving, and explorations. Teachers lectured less and were often used by students as more of a consultant than a task-setter (Dunham et al., 1994).

"Students who use graphing calculators are better able to read and interpret graphs, understand global features of graphs, relate graphs to their equations, and make connections among multiple representations of functions" (Dunham, 1996).

Technology based tools are supporting teachers as they work to change that trend and revise the way science is taught. Many can remember science lectures, discussions of data, and chalk-board-etched formulas. Contrast this with the current generation of students accustomed to video games, computers and other technologies, and MTV. How can teachers capture the attention of these students and excite them about math and science? Teachers are being encouraged to make science more interesting, and technology-based tools are assisting that effort. The Texas Instruments' Calculator-Based Laboratory System provides students with hand-held technology that allows them to get actively involved in experimentation. As in real-world scenarios, they can gather data, inside or outside the classroom; analyze the data they have found; solve problems and ask questions; and draw conclusions. They can see how science applies to the world around them by experiencing it firsthand (Curriculum Administrator, 1997).

Mathematical investigations of motion by middle school students can be accomplished with a motion lab consisting of a graphing calculator, a Calculator Based Laboratory (CBL) unit, and a motion detector. Students can run numerous trials in a short time, since each trial takes only a few seconds and is followed by an immediate visual representation of the motion. We have designed for pre – algebra students a suitable activity that begins with an exploration of simple distance-versus-time graphs. This activity is best done over several class periods by small groups of three or four students, followed by group presentations or whole-class discussion. Students with limited exposure to graphs rapidly comprehend the visual representations produced by the motion-detecting system. Since their own motion produces the graphs, students are quick to experiment and are readily able to describe the graphs in terms of their own motion. Students begin to describe a graph in terms of how fast they moved (slope) and where they started (y-intercept) (Doerr & Rieff, 1999).

The motion detector, the CBL unit, and the graphing calculator create a flexible and easy-to-use motion lab with which pre – algebra students can investigate the concepts of rate of change and velocity through the kinesthetic experience of their own motion. In instructional settings that blend small-group activities with whole-class discussion, we have found that seventh and eighth graders are eager to engage in these investigations and discussions. The technology gives students the opportunity to test their conjectures, to experiment with mathematical ideas, and to use and develop mathematical language for change and variation. Although we have shown only one activity, this motion lab can be used with activities that further quantify the notions of speed, explore periodic motion, and investigate intersecting linear graphs. Since students themselves are engaged in creating the motion, interpreting the graphs comes easily (Doerr et al., 1999).

The world of science has always fascinated young minds (Welker, 1999). He used CBL activities in amusement parks and tested students' learning's about motion theories. The students are first asked to hypothesize the acceleration statistics as they wait to get on the ride. They sketch out graphs such as Position vs. Time, Height vs. Time and Velocity vs. Time. After they gather these data, students went back to class and compare their original motion theories to the actual statistics gathered from the probe. To determine if students truly understand motion theory after their amusement park experience, the Physics and Math teachers give students a mythical ride with wild twists and turns. Students are asked to create graphs similar to the ones made at the park. Welker (1999) states that hands – on science lessons have never been so fun. Thanks to portable technology, it is possible to bring abstract theories, such as the effect of motion, to life in a whole new way.

Students have many difficulties interpreting graphs of kinematics variables. These difficulties are often based on misconceptions. Students cannot repair their misconceptions until they are confronted by them. Laboratory activities using MBL or CBL instruments supply a powerful setting and foster the opportunity for student discourse, both student – student and student – teacher (Dick et al., 2000).

2.5. Summary of the Literature Review

- The most powerful and important way of convincing the correctness of a particular scientific theory or hypothesis is experimental observations.
- Laboratory teaching is one of the hallmarks (Hegarty, 1987; Tobin, 1990)

and an integral part of science education that offers a different environment from traditional classroom settings (Henderson & Fisher, 1998).

- Science laboratories are intended to provide experience in the manipulation of instruments and materials which help students to develop conceptual understanding (Trumper, 2002).
- Graphical representations are the most valuable and useful way of representing the real world information with regard to tabular and algebraic representations (Kwon 2002).
- Graphics summarize large amount of data and this makes the graphs most powerful visual pattern to recognize the complex data and make them an integral part of experimentation (Makos et al., 1987).
- Science teachers have a narrow view that technology is the application of science. Technology in science classes may stimulate interest, motivate students and illustrate various aspects of modern technology (Barak et al., 1995).
- Svec (1999) showed that microcomputer based laboratories (MBL) was more effective than traditional laboratories at engendering conceptual change in students.

- Students unquestioningly accept computer presented data; they only linked this information to their other knowledge of natural world.

- Beichner (1990) stated that MBL experiments have significantly affects students overall learning.

- MBL tutorials were effective in helping students building conceptual understanding of students' but do not provide complete solution to the problem of building robust and functional knowledge for many students (Redish et al., 1997).

- A Calculator Based Laboratory (CBL) allows students to bring graphs to life by turning their own motion into motion in to graph that can be analyzed, investigated, and most important, interpret in terms of how they actually moved (Doerr et al., 1999).

- Dick et al. (2000) stated that students have trouble with motion graphs even they understand the mathematical concepts.

- The use of Calculator Based Laboratories (CBL) made students (a) replace their naive assumption of scientific concepts; (b) independently made connections between the results of experiments and their previous mathematical knowledge; (c) level of interest in physics had improved, (d) realized the importance of group work (Saeki et al., 2001).

- As a result of CBL studies students become more interested in learning mathematics and science (Saeki et al., 2001).

- Middle school students can learn to communicate with graphs in the context of appropriate CBL activities (Kwon 2002).

- Jones (1996) said that in almost all cases students taught with calculators had achievement scores higher that those taught without technology.

- Dunham et al. (1994) stated that with CBL students had more flexible approaches to problem solving, were more willingly to engage in problem solving and believed calculators improved their ability to solve problems.

- Students were more active and they participated more in group work, investigations, problem solving and explorations (Dunham 1993, Dunham et al., 1994).

- CBL provides students hand held technology that allows them to get actively involved in experimentation. They can gather data, analyze data, solve problems and draw conclusions (Curriculum Administrator, 1997).

- Students can run numerous trials in a short time, since each trial takes only a few seconds and is followed by an immediate visual representation of the motion (Doerr et al., 1999).

- The technology gives students the opportunity to test their conjectures, to experiment with mathematical ideas and to use and develop mathematical language for change and variation. Since students themselves were engaged in creating the motion, interpreting graphs comes easily (Doerr et al., 1999).

- Welker (1999) states that portable technology brings abstract theories, such as the effects of motion, to live in a whole new way.

- Laboratory activities using MBL and CBL instruments supply a powerful setting and foster the opportunity for student discourse (Dick et al., 2000).

CHAPTER 3

METHODS

In the previous chapters, the purpose and hypothesis of the study were presented and the review of the related literature and the significance of the study stated. In this chapter, population, sample, description of the variables, measuring tools and teaching/learning materials, procedure, data analysis methods and assumptions and limitations of the study are explained briefly.

3.1. Population and Sample

The target population of the study covers all students which are taken PHYS 101 or PHYS 111 in METU. The accessible population is determined as students in secondary school science and mathematics education department.

The study sample chosen from the accessible population and it is a convenient sample. 32 students from 2 classes of one teacher were involved in the study. Almost all students' socio-economic status including the educational level of parents, social life standards and their family income can be assumed as middle. The ages of the students are range from 21 to 26. The distribution of ages of the students who took the PRETEST and POSTTEST test with respect to gender is given in Table 3.1. Most of the students enrolled in this study are 23 years old. As seen from the Table 3.1 the number of male and female students is equal.

Table 3.1 Characteristics of the Sample.

	Gender		
Age	Female	Male	Total
21	4	1	5
22	4	2	6
23	6	10	16
24	1	0	1
25	0	2	2
26	0	1	1
All	16	16	32

3.2. Variables

There are 10 variables involved in this study that were named as independent variables (IVs) and dependent variables (DVs).

3.2.1. Dependent Variables

The DV is Students' Scores of Test of Understanding Graphics – Kinematics as posttest (POSTTEST). POSTTEST is continuous variable and measured on interval scale. Students' possible minimum and maximum scores range from 0 to 21 for POSTTEST.

3.2.2. Independent Variables

These variables are Students' Scores of Test of Understanding Graphics – Kinematics as pretest (PRETEST), gender, students' age (AGE), Physics 111 Course Grade (PHYS111), Physics Attitude Scores (PHYSAT), Calculator Attitude Score (CALAT), Activity Scores (ACTSCORE), and Previous Cumulative Grade Point Averages (CGPA). PRETEST, AGE, PHYS111, PHYSAT, CALAT, ACTSCORE, and CGPA are considered as continuous variables and measured on interval scales. Students' gender is determined as discrete variable and measured on nominal scale. The last IV is the treatment where CBL activities are used (TREAT). It is considered as discrete and measured on nominal scale.

The students' possible minimum and maximum scores range from 0 to 21 for PRETEST, 20 to 120 for PHYSAT, 9 to 18 for CALAT, 0 to 100 for ACTSCORE and 21 to 26 for AGE respectively. The students' gender was coded with male as 0 and female as 1.

3.3. Measuring Tools

For this study, four measuring tools were used. These are Test of Understanding Graphics-Kinematics (TUG-K), Physics Attitude Test, Calculator Attitude Test and Activity Sheets.

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

The instrument TUG-K used in this study was developed by Beichner

(1993) to find out students' problems with interpreting kinematics graphs. The TUG-K covers the kinematics graphs which have position, velocity, or acceleration as the ordinate and time as the abscissa. The test consists of 21 multiple choice questions. The scores of the test range from 0 to 21, higher score means greater achievement in understanding kinematics graphics.

Table 3.2 Identification of Variables

TYPE OF VARIABLE	NAME	TYPE OF VALUE	TYPE OF SCALE
DV	POSTTEST	Continuous	Interval
IV	PRETEST	Continuous	Interval
IV	GENDER	Discrete	Nominal
IV	AGE	Continuous	Interval
IV	CGPA	Continuous	Interval
IV	PHYS111	Continuous	Interval
IV	PHYSAT	Continuous	Interval
IV	CALAT	Continuous	Interval
IV	ACTSCORE	Continuous	Interval
IV	TREAT	Discrete	Nominal

The TUKG has seven objectives (see Appendix A) and three items were written for each objective (see Appendix B). It has developed to ensure that only kinematics graph interpretation skills were measured. Items and distracters were deliberately written so as to attract students holding previously reported graphing difficulties. Another way to ensure that common errors were included as distracters was to ask open-ended questions of a group of students and then use the most frequently appearing mistakes as distracters for the multiple-choice version of the test (Beichner, 1994).

3.3.2. Activity Sheets

Students' activity sheets are consists of purpose, tools, method and data collection, observation, and questions parts related with the activities. There are 4 activity sheets and they are given at Appendix C.

3.3.3. Questionnaire: Teacher Candidates' Opinions about the Treatment

To support the gathered data through the study a questionnaire conducted which aims to take opinions about the CBL activities and its results. There are four open – ended questions in the questionnaire which are listed in Appendix G. The opinions about the activities, likes and dislikes, the reasons why they scored high/low/same on the POSTTEST, and the question "what were the activities on kinematics subjects they have done after the PHYS111 course" were asked to the teacher candidates.

3.3.4. Calculator Attitude Test

The calculator attitude test was developed by Ersoy (2003). The test has nine yes – no questions (See Appendix F). The scores of the test range from 0 to 9, higher score means greater attitude towards calculators. The purpose of the test is to determine the subjects' trends and attitudes of using calculators.

3.3.5. Physics Attitude Test

The physics attitude (Sancar, 2002) test has 20 items. Each item is scored on a 6 – point Likert scale from strongly disagree to strongly agree (see Appendix E). The scores of the test range from 20 to 120, higher score means greater attitude towards physics.

3.3.6. Validity and Reliability of the Measuring Tool

Draft versions of the TUG – K test were administered to 134 community college students who had already been taught kinematics. These results were used to modify several of the questions. These revised tests were distributed to 15 science educators including high school, community college, four year college, and university faculty. They were asked to complete the tests, 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 (Beichner, 1994).

The reliability of the PRETEST scores, KR-20, average of point – biserial coefficient and the average of item discrimination index were reported as .83, .74

and .36 respectively. And point biserial coefficients and percentages of students selecting a particular choice for each test item are given in Table 3.3.

The reliability of the POSTTEST scores, KR-20, average of point – biserial coefficient and the average of item discrimination index were reported as .83, .74 and .36 respectively. And point biserial coefficients and percentages of students selecting a particular choice for each test item are given in Table 3.4.

The other descriptive statistics about the TUG – K such as mean, standard deviation, SEM, KR – 20, Point-biserial coefficient are given in Table 3.5.

The calculator attitude test has nine questions and the scores range from zero to nine higher score showing higher attitude. Calculator attitude test has given to 47 mathematics teachers. The mean of the attitude scores and the standard deviation of the teachers were 2.91 and 1.38 respectively. The reliability and the validity studies were done previously with a pilot study. The results were show the test was reliable and valid for using to measure the attitudes towards calculator.

In this study the mean and the standard deviation of the calculator attitude test scores are measured as 2.88, 1.98 respectively. And the KR – 20 of the test results is .61.

The physics attitude test developed as a course project. The reliability analyzes also performed for the physics attitude test. In the pilot study the KR – 20 was found as .80. The validity evidences and the reliability estimates for the physics attitude test implies that the scores obtained on these tests are reliable and valid measure of students' attitudes towards physics.

In our study the mean and the standard deviation of the physics attitude test scores are measured as 95.75, and 16.19 respectively. And the KR – 20 of the test results is .92.

Table 3.5. Descriptive Statistics About the TUG – K Test.

Name of Statistics	Desired Value	TUG-K Value	PRETEST	POSTTEST
Number of students	As high as possible	524	32	32
Mean	10.5	8.50	17.19	16.69
Standard deviation		4.60	3.04	3.51
SEM	As small as possible	0.20	0.54	0.62
KR-20	≥ 0.70	.83	.79	.78
Point-biserial coefficient	≥ 0.20	.74	.44	.39

3.4. Teaching and Learning Materials

Materials used in this study are objective list, table of test specification, CBL activities and objective-activity table.

CBL activities (see Appendix C) are translated and adapted from the original CBL activities (Getting Started with the CBL 2™ System, 2000) and xxx. Four CBL activities were prepared. Every activity has a purpose, materials, and procedure part.

Table 3.3. Point Biserial Coefficients and Number of Students Selecting a Particular Choice for Each Test Item for PRETEST

	objective	**point biserial**	**a**	**b**	**c**	**d**	**e**	**omit**
1	4	.43	1	**28**	0	2	0	1
2	2	.46	0	1	0	0	**31**	0
3	6	.38	0	1	2	**29**	0	0
4	3	.37	0	1	0	**26**	4	1
5	1	.64	0	1	**28**	1	1	1
6	2	.50	8	**20**	0	2	1	1
7	2	.54	**20**	6	2	2	0	2
8	6	.48	0	5	0	**27**	0	0
9	7	.38	3	4	4	1	**20**	0
10	4	.34	**24**	1	6	0	0	1
11	5	.47	1	8	0	**21**	1	1
12	7	1.00	0	**32**	0	0	0	0
13	1	.33	0	2	6	**23**	1	0
14	5	.38	0	**30**	1	1	0	0
15	5	.28	**29**	0	0	1	2	0
16	4	.34	0	0	2	**28**	1	1
17	1	.55	**18**	7	3	1	1	2
18	3	.50	0	**30**	0	0	1	1
19	7	.15	0	1	**29**	2	0	0
20	3	.63	0	0	0	0	**31**	1
21	6	.71	**25**	5	2	0	0	0

Table 3.4. Point Biserial Coefficients and Number of Students Selecting a Particular Choice for Each Test Item for POSTTEST

	objective	**point biserial**	**a**	**b**	**c**	**d**	**e**	**omit**
1	4	.90	0	**23**	1	6	2	0
2	2	.37	2	1	1	0	**28**	0
3	6	.20	2	0	0	**30**	0	0
4	3	.99	0	2	0	**28**	1	1
5	1	.79	0	0	**27**	4	0	1
6	2	.81	10	**17**	1	0	1	3
7	2	.51	**20**	7	0	1	1	3
8	6	.51	0	5	0	**26**	1	0
9	7	.41	4	1	8	8	**19**	0
10	4	.79	**23**	0	9	0	0	0
11	5	.43	0	13	1	**17**	1	0
7	2	.52	**19**	5	3	3	0	1
13	1	.51	0	0	7	**25**	0	0
14	5	.30	0	**31**	1	0	0	0
15	5	.17	**26**	0	0	3	3	0
16	4	.76	0	3	3	**25**	0	1
17	1	.74	**18**	6	4	2	1	1
18	3	.45	0	**27**	1	0	3	1
19	7	.80	1	5	**24**	1	1	0
20	3	1.00	0	0	0	0	**31**	1
21	6	.61	**26**	5	1	0	0	0

The titles of the activities are graph matching, motion with constant velocity, motion with constant acceleration I and II. All of the activities done with the CBL equipments which are: 1) Graphic Calculator (TI-83 Plus). 2) Motion Detector (Vernier MD-BTD) which is a sonar device that emits ultrasonic pulses and waits for an echo. The time it takes for the reflected pulses to return is used to calculate distance, velocity, and acceleration. The range of the detector is 0.4 meters to 6 meters. 3) 2.2 meters Classic Dynamic System produced by Pasco (ME – 9452). This dynamics system, with extra-long track, enables students to study linear motion, including acceleration, momentum, and conservation of energy.

In order to check whether CBL activities were planed a table of objective-activity (see Appendix D) prepared. This table shows which of the objectives match with the activities.

3.5. Procedure

At the beginning of the study a detailed review of the literature search was carried out. After determining the keyword list, Educational Resources Information Center (ERIC), International Dissertation Abstracts (DAI), Social Science Citation Index (SSCI), Academic Search Premier, Ebscohost, Science Direct and Internet Search Engines such as Yahoo, Google and Copernic were searched systematically. Photocopies of obtainable documents were taken from METU library. All of the materials obtained were read results of the studies were compared with each other.

The One – Group Pretest – Posttest experimental design (Fraenkel &

Wallen 2003) was used in the study. The researcher him self carried out the laboratory activities and the administration of the tests. The PRETEST was administered before the laboratory activities started. 25 minutes was given to students to complete the TUG-K. Time was adequate to complete the given test.

As the next step CBL activities were prepared. Then as measuring tool (TUG-K) chosen and teaching/learning materials are developed as mentioned in sections 3.3 and 3.4.

The students carried out the CBL activities with the help of the researcher. The researcher arranged the students in 8 groups; each group consisted of 4 students. They followed the procedure and answered the questions in the activity sheets. The researcher mostly acted as a facilitator of the activities and helped the students when they were in need. Finally, after three weeks of treatment period, the TUG-K was again administered as posttest. The data taken from the both PRETEST and the POSTTEST scores was entered to computer for further analysis.

Finally to support the study a questionnaire has been conducted in order to collect prospective teacher candidates' opinions about the study and its results. Then the responses of the students recorded for further investigation.

3.6. Analysis of Data

Data list (see Appendix H) consist of students' PRETEST and POSTTEST scores, which are PRETEST and POSTTEST. The raw data is enter to computer via

SPSS program and the data list was prepared where columns show variables and the rows show the students participated in the study. For the statistical analysis SPSS™ ITEMAN™ and Excel™ programs were used.

3.6.1. Descriptive and Inferential Statistics

The mean, standard deviation, skewness, kurtosis, range, minimum, maximum and the histograms were presented for the experimental group. In order to test the null hypothesis, all statistical computations were done by using statistical package program SPSS. Statistical technique named Paired Samples T – Test was used.

3.6.2. Analysis of Teacher Candidates' Opinions about the Treatment

In order to analyze the data collected from four open – ended questions one research question was determined and the responses of the students are grouped according to the questions of the questionnaire.

3.7. Assumptions and Limitations

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

The subjects of the study answered the items of the test sincerely.

The administration of the PRETEST and POSTTEST was under standard conditions.

Students were assessed with paper and pencil test in this study. However, one must consider whether or not science achievement is measured by a paper and pencil test is an appropriate measure of performance those students engaged in CBL activities.

Generalizations from this The One – Group Pretest – Posttest experimental design study are limited because the participants of the study were not selected randomly. However same conclusions could be arrived at samples that show same conditions with the study.

The subject of the study was limited to 32 Secondary Science and Mathematics Education Students in the Middle East Technical University Education Faculty during the Spring Semester 2002 – 2003.

The study is limited to the objectives of Kinematics Graphs which are position – time, velocity – time, and acceleration – time graphs in the Kinematics Lessons.

CHAPTER 4

RESULTS

The results of this study are explained in there sections. Descriptive statistics associated with the data collected from the administration of the TUG-K PRETEST and the POSTTEST is presented in the first section. In the second section the inferential statistical data is presented. In the third and the last section the findings of the study summarized.

4.1. Descriptive Statistics

Descriptive statistics related to the students' PRETEST and POSTTEST scores of Test of Understanding Graphics - Kinematics (TUG-K) is presented in Table 4.1.

Students' TUG-K scores range from 0 to 21. Higher scores mean greater achievement. The Table 4.1 indicates that the mean of PRETEST is 17.19 and POSTTEST is 16.59. It can be seen that the POSTTEST scores' mean decreased by 0.59 according to PRETEST scores' mean.

Table 4.1 also presents some other basic descriptive statistics like standard deviation, minimum, maximum, range, skewness, kurtosis values. The skewness' of the PRETEST and the POSTTEST are -1.80 and -1.04 respectively.

Table 4.1 Descriptive Statistics of Students' TUG-K Scores (N = 32)

Scores on TUK-G	PRETEST	POSTTEST
N	32	32
Mean	17.19	16.59
Std. Deviation	3.04	3.52
Minimum	6	21
Maximum	6	21
Range	15	15
Skewness	-1.80	-1.04
Kurtosis	5.02	1.07

The kurtosis values of the PRETEST and POSTTEST are 5.02 and 1.07 respectively. Kunnan (as cited in Hardal, 2003) states that the skewness and kurtosis values between -2 and +2 can be assumed as approximately normal. Therefore, the skewness and the kurtosis values can be accepted as normal except the kurtosis value of PRETEST as shown in Table 4.1.

Figure 4.1 shows the histogram with the normal curves related to TUG-K PRETEST and POSTTEST scores.

The mean and standard deviation of PHYSAT are 95.75 and 16.18 respectively. The PHYSAT was a 6 point likert-scale attitude test. The mean indicating that the students have positive attitude towards physics.

The mean and standard deviation of CALAT are 2.86 and 1.98 respectively. The mean indicating that the students have negative attitude towards calculators.

The other descriptive statistics related with the sample such as AGE, CGPA, and PHYS111 are given in Table 4.2.

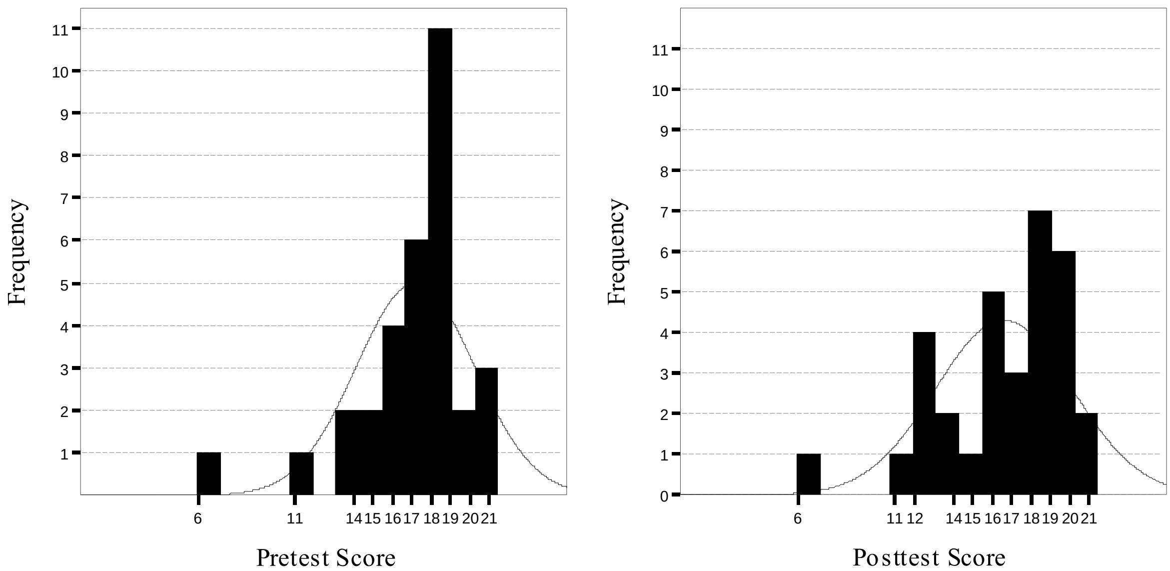

Figure 4.1 Histograms with Normal Curves Related to the TUG-K PRETEST and POSTTEST Scores (N = 32).

4.2. Inferential Statistics

This section deals with the missing data analysis, verification of the assumptions of the statistical methods, the Paired-Samples T Test, Wilcoxon Signed Ranks Test and the analysis of the hypothesis.

Table 4.2 Descriptive Statistics of Students' AGE, CGPA, and PHYS111.

	AGE	CGPA	PHYS111
N	32	32	32
Mean	22.72	2.59	1.95
Std. Deviation	1.18	0.46	1.01
Minimum	21	1.86	0
Maximum	26	3.58	4
Range	5	1.72	4
Skewness	0.72	0.31	-0.43
Kurtosis	1.22	-0.74	1.72

4.2.1 Missing Data Analysis

In this study three is no missing data. 32 of the students were taken the PRETEST and the POSTTEST.

4.2.2 Assumptions of Paired-Samples T Test

Paired-Samples T Test has two assumptions which are observations for each pair should be made under the same conditions and the mean differences should be normally distributed. Variances of each variable can be equal or unequal.

The PRETEST and POSTTEST are held in similar classes and in similar conditions to set the assumptions of the Paired-Samples T Test.

For normality assumption skewness and kurtosis values were used. The values for skewness and kurtosis of PRETEST and POSTTEST scores were given in Section 4.1. The skewness and kurtosis values except kurtosis of PRETEST can be assumed in approximately acceptable range for a normal distribution.

4.2.3 Paired-Samples T Test

DV of the research is POSTTEST and the IV is PRETEST. As seen form the Table 4.3 there is no significant effect of CBL on students' understandings of kinematics graphs.

Table 4.3 Paired-Samples T Test (N = 32)

	Mean	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)
POSTTEST - PRETEST	-0.59	2.434	0.43	-1.38	31	.178

4.2.4 Assumptions of Wilcoxon Signed Ranks Test

Wilcoxon Signed Rank Test is a nonparametric procedure used with two related variables to test the hypothesis that the two variables have the same distribution. It makes no assumptions about the shapes of the distributions of the two variables.

4.2.5 Wilcoxon Signed Ranks Test

One may consider that the assumptions of the Paired-Samples T Test was not achieved a nonparametric test must be used. The result of Wilcoxon Signed Ranks Test indicated that there is no significant difference between PRETEST and POSTTEST, $z = -1.13$, $p = 0.26$. The mean of the negative ranks showing lower score on POSTTEST was 15.68; the mean of the positive ranks showing higher score on POSTTEST was 10.96.

4.2.4 Null Hypothesis

The Null Hypothesis was "there will be no significant effect of CBL on students' means of POSTTEST and PRETEST scores".

Paired-Samples T Test was conducted to determine the effect of CBL on students' means of POSTTEST and PRETEST scores. As seen from the Table 4.3 the null hypothesis was accepted ($t = -1.38$, $p = .178$). There is no significant difference between the students' PRETEST and POSTTEST scores after the CBL activities carried out.

4.3 Results of the Questionnaire: The Teacher Candidates' Opinions about the Treatment.

In this study, after the treatment the open – ended questions was given to 22 teacher candidates who are previously involved in the study. In the following part the open – ended questions and the results of them are given in Table 4.4.

Table 4.4 Students' Responses To Open – Ended Questions (N = 22)

Questions	ScoreDif	Students' responses to open - ended questions	Group %	Total %
What is your opinion about the CBL activities and the ways you like and dislike?	LOW (N = 9)	The activities were very useful and enjoying	77,8	31,8
		Students can see the results immediately which help them to understand better and makes the activities more concrete	55,6	22,7
		This type of activities motivates the students	33,3	13,6
		The calculators were not simple to use	11,1	4,5
	SAME (N = 7)	The activities were interesting. They will be very useful for high school students	57,1	18,2
		This type of activities will be helpful for us when we become teachers	28,6	9,1
		Students should also learn to draw graphics from the collected data	14,3	4,5
	HIGH (N = 6)	The activities were enjoying, interesting and useful	66,7	18,2
		The apparatus were small and easy to install and conduct experiments	66,7	18,2
		Students can see the results immediately this makes students easy to understand and motivate them	50,0	13,6
You take higher/lover/same score on POSTTEST. What are your opinions about this result?	LOW (N = 9)	The POSTTEST was at the same day with our final exams	88,9	36,4
		I may be careless at that time	22,2	22,2
	SAME (N = 7)	We all know these subjects	85,7	27,3
		Some of us are not cared the activities	28,6	9,1
	HIGH (N = 6)	The graphs we were studied in the activities helped me answering questions	66,7	18,2
		I have over come my misconceptions related with graphs	33,3	9,1
		I do not think that my score was increased; I did one or two questions wrong unconsciously.	16,7	4,5

Table 4.4 (continued)

Questions	ScoreDif	Students' responses to open - ended questions	Group %	Total %
The results of the PRETEST were much higher than the expected values. (The mean of the test results of TUG – K which was conducted in USA was 40 out of 100. Yours was 78 out of 100). What is the reason of this high result?	**LOW (N = 9)**	University entrance examinations (OSS – OYS) and the curriculum in high schools make us to study hard on these topics	88,9	36,4
		I teach these subjects	22,2	9,1
	SAME (N = 7)	We have studied very hard on these topics while studying for University entrance examinations	85,7	27,3
		Because we were physics students	14,3	4,5
	HIGH (N = 6)	We were studied on similar questions while studying for University entrance examinations	83,3	22,7
		We were at a higher level	16,7	4,5
Have you ever studied on a subject which may affect the results of PRETEST after you have taken PHYS111 course?	**LOW (N = 9)**	No	88,9	36,4
		I teach these subjects	11,1	4,5
	SAME (N = 7)	No	100,0	31,8
	HIGH (N = 6)	No	66,7	18,2
		I teach these subjects	33,3	9,1

1) What is your opinion about the CBL activities and the ways you like and dislike?

2) You take higher/lover/same score on POSTTEST. What are your opinions about this result?

3) The results of the PRETEST were much higher than the expected values. (The mean of the test results of TUG – K which was conducted in USA was 40 out of 100. Yours was 78 out of 100). What is the reason of this high result?

4) Have you ever studied on a subject which may affect the results of PRETEST after you have taken PHYS111 course?

Students found the CBL activities useful, interesting and enjoying. Students can see the results immediately this makes students easy to understand and this motivates them. According to students the most probable reason of getting low scores on POSTTEST was the time of the POSTTEST which was at the same time with their finals. They found the questions of PRETEST easy because they were familiar with them as they had solved similar questions while studying for university entrance exams (OSS/OYS).

4.4 Summary of the Results

Parametric and nonparametric analysis of the test scores indicated that there is no statistically significant difference between the PRETEST and POSTTEST scores of the students. This result points to there is no effect of Calculator Based Laboratories on students' understandings of kinematical concepts. In order to find out if there was an effect of CBL on some objectives of the test the test scores are calculated according to objectives where the TUG – K has seven objectives so that each student had seven scores on each test. A Paired-Samples T Test was carried out to find out if there is a statistically significant difference between the objective scores of the students'. The Table 4.5 describes that there is no statistically significant change in students' objective scores.

Table 4.5 Paired-Samples T Test of the TUG – K Objectives (N = 32)

Scores on TUK-G	Mean	SD	Std. Error Mean	Sig. (2-tailed)
POSTOBJ1 - PREOBJ1	0,03	0,74	0,131	0,813
POSTOBJ2 - PREOBJ2	-0,25	0,984	0,174	0,161
POSTOBJ3 - PREOBJ3	0,09	0,893	0,158	0,557
POSTOBJ4 - PREOBJ4	-0,31	0,965	0,171	0,077
POSTOBJ5 - PREOBJ5	-0,22	0,751	0,133	0,109
POSTOBJ6 - PREOBJ6	-0,06	0,716	0,127	0,625
POSTOBJ7 - PREOBJ7	-0,19	0,78	0,138	0,184

Final calculations made to find out if there are any statistically significant correlations between students SCOREDIF and PHYS111, PHYSAT, CALAT and ACTSCORE. Correlation coefficients were computed among the five variables. The results of the correlational analysis are presented in the Table 4.6. None of the four correlations were statistically significant with *p* values grater than .01 (Bonferroni approach was used to control Type I error across the correlations between five variables).

Table 4.6 Partial Correlations among the IVs of the Study

	PHYS111	PHYSAT	CALAT	ACTSCORE
SCOREDIF	-,02	-,27	-,13	-,07

Analysis of open – ended questions showed that most of the students believed that the activities are useful and interesting. The most probable result that affects the significance of the study is the time of the POSTTEST which was conducted in the same time with the final exams of the students. Most of the opinions of the students are the TUG – K questions are similar with the questions of university entrance examinations this caused a high mean score in PRETEST. And most of them said that they did not studied similar subjects after they have taken PHYS111 course.

CHAPTER 5

CONCLUSIONS, DISCUSSION AND IMPLICATION

The purpose of this study was to investigate the effects of Calculator Based Laboratories (CBL) on students' understandings of kinematics graphs. To achieve this purpose, this chapter is given in six sections. The conclusions are given in the first section. The discussion of the results is given in the second section. Internal and external validity are given in the third and the fourth section respectively. The fifth section comprises implications of the study. Finally in the last section, recommendations for further studies are introduced.

5.1. Conclusions

The sample of the study chosen from accessible population was a sample of convenience. Consequently there is a limitation about the generalizability of this study. On the other hand the conclusions presented beneath can be applied to a broader population of similar students.

The Calculator Based Laboratory Activities was not affecting students' understandings of kinematics graphs. So we can conclude that Calculator Based Laboratory Activities did not increase the level students' understandings of kinematics graphs.

5.2. Discussion of the Results

Findings of this study implied that there is no significant effect of the Calculator Based Laboratories on students' understandings of kinematics graphs. The students POSTEST mean was 17.19 out of 21 questions it was very high with respect to Beicher's findings which was 8.4. Depending on these high scores it was hard to improve students' scores on POSTTEST. Besides that the POSTTEST was administered at the final dates of the students which may be another reason of students' getting lover scores on POSTTEST. All students in the sample were physics teacher candidates. This might also lead students to take high scores on PRETEST.

Thornton et al. (1990) warn that the tools themselves are not enough but that gains in learning appear to be produced by a combination of the MBL devices and appropriate curricular material that guides the students to examine appropriate phenomena. MBL use multiple modalities, pair events in real time with their symbolic representations, provide scientific experiences similar to those of scientists in actual practice, and eliminate the drudgery of graph production. These were the reasons why MBL technology is useful according to Mokros et al. (1987). They also suggest that encouraging collaboration is an added benefit of MBL. For motion phenomena, using simultaneous graph production to link a graph with a physical concept seems to be essential.

Although the literature suggests benefits from using MBL technology, we must also consider problems that may arise if we do not pay attention to how the technology is implemented. Some studies indicate that without proper precautions, technology can become an obstacle to understanding (Lapp et al., 2000).

Future research also should address how students view the authority of technology in problem solving. Research suggests that we can be optimistic about the benefits of MBL and CBL use in forming graphical concepts. However, it is too early to draw final conclusions. Further study is needed before the research community can make any definitive statements on the pedagogical advantages of data collection devices.

Similar studies showed that this type of activities increases the students' level of understandings. Students believe that these activities are useful. They also believe that the scores on POSTTEST that they got would be higher if the test was not administered at the same time with their final examinations.

5.3. Internal Validity

Internal validity of a study means that the observed differences on the dependent variable are related with the independent variable, not some other unintended variables which are not controlled (Fraenkel & Wallen, 2003). In this section possible threats to internal validity and the methods used to manage them are discussed.

As known from the previous studies some subject characteristics such as previous cumulative grade point average, age, gender, and physics attitudes might affect students' difference in PRETEST and POSTTEST scores. However they are not used in statistical analysis because there is no statistically significant effect of CBL on students' difference between PRETEST and POSTTEST scores. Students' cognitive development, mathematical skills, and problem solving skills can also be mentioned as effective variables affecting internal validity.

Other variables such as history, maturation, instrument decay, data collector characteristics, data collectors' bias, testing, statistical regression, attitude of subjects and implementation may have effect on the dependent variables as mentioned in Frankel et. al. 2003.

Besides the other variables history threat might affect the results of the study. History may be a threat when an unplanned event occurs (Frankel et. al. 2003). In this study students' final dates and the posttest date are coincided. This may explain why students didn't do well in posttest.

The study was completed in 4 weeks. As a result maturation of the subjects shouldn't be a threat to internal validity of the study.

There were 32 subjects which were involved in the study. The instrument was a multiple choice type test so the nature of the instrument did not change. So instrument decay threat to internal validity was controlled.

Data collector characteristics, data collector bias and implementation should not be threat for the study since there was one data collector, he was the researcher himself, and the data collection procedure was standardized.

In order to minimize the effects of testing threat the time difference between the POSTTEST and the PRETEST is more than 3 weeks, approximately 4 weeks. It would be better if the POSTTEST questions were different but identical to PRETEST questions or at least an alternate test of which questions modified. For example, graph scales were shifted slightly, graphed lines were made superficially steeper or flatter, etc (Beichner, 1994).

One another threat to internal validity is statistical regression. In this study because of the time limitations and the convenience of the sample the physics teacher candidates were involved in the study which has higher achievement scores on the subject of the study. This may explain why there is no statistically significant between PRETEST and POSTTEST scores.

In order to eliminate the effect of attitudes of subjects to the internal validity is to make students to believe that the treatment is just a regular part of their instruction (Frankel et. al. 2003).

The names of the students were taken for the sake of statistical analyses. And these data are not used in any forms. As a result confidentiality wouldn't be a problem for this study.

5.4. External Validity

Population Generalizability: The population generalizability refers to the degree to which a sample of study represents the population of interest (Frankel &

Wallen, 1996).

Ecological Generalizability: The ecological generalizability is the degree to which the results of a study can be extended to other settings or conditions (Frankel & Wallen, 1996). For this study, the treatments and testing procedure took in place in ordinary classrooms in the education faculty during regular class time. Therefore, the results of the study can be generalized to similar cases.

5.5. Implications

According to results of the study it couldn't be shown the effectiveness of the Calculator Based Laboratories. But it doesn't mean that that the CBL is ineffective. In the light of previous studies on the same topic, the effectiveness of CBL/MBL the following suggestions can be offered.

As Beichner (1994) suggested he first step is for teachers to become aware of the problem. The major problem of the students' is inability to use graphs as "fluently" as they should. Students need to understand graphs before they can be used as a language for instruction. Teachers should have students examine motion events where the kinematics graphs do not look like photographic replicas of the motion and the graph lines do not go through the origin. Students should be asked to translate from motion events to kinematics graphs and back again. Instruction should also require students to go back and forth between the different kinematics graphs, inferring the shape of one from another. Teachers should have students determine slopes and areas under curves and relate those values to specific times during the motion event. All these suggestions for modifying instruction can be summarized by one phrase-teachers should give students a large variety of "interesting" motion situations for careful, graphical examination and explanation. The students must be given the opportunity to consider their own ideas about kinematics graphs and then encouragement to help them modify those ideas when necessary. Teachers cannot simply tell students what the graphs' appearance should be. These suggested ways can be simply conducted with CBL Activities.

Further suggestions can be listed as follows:

1. Teachers should prepare themselves to carry out CBL activities. They should improve themselves about how to encourage their students to perform CBL activities and how to make physics more exiting for them. They should also know how to cooperate with administrators and gain their support and encouragement.

2. Administrators of school should investigate the possibilities of using CBL activities in their schools and then support these efforts.

3. Universities should evaluate the strengths and weaknesses, and develop lessons including CBL activities, pre-service and in-service workshops.

4. Curriculum developers should require the use of CBL activities as standard part of physics instruction.

5. Educators must replace teaching methods that hinge on rote memorization with genuine experiences like CBL activities.

5.6. Recommendations for Further Research

For the further studies the followings can be suggested.

1. Further studies could investigate the effects of CBL on improving students' understanding and interpretation of kinematics graphs with a control group and a sample which gives higher opportunity no generalize the results of the study.

2. Future research could perform a replication of the current study with a larger, more diverse sample.

3. Future research could investigate the effects of CBL in different physics topics, different science subjects and different grade levels.

4. Future research could use extra assessment strategies, observational checklists and portfolios in order to extend the analysis.

5. Future research could perform a replication of this study for a longer time that is integrated in the flow of physics course.

6. Future research could investigate the change in the students' levels of understandings of graphics by using Palms instead of using Calculators.

REFERENCES

Adams, T. L. (1997). Addressing students' difficulties with the concept of function: Applying graphing calculators and a model of conceptual change. Focus on Learning Problems in Mathematics, 19 (2), 43 – 57.

Adie, G. (1998). The impact of the graphics calculator on physics teaching. Physics Education, 33, 50 – 54.

Arkin H. & Colton R. R. (1940). Graphs, how to make and use them (5th Ed.) New York & London.

Arons, A.B. (1983) Student patterns of thinking and reasoning: part one of three parts, The Physics Teacher, 21, 576–581.

Ates, S. & Truman, J. S. (2003). Teaching Line Graphs to Tenth Grade Students Having Different Cognitive Developmental Levels by Using Two Different Instructional Modules. Research in Science & Technological Education, 21 (1), 55 – 66.

Beichner, J, R. (1990). The effects simultaneous motion representation and graph generation in a kinematics laboratory. Journal of Research in Science Teaching, 27 (8), 803 – 815.

Beichner, J, R. (1994). Testing students' interpretation of kinematics graphs. American Journal of Physics, 62 (8), 750 – 762.

Berg, C. A. & Philips, D.G. (1994). An investigation of the relationship between logical thinking and the ability to construct and interpret line graphs. Journal of Research in Science Teaching, 31 (4), 323 – 344.

Brasell, H. (1987). The effects of real-time laboratory graphing on learning graphic representations of distance and velocity. Journal of Research in Science Teaching, 24 (4), 385 – 395.

Curriculum Administrator (1997). Science teachers are making connections with students using Texas Instruments Calculator – Based Laboratory trade mark system. Curriculum Administrator, 3 (17), 4 – 5.

Dick, T. & Dunham, P. H. (2000). Kinematics and Graphs: Students' difficulties and CBLs. The Mathematics Teacher, 93 (5), 414 – 417.

Doerr, H. M. & Rieff, C. (1999). Putting Math in Motion with Calculator-Based Labs. Mathematics Teaching in the Middle School, 4 (6), 364 – 367.

Dunham, P. H. & Osborne, A. (1991). Learning how to see: Students' graphing difficulties. Focus on Learning Problems in Mathematics, 13 (4), 35–49.

Dunham, P. H. (1993). Does using calculators work? The jury is almost in. UME Trends, 5 (2), 8-9.

Dunham, P. H., & Dick, T. P. (1994). Research on graphing calculators. Mathematics Teacher, 87, 440 – 445.

Dunham, P. H. D., Thomas P. (1994). Connecting research to teaching: research on graphing calculators. Mathematics Teacher, 87 (6), 440 – 445.

Dunham, P. H. (1996). Looking for trends: What's new in graphing calculator research? In G. Goodell (Ed.), Proceedings of the Eighth International Conference on Technology in Collegiate Mathematics 120-124. Reading, MA: Addison-Wesley.

Educational Technology & Calculators. Retrieved December, 11th 2002 from World Wide Web: http://education.ti.com/educationportal/

Ersoy, Y. (2003). Teknoloji destekli matematik öğretimi – II: Hesap makinelerin matematik etkinliklerinde kullanımı. İlköğretim On – Line, 2 (2), 35 – 60.

Forinash, K. & Wisman, R. (2001). Science Laboratories. T H E Journal, 29 (2), 38 – 43.

Fraenkel, J. R., & Wallen, N. E. (2003). How to design and evaluate research in science education. (5th Ed.) NY. McGraw – Hill, Inc.

Fey, J. T., Hirsch, C. R. (1992). Calculators in mathematics education. Reston, Va.: National Council of Teachers of Mathematics.

Goldberg, F. M., & Anderson, J. H. (1989). Student Difficulties with Graphical Representations of Negative Values of Velocity. The Physics Teacher 27, 254 – 60.

Goldenberg, E. P., Harvey, W., Lewis, P. G., Umiker, R. J., West, J., & Zodhiates, P. (1988). Mathematical, technical, and pedagogical challenges in the graphical representation of functions (Tech. Rep. No. 88-4). Cambridge, MA: Harvard University, Educational Technology Center.

Hale, P. L. (1996). Building conceptions and repairing misconceptions in student understanding of kinematics graphs: Using student discourse in Calculator-Based Laboratories (Doctoral dissertation, Oregon State University). Dissertation Abstracts International, 57, 08A.

Hardal O. (2003). The effects of hands – on activities on students' achievement and attitudes towards physics. Unpublished Master Thesis, Middle East Technical University, Ankara.

Hegarty, E. (1987) Science laboratory teaching, in: M. J. DUNKIN (Ed.) International Encyclopedia of teaching and Teacher Education (Oxford, Pergamon Press).

Henderson, D. & Fisher, D. (1998). Assessing Learning Environments in Senior Science Laboratories. Australian Science Teachers Journal, 44 (4), 57 – 62.

Hennessy, S. (1999). The potential of portable technologies for supporting graphing investigations. British Journal of Educational Technology, 30 (1), 57-60.

Jones, P. L. (1993). Realizing the educational potential of the graphics calculator. In L. Lum (Ed.), Proceedings of the Sixth International Conference on Technology in Collegiate Mathematics, 212-217. Reading, MA: Addison-Wesley.

Kwon, O. N. (2002). The effect of calculator based ranger activities on students' graphing ability. School Science and Mathematics 102 (2), 57 – 67.

Lapp D. A., Cyrus, V. F., Dick, T., Dunham, P. H. (2000). Using Data – Collection Devices to Enhance Students' Understanding. Mathematics Teacher, 93 (6), 504 – 510.

Lauten, A. D., Graham, K., & Ferrini-Mundy, J. (1994). Student understanding of basic calculus concepts: Interaction with the graphics calculator. Journal of Mathematical Behavior, 13, 225 – 237.

Leinhardt, G., Zaslavsky, O., and Stein, M. K. (1990). Functions, graphs, and graphing: Tasks, learning, and teaching. Review of Educational Research, 60 (1), 1 – 64.

Linn, M. C. (1988). Perspectives for research in science teaching: Using the computer as laboratory partner. Paper presented at the European Conference for Research on Learning, Tubingen, West Germany, September 19–22, 1987. (ERIC Document Reproduction Service No. ED 308 853)

Linn, M. C., & Songer, N. B. (1988). Curriculum reformulation: Incorporating technology into science instruction. Paper presented at the annual meeting of the American Educational Research Association, New Orleans, LA, April 1988. (ERIC Document Reproduction Service No. ED 303 352)

Linn, M.C., Layman, W.J. & Nachmias, R. (1987) Cognitive consequences of microcomputer based laboratories: graphing skills development, Contemporary Educational Psychology, 12, 244–253.

McDermott, L. C., Rosenquist M. L. & Van Zee E. H. (1987). Student difficulties in connecting graphs and physics: Examples from kinematics. American Journal of Physics, 55 (6), 503 – 513.

Meltzer, D. E. (2003).The Questions We Ask and Why: Methodological Orientation in Physics Education Research. Retrieved December, 19th 2003 from World Wide Web: http://www.physics.iastate.edu/per/docs/Meltzer_PERC_2003_paper.pdf

Mokros, J. R. & Tinker, J. F. (1987). The impact of microcomputer based laboratories on children's' ability to interpret line graphs. Journal of Research in Science Teaching, 24 (4), 369 -383.

McKenzie, D. L. & Padilla, M. J. (1986). The construction and validation of The Test of Graphing in Science (TOGS). Journal of Research in Science Teaching, 23 (7), 571 – 579.

Michael, T.S. (1995). Effect of microcomputer based laboratory on graphing interpretation skills and understanding of motion. Paper presented at the annual meeting of the National Association of Research in Science Teaching, San Francisco, CA.

Nachmias, R. & Linn, M. C. (1987). Evaluations of science laboratory data: The role of computer presented information. Journal of Research in Science Teaching, 24 (5), 491 – 506.

Norman, F. A. (1993). Integrating research on teachers' knowledge of functions and their graphs: Integrating research on the graphical representation of functions. Integrating research on the graphical representation of functions, 159 - 187. Hillsdale, NJ. Lawrence Erlbaum Associates.

Olme, A. (2000). Views on the physics curriculum beyond 2000. Physics Education, 35 (3), 195 – 198.

Padilla, J.M., McKenzie, L.D. & Shaw, L.E., JR. (1986). An examination of line graphing ability of students in grades seven through twelve, Scholl Science & Mathematics, 86, 20–26.

Penglase, M., & Arnold, S. (1996). The graphics calculator in mathematics education: A critical review of recent research. Mathematics Education Research Journal, 8, 58 – 90.

Pomerantz H. (1997). The role of calculators in math education. Urban Systemic initiative/comprehensive partnership for mathematics and science achievement superintendents' forum, Dallas, Texas.

Quesada, A. R. M., Mary E. (1994). The effects of using graphing calculators to enhance college students' performance in Precalculus. Educational Studies in Mathematics, 27 (2), 205-15.

Redish, E. F. (1993). What can a physics teacher do with a computer? Invited talk presented at Robert Resnick Symposium RPI, Troy NY, May, 1993.

Redish, E. F., Steinberg, R., Saul, J. (1997). On the effectiveness of active-engagement microcomputer – based laboratories. American Journal of Physics, 65 (1), 45 – 54.

Rieff, C., Doerr, H. M., & Tabor, J. (1999). Putting Math in Motion with Calculator-Based Labs, Mathematics Teaching in the Middle School, Mar 1999, 364 – 367.

Saeki, A., Ujiie, A., & Tsukihashi, M. (2001). A cross – curricular integrated learning experience in mathematics and physics. Community College Journal of Research and Practice 25, 417 – 424.

Sancar, M. (2002). Unpublished lecture notes. Project on Science Teaching.

Svec, M.T. (1995, April) Effect of Micro-Computer based laboratory on graphing interpretation skills and understanding of motion. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, San Francisco (ERIC Document Reproduction Service No. ED 383 551).

Svec, M.T. (1999). Improving graphing interpretation skills and understanding of motion using microcomputer based laboratories. Retrieved May, 13th 2001 from World Wide Web: http://unr.edu/homapage/crowther/ejse/svec.html

Taylor, L.R. (1995). Using the graphing calculator – in physics labs. The physics Teacher 33, (5), 312 – 319.

The On – Line Education Center. Science in the New Zealand curriculum. Retrieved October, 23rd 2003 from World Wide Web: http://www.tki.org.nz/r/science/curriculum/p9_e.php

Thornton, R. K. & Sokoloff, D. R. (1990). Learning motion concepts using real – time microcomputer based laboratories. American Journal of Physics, 58 (9), 858 – 867.

Tobin, K. (1990) Research on science laboratory activities: in pursuit of better questions and answers to improve learning, School Science and Mathematics, 90, 403-418.

Trumper, R. (2002). What Do We Expect From Students' Physics Laboratory Experiments? Journal of Science Education and Technology, 11 (3), 221 – 228.

Svec, M.T. (1995) Effect of Micro-Computer based laboratory on graphing interpretation skills and understanding of motion. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, San Francisco

Welker, J. (1999). Using technology to teach sciences. Media & Methods, 36, 63.

APPENDICES

APPENDIX A

OBJECTIVE LIST

Students will be able to:

1. determine velocity from the given position - time graph
2. determine acceleration from the given velocity-time Graph
3. determine displacement from the given velocity - time graph
4. determine change in velocity from the given acceleration - time graph
5. select another corresponding graph from the given kinematics graph
6. select textual description from the given kinematics graph
7. select corresponding graph from the given textual motion description

APPENDIX B

TEST OF UNDERSTANDING GRAPHS – KINEMATICS (TUG – K)

Test of Understanding Graphs – Kinematics

version 2.6

Instructions

Wait until you are told to begin, then turn to the next page and begin working. Answer each question as accurately as you can. There is only one correct answer for each item. Feel free to use a calculator and scratch paper if you wish.

Use a #2 pencil to **record your answers** on the computer sheet, but **please do not write in the test booklet.**

You will have approximately one hour to complete the test. If you finish early, check over your work before handing in both the answer sheet and the test booklet.

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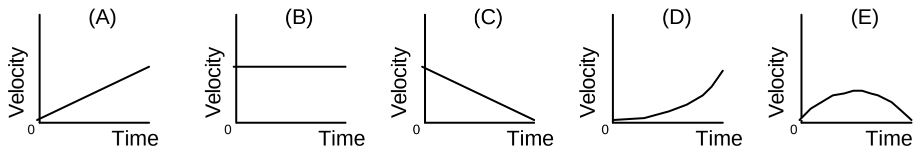
1. Velocity versus time graphs for five objects are shown below. All axes have the same scale. Which object had the greatest change in position during the interval?



2. When is the acceleration most negative?

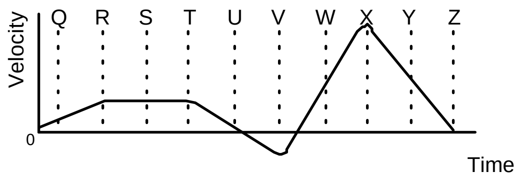
(A) R to T

(B) T to V

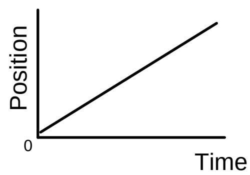
(C) V

(D) X

(E) X to Z



3. To the right is a graph of an object's motion. Which sentence is the best interpretation?



(A) The object is moving with a constant, non-zero acceleration.

(B) The object does not move.

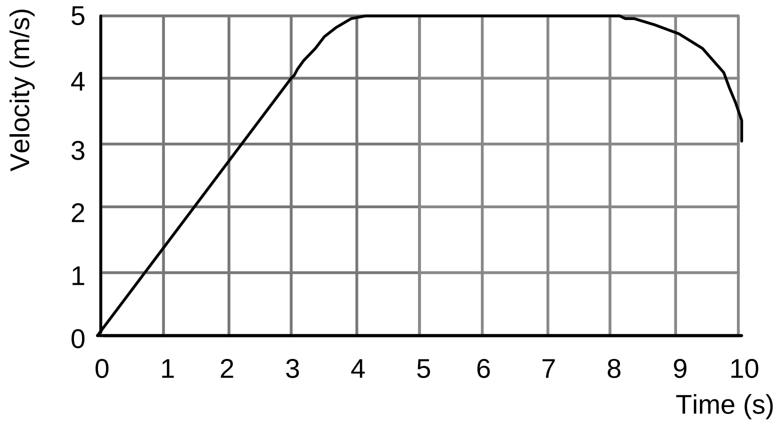
(C) The object is moving with a uniformly increasing velocity.

(D) The object is moving with a constant velocity.

(E) The object is moving with a uniformly increasing acceleration.

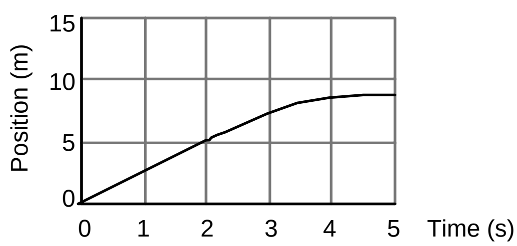
4. An elevator moves from the basement to the tenth floor of a building. The mass of the elevator is 1000 kg and it moves as shown in the velocity-time graph below. How far does it move during the first three seconds of motion?

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



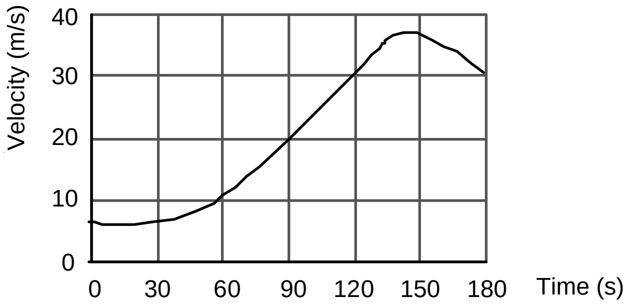
5. The velocity at the 2 second point is:

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



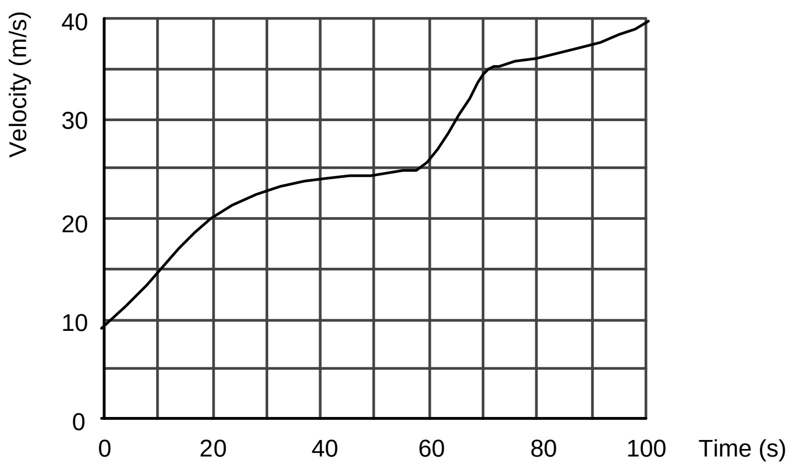
6. This graph shows velocity as a function of time for a car of mass 1.5 x 103 kg. What was the acceleration at the 90 s mark?

(A) 0.22 m/s^2
(B) 0.33 m/s^2
(C) 1.0 m/s^2
(D) 9.8 m/s^2
(E) 20 m/s^2

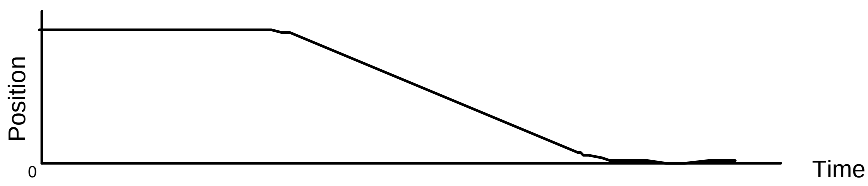


7. The motion of an object traveling in a straight line is represented by the following graph. At time = 65 s, the magnitude of the instantaneous acceleration of the object was most nearly:

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



8. Here is a graph of an object's motion. Which sentence is a correct interpretation?



(A) The object rolls along a flat surface. Then it rolls forward down a hill, and then finally stops.

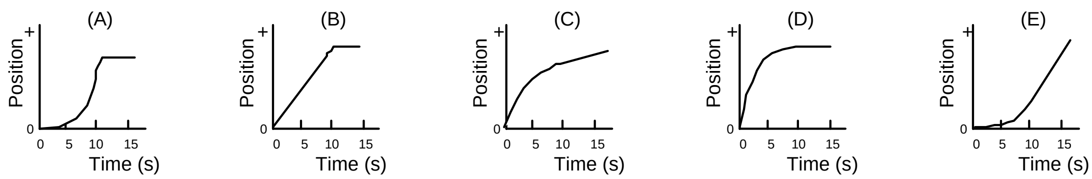
(B) The object doesn't move at first. Then it rolls forward down a hill and finally stops.

(C) The object is moving at constant velocity. Then it slows down and stops.

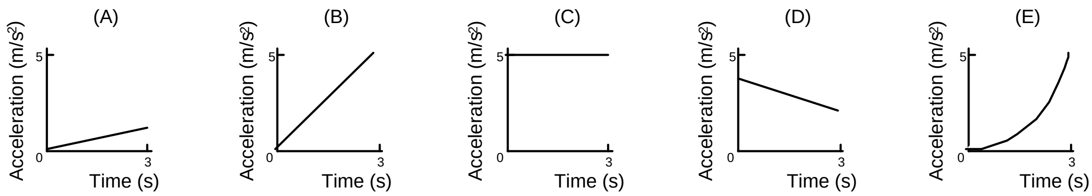
(D) The object doesn't move at first. Then it moves backwards and then finally stops

(E) The object moves along a flat area, moves backwards down a hill, and then it keeps moving.

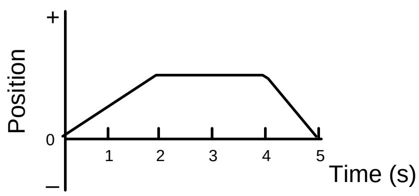
9. An object starts from rest and undergoes a positive, constant acceleration for ten seconds. It then continues on with a constant velocity. Which of the following graphs correctly describes this situation?



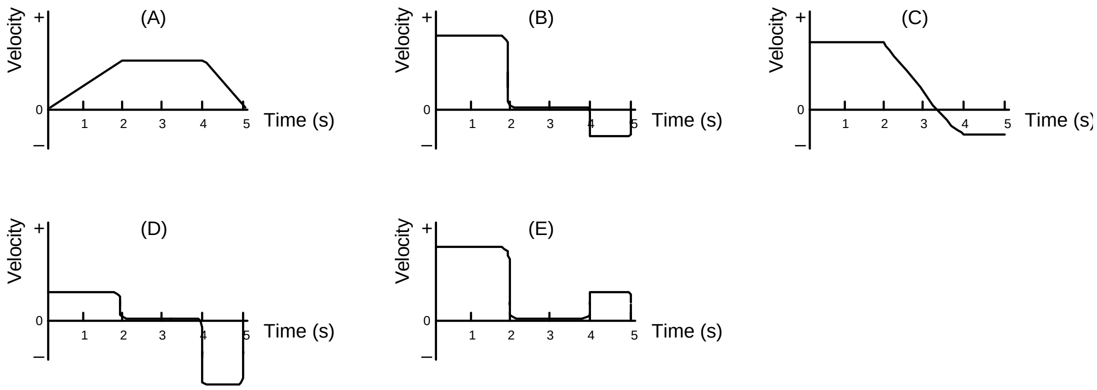
10. Five objects move according to the following acceleration versus time graphs. Which has the smallest change in velocity during the three second interval?



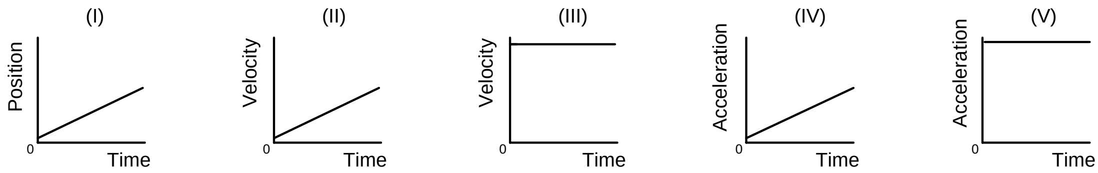
11. The following is a position-time graph for an object during a 5 s time interval.



Which one of the following graphs of velocity versus time would best represent the object's motion during the same time interval?



12. Consider the following graphs, noting the different axes:



Which of these represent(s) motion at constant velocity?

(A) I, II, and IV

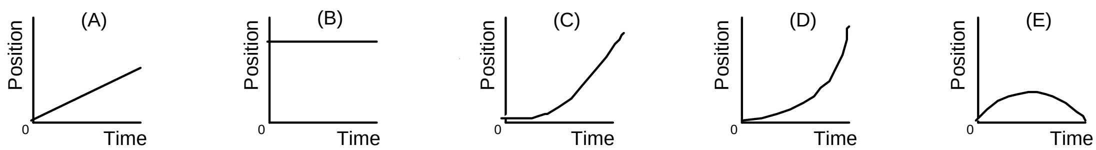
(B) I and III

(C) II and V

(D) IV only

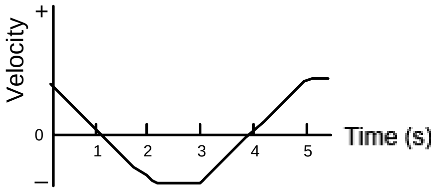
(E) V only

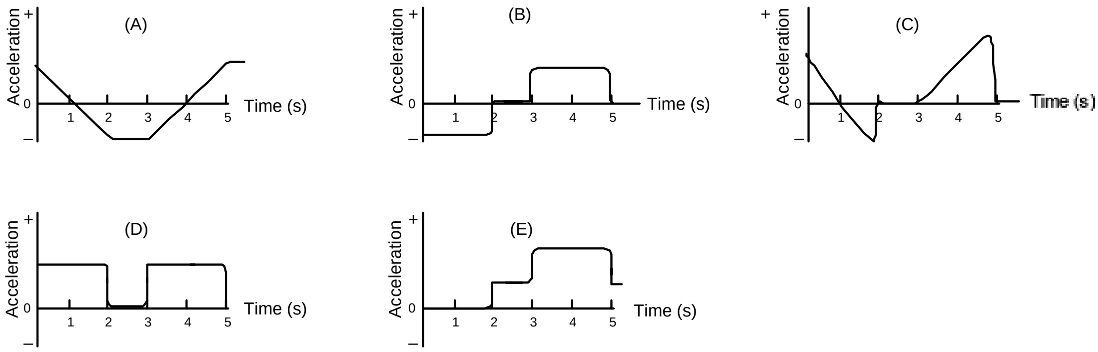
13. Position versus time graphs for five objects are shown below. All axes have the same scale. Which object had the highest instantaneous velocity during the interval?



14. The following represents a velocity-time graph for an object during a 5 s time interval.

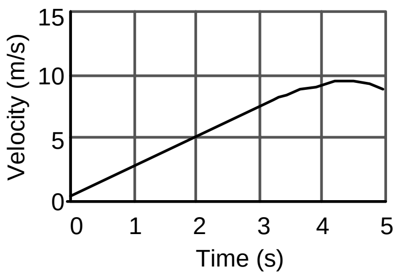
Which one of the following graphs of acceleration versus time would best represent the object's motion during the same time interval?

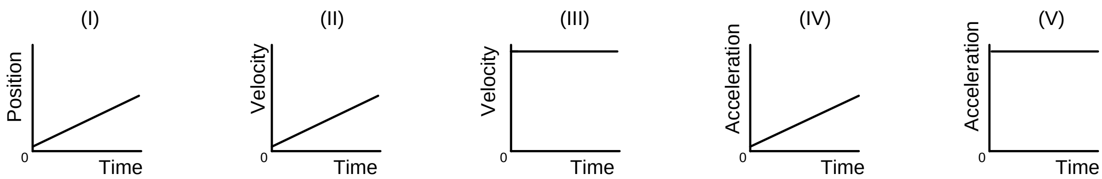




15. The following represents an acceleration graph for an object during a 5 s time interval.

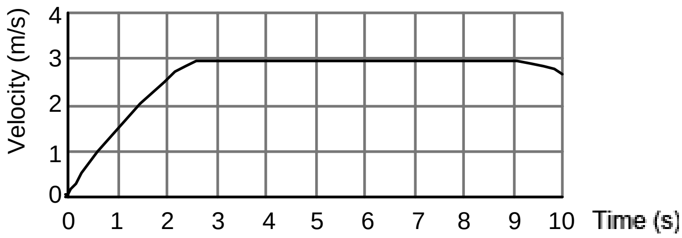
Which one of the following graphs of velocity versus time would best represent the object's motion during the same time interval?





16. An object moves according to the graph below:

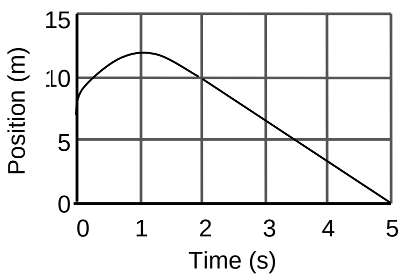
The object's change in velocity during the first three seconds of motion was:



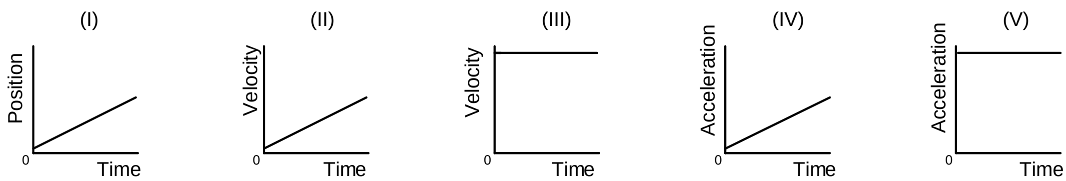
(A) 0.66 m/s (B) 1.0 m/s (C) 3.0 m/s (D) 4.5 m/s (E) 9.8 m/s

17. The velocity at the 3 second point is about:

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



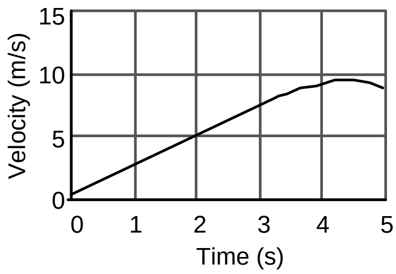
18. Consider the following graphs, noting the different axes:



Which of these represent(s) motion at constant, non-zero acceleration?

(A) I, II, and IV (B) I and III (C) II and V (D) IV only (E) V only

19. If you wanted to know the distance covered during the interval from t = 0 s t=2s, from the graph below you would:



(A) Read 5 directly off the vertical axis

(B) Find the area between that line segment and the time axis by calculating (5 x 2)/2

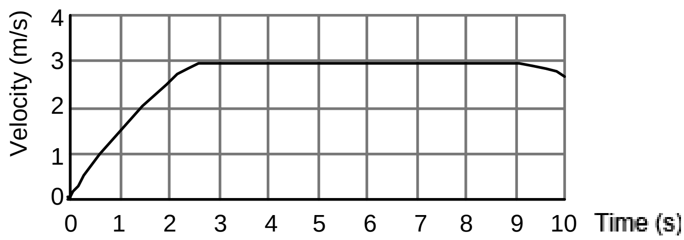
(C) Find the slope of that line segment by dividing 5 by 2.

(D) Find the slope of that line segment by dividing 15 by 5.

(E) Not enough information to answer.

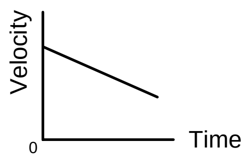
20. An object moves according to the graph below:

How far does it move during the interval from t=4 s to t = 8s?



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

21. To the right is a graph of an object's motion. Which sentence is the best interpretation?



(A) The object is moving with a constant acceleration

(B) The object is moving with a uniformly decreasing acceleration.

(C) The object is moving with a uniformly increasing velocity.

(D) The object is moving at a constant velocity.

(E) The object does not move.

Answers:

1.	B
2.	E
3.	D
4.	D
5.	C
6.	B
7.	A
8.	D
9.	E
10.	A
11.	D
12.	B
13.	D
14.	B
15.	A
16.	D
17.	A
18.	B
19.	C
20.	E
21.	A

APPENDIX C

CBL ACTIVITIES

ACTIVITY 1 (Graphics Matching)

Aktivite 1 - Grafik Eşleştirme:

Amaç:
Hesap makinesi tarafından verilen konum – zaman grafiklerini eşleştirmek.

Araç ve Gereçler:
Grafik hesap makinesi (TI – 83 Plus), CBL ve sonik mesafe ölçer (CBR).

Yöntem ve Data Toplama:

1) Bir elinize **CBR** diğer elinize de hesap makinesini alın. **CBR '**yi direkt olarak duvara yönlendirin.

İpucu: Verilen grafiklerde en yakın mesafe 0,5 m en uzak mesafe de 4 m.dir.

2) Hesap makinesinin **APPS** tuşuna basın.**CBL/CBR** uygulamasından, **RANGER** programını çalıştırın.

3) **MAIN MENU** den **APPLICATIONS** ve **METERS** seçeneğini seçin.

4) **APPLICATIONS** dan **DISTANCE MATCH** i seçin.

5) Hesap makinesinin **ENTER** tuşuna basarak eşleştirme yapacağınız grafiği seçin. Bir süre grafiğin üzerinde düşünün daha sonra **1 ve 2. soruların** cevaplarını verin.

6) Grafiği değerlendirerek duvardan uzaklığınızı belirleyiniz. **ENTER** tuşuna basarak ölçümü başlatın. **CBR** üzerindeki yanıp sönen yeşil ışık datanın toplandığını gösterir.

7) İleri ve geri yürüyerek verilen grafiğe eşdeğer bir grafik elde etmeye çalışın. Konumunuz ekranda görünecektir.

8) Ölçüm bitiğinde grafiklerin ne kadar eşleştiğine bakın ve **3. soruya** cevap verin.

9) Gerekirse **ENTER** tuşuna basarak **OPTIONS** dan **SAME MATCH** i seçerek eşleştirmenizi daha iyi hale getirin.

10) **4, 5 ve 6. sorulara** cevap verin.

Gözlemler:

Grafik eşleştirmelerinde grafik 3 doğru parçasından oluşmaktadır.

1) **ENTER** tuşuna basarak **OPTIONS** dan **NEW MATCH** ı seçin. İlk doğru parçasını seçerek **7 ve 8. sorulara** cevap verin.

2) Tüm grafiği gözden geçirerek **9 ve 10. sorulara** cevap verin.

3) **ENTER** tuşuna basarak grafiği eşleştirmeye çalışın.

4) **11 ve 12.** sorulara cevap verin.

5) **ENTER** tuşuna basarak **OPTIONS** dan **NEW MATCH** ı seçin.

6) Grafiği değerlendirerek **13, 14 ve 15. soruları** cevaplandırın.

Adı Soyadı:

Sorular:

1) X-ekseninde hangi fiziksel değer gösterilmektedir? ___________

   Birimi nedir?____

   Y-ekseninde hangi fiziksel değer gösterilmektedir? ____________

   Birimi nedir? ____

2) Harekete duvardan ne kadar mesafeden başlamayı düşünüyorsunuz? _______________________________________

3) Başlangıç noktanız doğrumuydu? _____________ Eğer değilse ne kadar hata yaptınız? _____________________________________

4) Eğim yukarı doğruysa ileri mi yoksa geri mi yürümelisiniz? Neden?____

5) Eğim aşağı doğruysa ileri mi yoksa geri mi yürümelisiniz? Neden?____

6) Eğim düz ise ileri mi yoksa geri mi yürümelisiniz? Neden?____

7) Her saniyede 1 adım atıyorsanız her adımda kaç metre yol almanız gerekir? ___________

8) Her adımını 1 metre ise saniyede kaç adım atmalısınız? ____________________________

9) Hangi doğru parçasında hızınız en fazla idi? Neden? ____

10) Hangi doğru parçasında hızınız en az idi? Neden? ____

11) İleri yada geri yürümeye karar verirken başka hangi faktörler sizin için etkili oldu? ____

12) Doğru parçalarının eğimi hangi fiziksel değeri vermektedir? ____

13) İlk doğru parçası için kaç saniyede kaç metre yürümeniz gerekti?

____

14) 13. sorudaki değeri metre/saniye 'ye çevirin. __________________

metre/dakika ____

metre/saat ____

kilometre/ saat _______________________________________

15) Grafiği eşleştirmek için kaç metre yürüdünüz? ________________

ACTIVITY 2 (Constant Velocity)

Aktivite 2 - Oyuncak Araba (Sabit Hızlı Hareket):

Amaç:

Sabit hızla hareket eden cisimlerin incelenmesi.

Araç ve Gereçler:

Grafik hesap makinesi (TI – 83 Plus), CBL, sonik mesafe ölçer (CBR), ray ve araba.

Yöntem ve Data Toplama:

1) Arabayı **CBR** den en az 15 cm ileriye yerleştirin.

2) Data toplamaya başlamadan önce **1. soruyu** cevaplandırın.

3) **Ranger** programını çalıştırın.

4) **MAIN MENU** den **SETUP/SAMPLE** ı seçin ve aşağıdaki ayarlamaları yapın.

REALTIME:	**NO**
TIME(S):	**5 SECONDS**
DISPLAY:	**DISTANCE**
BEGIN ON:	**[ENTER]**
SMOOTHING:	**LIGHT**
UNITS:	**METER**

5) **START NOW** a basın.

6) Hazır olduğunuzda **ENTER** tuşuna basın ve arabayı hareket ettirin.

7) Data toplama bittiğinde hesap makinesi otomatik olarak Konum-Zaman grafiğini çizecektir.

8) **1. soruda** vermiş olduğunuz cevap ile sonucu karşılaştırın benzerlik ve farklılıkları değerlendirin.

Gözlemler:

1) **1. soruda** verilen tabloya grafikten elde ettiğiniz verileri girin.

2) **3 ve 4. sorulara** cevap verin.

3) Her zaman dilimindeki konum değişimlerini hesaplayın.

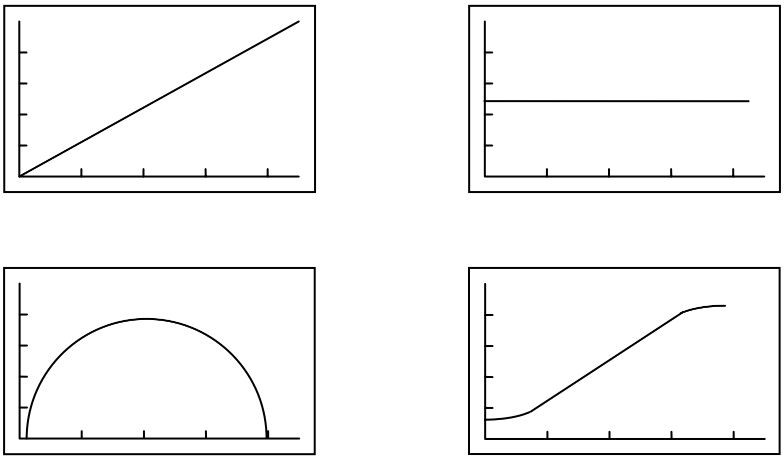
4) Daha sonra eğimi hesaplayarak tabloya yazın.

5) **5, 6 ve 7.** sorulara cevap verin.

Adı Soyadı:

Sorular:

1) Arabanın Konum-Zaman grafiği sizce aşağıdakilerden hangisi gibi olacaktır?



Neden? ____

2)

Zaman	**Konum**	**Δ Konum**	**Δ Zaman**	**m**
1		**xxx**	**xxx**	**xxx**
1,5				
2				
2,5				
3				
3,5				
4				
4,5				
5				

3) Konum ile ilgili olarak ne fark ettiniz? ________________________

4) Bu sonuca göre arabanın hızı ile ilgili ne söyleyebiliriz, neden?
____

5) Arabanın hız zaman grafiğini çiziniz.

6) Zaman = 2 ile Zaman = 4 arasındaki Δ Konum, Δ Zaman oranını hesaplayın. ____

Bu sonuç ile ilgili ne fark ettiniz? ___________________________

Bulduğunuz "m" neyi ifade ediyor? ___________________________

7) Bu hareketin denklemini bulduğunuz değerleri kullanarak yazınız (y = ax + b). ____

8) Araba eğer hareketine devam etseydi 10 saniye içinde ne kadar hareket ederdi? ____

9) 10 dakika içinde ne kadar hareket ederdi? ____________________

ACTIVITY 3 (Constant Acceleration I)

Aktivite 3 – Oyuncak Araba (Düzgün Hızlanan Hareket)

Amaç:

Düzgün hızlanan cisimlerin incelenmesi.

Araç ve Gereçler:

Grafik hesap makinesi (TI – 83 Plus), CBL, sonik mesafe ölçer (CBR), ray ve araba.

Yöntem ve Data Toplama:

1) Data toplamaya başlamadan önce **1. soruyu** cevaplandırın.

2) **DataMate** programını çalıştırın. **SETUP** tan **MODE** u seçin. **TIME GRAPH** ı seçin ve aşağıdaki ayarları yapın.

   TIME INTERVAL: **.05**
   NUMBER OF SAMPLES: **100**
   EXPERIMENT LENGHT: **5**

3) **START** a basarak deneyi başlatın. **CBR** data almaya başladığında arabayı serbest bırakın.

4) **DIG – DISTANCE** ı seçerek Konum – Zaman, **DIG – VELOCITY** ı seçerek Hız – Zaman, **DIG – ACCELERATION** ı seçerek de İvme – Zaman grafiğini inceleyebilirsiniz. Eğer gerekliyse **RESCALE** den grafiklerin minimum ve maksimum değerlerini ayarlayabilirsiniz. **SELECT REGION** dan hesaplarınızı yapacağınız zaman aralığını belirleyebilirsiniz.

5) **Konum – Zaman** grafiğini inceleyin, **2, 3, 4 ve 5. soruları** cevaplandırın.

Gözlemler:

6) Eğer eğik düzlemin açısını artırırsak Konum – Zaman grafiği nasıl olur, cevabınızı **6. soruda** verilen grafiğe çizin.

7) Eğik düzlemin açısını arttırarak deneyi tekrarlayın.

8) Eğer eğik düzlemin açısını 0^o sonrada 90^o ye ayarlamış olsaydık Konum – Zaman grafikleri nasıl olurdu? Tahminlerinizi **7. soruda** verilen tabloya çizin.

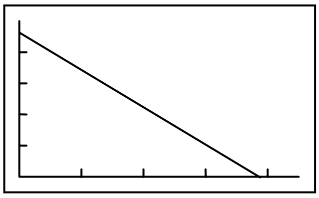
Gelişmiş Gözlemler:

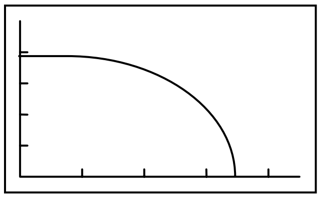
ANALYZE dan **CURVE FIT** i seçin. Daha sonra da uygun seçeneği seçin. **8 ve 9. sorulara** cevap verin.

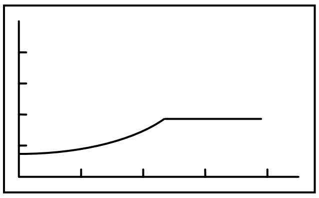
Adı Soyadı:

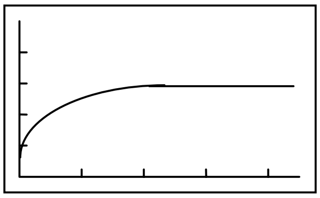
Sorular:

1) Arabanın Konum-Zaman grafiği sizce aşağıdakilerden hangisi gibi olacaktır?









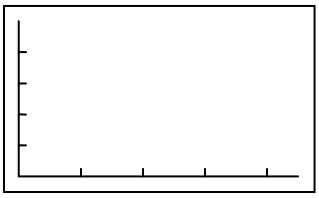
2) X-ekseninde hangi fiziksel değer gösterilmektedir? ______________

Birimi nedir? ____

Y-ekseninde hangi fiziksel değer gösterilmektedir? ______________

Birimi nedir? ____

3) Elde ettiğiniz grafiği aşağıdaki tabloya çizip eksenleri birimleriyle beraber adlandırın. Arabanın eğik düzlemin başında ve sonunda bulunduğu yerleri grafikte gösteriniz.



4) Bu grafik nasıl bir fonksiyonudur? ______________________________

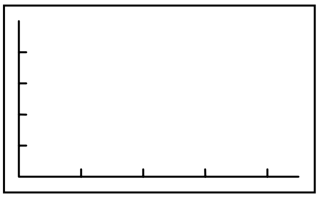
5) **1. soruya** vermiş olduğunuz cevap ile deney sonucunda elde ettiğiniz grafiğin benzerlik ve farklarını tartışın.

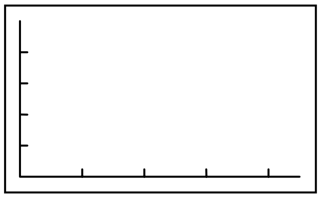
____

____

6) Eğik düzlemin açısı arttırıldığında grafik nasıl olacak, aşağıdaki tabloya çizin.

7) Eğer eğik düzlemin açısını 0° sonrada 90° ye ayarlamış olsaydık Konum – Zaman grafikleri nasıl olurdu?





8) Hesaplama sonucunda elde ettiğiniz sabitler hangi fiziksel değerleri ifade etmektedir? ______________________________

____

9) Hareketin denklemini yazınız. ______________________________

10) Bulduğunuz değerlere göre hareketin hız – zaman ve ivme – zaman grafikerini çiziniz.

ACTIVITY 4 (Constant Acceleration II)

Aktivite 4 – Oyuncak Araba (Newton Dinamiği):

Amaç:

Hesap makinesi tarafından verilen konum – zaman grafiklerini eşleştirmek.

Araç ve Gereçler:

Grafik hesap makinesi (TI – 83 Plus), CBL, sonik mesafe ölçer (CBR), ray, çeşitli ağırlıklar, ip ve araba.

Yöntem ve Data Toplama:

1) Deney düzeneğini kurun. Arabayı çekmesi için 5 gramlık ağırlığı yerleştirin ve toplam kütleyi belirleyin.

2) Data toplamaya başlamadan önce **1. soruyu** cevaplandırın.

3) **DataMate** programını çalıştırın. **SETUP** tan **MODE** u seçin. **TIME GRAPH** ı seçin ve aşağıdaki ayarları yapın.

TIME INTERVAL:	**.05**
NUMBER OF SAMPLES:	**100**
EXPERIMENT LENGHT:	**5**

4) **START** a basarak deneyi başlatın. **CBR** data almaya başladığında arabayı serbest bırakın.

5) **DIG – DISTANCE** ı seçerek Konum – Zaman, **DIG – VELOCITY** ı seçerek Hız – Zaman, **DIG – ACCELERATION** ı seçerek de İvme – Zaman grafiğini inceleyebilirsiniz. Eğer gerekliyse **RESCALE** den grafiklerin minimum ve maksimum değerlerini ayarlayabilirsiniz. **SELECT REGION** dan hesaplarınızı yapacağınız zaman aralığını belirleyebilirsiniz. **2, 3, 4, 5 ve 6. soruları** cevaplandırın.

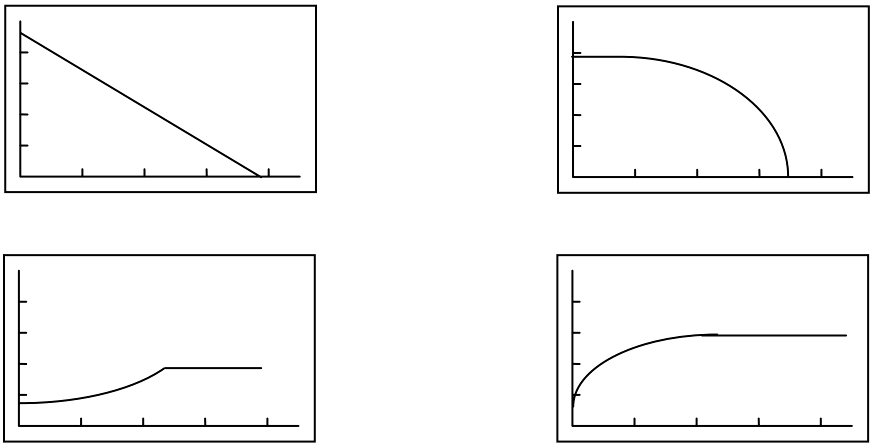
6) Toplam kütleyi 2 katına çıkaracak şekilde arabanın üzerine ağırlık koyun ve ölçümleri tekrar yapın. **7. soruyu** cevaplandırın.

7) Arabayı çeken kütleyi 5 gramdan 10 grama çıkarın ve ölçümleri tekrar yapın. **8. soruyu** cevaplandırın.

Sorular:

Adı Soyadı:

1) Arabanın Konum-Zaman grafiği sizce aşağıdakilerden hangisi gibi olacaktır?



1) X-ekseninde hangi fiziksel değer gösterilmektedir? ____________

Birimi nedir? ______________________________________

Y-ekseninde hangi fiziksel değer gösterilmektedir? ____________

Birimi nedir? ______________________________________

2) Elde ettiğiniz grafiği aşağıdaki tabloya çizip eksenleri birimleriyle beraber adlandırın. Arabanın düzlemin başında ve sonunda bulunduğu yerleri grafikte gösteriniz.

3) Bu grafik nasıl bir fonksiyonudur? ______________________________

4) **1. soruya** vermiş olduğunuz cevap ile deney sonucunda elde ettiğiniz grafiğin benzerlik ve farklarını tartışın.

____

____

5) **ANALYZE** dan **CURVE FIT** i seçin. Daha sonra da uygun seçeneği seçin. Elde ettiğiniz sabitler hangi fiziksel değerleri ifade etmektedir? ____

Hareketin denklemini yazınız. __________________________________

6) Elde ettiğiniz denklemdeki sabitleri kullanarak arabanın hız – zaman ve ivme zaman grafiklerini çiziniz.

7) Toplam kütle iki katına çıktığında hareket nasıl değişti? _________

Hareketin denklemini yazınız. ________________________________

8) Arabayı çeken kütle iki katına çıktığında hareket nasıl değişti? _____

Hareketin denklemini yazınız. ________________________________

9) Hareketin ivmesi ile arabayı çeken kütle arasında nasıl bir ilişki buldunuz? ____

APPENDIX D

OBJECTIVE - ACTIVITY TABLE

	Activity			
Objective	Act. 1	Act. 2	Act. 3	Act. 4
1	X		X	
2		X		X
3	X		X	
4		X		
5	X			
6			X	X
7		X		X

APPENDIX E

PHYSICS ATTITUDE TEST

Adı Soyadı:

Bölüm:

GPA:

CGPA:

ÖSS (giriş yılı ile beraber):

Fizik 111 notunuz:

Babanızın Eğitim Düzeyi

a) İlk **b)** Orta **c)** Lise **d)** Üniversite **e)** Yüksek Lisans

Annenizin Eğitim Düzeyi

a) İlk **b)** Orta **c)** Lise **d)** Üniversite **e)** Yüksek Lisans

Babanızın Mesleği:

Annenizin Mesleği:

Kardeş sayınız :

Kardeşlerinizin eğitim düzeyleri:

a) İlk **b)** Orta **c)** Lise **d)** Üniversite **e)** Yüksek Lisans

Okumakta olduğunuz bölüm kaçıncı tercihinizdi?

Bu bölümü tercih etme sebebiniz nedir (isteyerek yada puanınız tuttuğu için)?

Bu bölüme gelmeseydiniz hangi bölümde okumak isterdiniz?

Aldığınız dersler içinde en ilgili olduğunuz hangileridir?

Aldığınız dersler içinde en güçlük çektiğiniz dersler hangileridir?

Sizin için En Uygun olan Cevabı İşaretleyin:

1)Kesinlikle Katılmıyorum **6)**Kesinlikle Katılıyorum

1)	Fizik dersi benim için angaryadır.	1	2	3	4	5	6
2)	Fizik dersi beni huzursuz eder.	1	2	3	4	5	6
3)	Fizik dersi beni ürkütür.	1	2	3	4	5	6
4)	Fizik dersinden hoşlanmam.	1	2	3	4	5	6
5)	Fizik dersi bütün dersler içinde en korktuğum derstir.	1	2	3	4	5	6
6)	Fizik dersi benim için ilgi çekicidir.	1	2	3	4	5	6
7)	Fizik sevdiğim bir derstir.	1	2	3	4	5	6
8)	Fizik dersi benim için ilgi çekicidir.	1	2	3	4	5	6
9)	Fizik dersi olmasa öğrencilik hayatı daha ilgi çekici olur.	1	2	3	4	5	6
10)	Derslerim içinde en sevimsizi Fizik dersidir.	1	2	3	4	5	6
11)	Fizik dersi sınavından çekinirim.	1	2	3	4	5	6
12)	Fizik dersinde zaman geçmek bilmez.	1	2	3	4	5	6
13)	Arkadaşlarımla Fizik konularını tartışmaktan zevk alırım.	1	2	3	4	5	6
14)	Fiziğe ayrılan ders saatlerinin daha fazla olmasını dilerim.	1	2	3	4	5	6
15)	Fizik dersi çalışırken canım sıkılır.	1	2	3	4	5	6
16)	Yıllarca fizik okusam bıkmam.	1	2	3	4	5	6
17)	Diğer derslere göre fiziği daha çok severek çalışırım.	1	2	3	4	5	6
18)	Fizik dersinde neşe duyarım.	1	2	3	4	5	6
19)	Fizik dersi eğlenceli bir derstir.	1	2	3	4	5	6
20)	Çalışma zamanımın çoğunu fiziğe ayırmak isterim.	1	2	3	4	5	6

APPENDIX F

CALCULATOR ATTITUDE TEST

Adı Soyadı:

Aşağıdaki sorula kendiniz için en uygun olan cevabı veriniz.

	evet	hayır
1) Günlük çalışmalarınızda ve/veya işinizde Hesap Makinelerini kullanır mısınız?		
2) Hesap Makinelerini kullanmada yeterli bilgi/deneyiminiz var mı?		
3) Hesap Makineleri ve bilgisayar konusunda kitap/yayınları okur musunuz?		
4) Hesap Makineleri ve bilgisayar ile ilgili gelişmeler ilginizi çeker mi?		
5) Bazı Hesap Makineleri ile ilgili olarak ayrıntılı bilgi edinmek ister misiniz?		
6) Kendinizin bir Hesap Makinesi olsun ister misiniz?		
7) Hesap Makineleri ile ilgili bir seminere katılmak ister misiniz?		
8) Hesap Makineleri Fizik derslerinde kullanılsın mı?		
9) Fizik derslerinde Hesap Makinelerinin kullanılması fiziksel kavramların öğrenilmesinde yardımcı olur mu?		

APPENDIX G

QUESTIONNAIRE: TEACHER CANDIDATES' OPINIONS ABOUT THE TREATMENT

Adı Soyadı:

Gecen Mayıs ayı içerisinde yapmış olduğumuz Hesap Makineleri destekli laboratuar (HeMa Lab) etkinlikleri ile ilgili yapacağımız analiz ve değerlendirmeleri daha sağlıklı bir şekilde yapabilmemiz için aşağıdaki sorulara cevap vermenizi istiyoruz.

Katkılarınız için teşekkür ederim.

1) Yapmış olduğumuz HeMa Lab etkinlikleri ile ilgili görüşleriniz, beğendiğiniz ve beğenmediğiniz yönleri nelerdir?

2) Uygulamış olduğumuz testlerde başarınızın azaldığını/değişmediğini/arttığını gördük. Sizce bunun sebepleri neler olabilir.

3) Uygulamış olduğumuz testte sonuçlarına göre başarı ortalamanız 100 üzerinden 78 çıktı (Bu test Amerika uygulandığında başarı % 40 çıkmış). Sizce bunun sebepleri neler olabilir?

4) Lisans eğitiminiz boyunca; size uygulamış olduğumuz testte başarınızı etkileyebilecek bir çalışmanız yada almış olduğunuz bir ders oldu mu (Phys 111 haricinde) ?

APPENDIX H

RAW DATA

NO	GENDER	LGPA	CGPA	FGPA	PHYS111	AGE	FED
1	1	2,9	2,9	3,1	2	21	3
2	0	2,6	2,7	1	0	23	0
3	1	2,2	2,4	1,4	0	23	4
4	0	2,8	3,2	3,5	4	22	3
5	1	3,2	2,7	2,1	2	23	3
6	0	2,5	2,5	2,8	4	21	2
7	0	1,9	2,4	1,9	2	23	0
8	1	2,2	2,3	1,3	2	22	3
9	1	2,7	3,1	1,5	2	22	0
10	1	3,2	3,3	2,3	3	23	2
11	1	1,1	2,1	1,8	3	23	3
12	1	3,6	2,9	2,5	3	21	1
13	1	2,3	2,4	0,95	1	21	3
14	0	1,5	2	2,2	2	26	3
15	0	2,2	2,4	1,3	3	23	0
16	0	1,1	2	1,4	3	23	4
17	1	1,4	2	0,32	0	24	3
18	0	2,6	3,3	0,84	0	23	0
19	0	1,2	1,9	1,2	2	25	1
20	1	1,9	2,5	2,4	2	22	0
21	0	3,5	3,6	3,8	4	23	1
22	0	2,6	2,8	1,3	2	23	0
23	1	3	2,8	3,4	2	23	0
24	0	2,8	2,5	1,4	2	25	2
25	1	2,8	3,2	2	3	23	2
26	1	2,3	2,6	1,5	2	21	3
27	0	2,5	3	3,5	3	23	3
28	0	2,7	2,4	1,6	2	23	1
29	1	3,3	2,8	2,2	2	22	0
30	0	1,1	2	1,3	3	22	0
31	1	1,8	2,1	1,2	2	22	0
32	0	1,4	2,2	0,39	2	23	0

NO	MED	NC	PREF	REASON	PHYSAT	CALAT	ACTSCORE
1	3	2	6	1	65	10	91,22
2	0	2	11	0	69	9	76,5
3	4	2	1	0	70	16	61,67
4	3	1	14	1	65	12	66,89
5	3	1	9	1	77	9	71,72
6	2	1	9	0	62	10	85,56
7	0	2	8	1	71	13	60,61
8	3	2	6	1	71	13	68,56
9	0	5	7	2	58	11	57,39
10	0	1	11	1	56	12	74,22
11	2	1	16	1	67	11	71,5
12	0	2	4	1	76	12	85,06
13	2	1	17	0	47	12	61,11
14	2	1	5	0	52	9	63,06
15	1	1	9	1	50	16	46,83
16	1	1	3	3	59	11	62,61
17	3	2	18	0	75	10	56,39
18	0	2	3	0	68	10	82,22
19	2	1	13	0	45	13	44,5
20	0	2	5	0	62	12	78,56
21	0	1	,	0	63	14	76,89
22	0	1	12	0	63	11	78,39
23	0	2	8	1	61	13	58,89
24	0	2	9	0	66	12	73,06
25	0	2	1	0	70	9	80,67
26	3	1	8	4	63	10	70,89
27	1	1	12	1	58	16	59,89
28	0	2	11	1	70	12	86,39
29	3	1	4	0	75	13	67,72
30	0	0	10	1	51	14	64
31	0	1	5	1	76	12	84,83
32	0	3	13	0	49	13	74,78

NO	PRETEST	POSTTEST	SCOREDIF
1	17	16	-1
2	18	18	0
3	17	11	-6
4	21	21	0
5	19	17	-2
6	19	18	-1
7	20	19	-1
8	11	12	1
9	15	17	2
10	19	21	2
11	21	20	-1
12	16	12	-4
13	17	17	0
14	17	18	1
15	19	14	-5
16	20	20	0
17	6	6	0
18	21	19	-2
19	16	19	3
20	17	19	2
21	19	20	1
22	19	14	-5
23	14	16	2
24	16	16	0
25	15	12	-3
26	18	16	-2
27	19	16	-3
28	19	20	1
29	16	12	-4
30	17	20	3
31	14	15	1
32	18	20	2

NO	preobj1	preobj2	preobj3	preobj4	preobj5	preobj6	preobj7
1	3	1	3	2	2	3	3
2	2	2	2	3	3	3	3
3	2	2	3	3	2	3	2
4	3	3	3	3	3	3	3
5	2	3	3	2	3	3	3
6	3	2	3	3	3	3	2
7	3	3	3	3	2	3	3
8	0	0	3	2	1	1	2
9	1	2	3	3	2	2	2
10	2	3	3	2	3	3	3
11	3	3	3	3	3	3	3
12	1	2	2	2	3	3	2
13	2	3	3	3	2	3	2
14	2	2	2	3	2	2	3
15	3	2	3	2	3	3	3
16	3	2	3	3	3	3	3
17	1	1	0	0	1	1	2
18	3	3	3	3	3	3	3
19	2	2	3	2	3	2	2
20	3	2	3	2	2	3	2
21	3	2	3	3	3	3	2
22	2	3	3	3	3	3	2
23	1	1	3	3	2	1	3
24	2	3	1	2	3	3	2
25	2	1	3	2	3	2	2
26	2	3	3	2	3	2	3
27	3	2	3	3	3	3	3
28	3	3	3	2	3	3	2
29	1	3	3	2	3	1	3
30	2	3	2	3	2	3	3
31	2	1	3	3	2	1	2
32	3	3	3	3	2	3	3

NO	postobj1	postobj2	postobj3	postobj4	postobj5	postobj6	postobj7
1	2	2	3	2	2	2	3
2	2	3	3	2	2	3	3
3	2	0	2	2	2	2	2
4	3	3	3	3	3	3	3
5	2	3	3	2	2	3	2
6	3	2	3	2	3	3	2
7	2	3	2	3	3	2	2
8	2	0	3	1	2	2	3
9	2	2	3	3	3	2	2
10	3	2	3	3	3	3	3
11	2	1	3	3	3	3	3
12	1	1	2	0	3	3	2
13	2	3	3	2	2	3	1
14	3	3	3	2	2	3	1
15	2	2	2	2	2	3	1
16	2	3	3	3	3	3	3
17	0	1	0	0	2	2	1
18	3	3	2	3	2	1	3
19	3	1	3	3	3	3	3
20	3	2	3	3	2	3	3
21	3	3	3	3	3	2	3
22	1	1	3	2	3	3	2
23	2	2	3	3	1	2	3
24	2	1	2	3	3	3	2
25	2	2	3	1	2	2	1
26	2	1	3	3	1	2	3
27	3	2	2	1	1	2	2
28	3	2	3	3	3	2	2
29	1	2	3	1	2	1	2
30	3	3	3	3	2	3	3
31	2	1	3	0	2	2	3
32	3	3	3	3	2	3	2