The Effects of Computer Simulated Experiments on High School Students' Understanding of the Displacement and Velocity Concepts

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Abstract

Problem Statement: The number of relationships between important concepts is higher in physics courses than in other courses. As well as the definitions of complicated concepts, the feature of concepts should be learned. Using traditional instructional methods are sometimes not enough to teach physics concepts like velocity and displacement. Based on implications in the literature, Computer Simulated Experiment (CSE) seems to be a satisfactory approach that can be used to promote students' science achievement, and it is important to test how successful it will be when compared to Hands on Laboratory (HOL) study.

Purpose of Study: The main purpose of this study was to investigate the effectiveness of CSE over HOL study on the understanding of velocity and displacement concepts when both teaching methods were used as a supplement to regular classroom instruction. The second purpose was to identify whether logical thinking ability accounted for a significant portion of variation in achievement related to velocity and displacement concepts.

Methods: In this study, the pretest/post-test control group design was used. Each treatment (CSE & HOL) was randomly assigned to the experiment group and the control group. Both groups were administered a pretest of Velocity and Displacement Concepts Achievement Test (VDCAT) and a Logical Thinking Ability Test as dependent variables. Then, both groups

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were post-tested with the same VDCAT. The sample of the present study consisted of 61 tenth grade students enrolled in two physics classes of the same teacher in a high school.

Findings and Results: Post-test scores revealed that a significant difference was obtained between the mean scores attained by the CSE group and hands-on group with respect to physics achievement. The CSE group scored significantly higher than the hands-on group with respect to achievement in physics related to velocity and displacement concepts. On the other hand, logical thinking ability accounted for a significant portion of variance in physics achievement.

Conclusions and Recommendations: Computer-simulated laboratory experiments, together with classroom instruction, appear to be a practical strategy in implementing a physics program. They can be organized such that the application of physics concepts is stressed. This approach will improve understanding of physics subject matter. Well-designed computer simulations can be used for teaching some concepts without extra effort and time from the teacher to prepare materials.

Keywords: Computer simulated experiments, computer assisted instruction, logical thinking ability, physics education

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Physics courses, in comparison to other courses, cover concepts that are more leading, more significant, and at the same time, are technical (Donald, 1993). The relationships between the concepts are causal. The number of relationships between important concepts is higher in physics courses than in other courses. As well as the definition of complicated concepts, the feature of concepts should be learned. For this reason, an important goal of physics education is to help students develop an understanding of concepts and use them when solving a problem in a new situation. Students frequently find solving science problems difficult (Jimoyiannis & Komis, 2001). The major difficulty in solving physics problems is the lack of understanding physics concepts (Wilt, 2005).

Many researches indicate that many high school students have some problems in understanding fundamental concepts and principles in physics (Idar & Ganiel, 1985; Reif & Larkin, 1991; Andaloro, Bellomonte, Lupo, & Sperandeo-MÝneo, 1994). In order to solve physics problems, students should have mathematical and thinking skills (Wilt, 2005). Mechanics is a prior condition for most of the rest of physics. Therefore, the student's knowledge of mechanics is important for his course performance to understand physics better. Hence, we can restrict our attention to that domain of physics.

Kinematics is often treated as a sequence of definitions and operations by giving examples of motion of objects. Trowbridge and McDertmott (1980) and Çataloğlu (1996) found that students could not discriminate between position and velocity. Students' alternative conceptions of velocity and acceleration, for example, are considered to be as not easily affected by traditional instructional methods. Students often have major difficulties when using graphical representations of motions (McDertmott, 1987; and Beichner, 1994). One of the difficulties of students in these concepts is representing such features as speeding up, and speeding down, and also in recognizing that the velocity versus time graph should be a plot of the position versus time graph. These concepts require students to function at the level of formal operations such as hypothetical, proportional, probabilistic reasoning, and identifying and controlling relevant variables. Researches in science education have brought to light the importance of formal reasoning influencing achievement in science courses (Geban, Aşkar, & Özkan, 1992). In the present study, the role of logical thinking ability on achievement was investigated.

On the other hand, the teaching style for teaching physics is very important as a quality of instruction. This study compared two approaches: HOL experiments and CSE (both used as a supplement to classroom instruction). Probably one of the important aspects of the laboratory is the verbal interaction that takes place between instructor and student. This interaction gives the instructor an opportunity to obtain feedback from the students on their level of understanding. "Most science educators agree that the laboratory is a necessary aspect of the learning experience in science courses" (Kyle, Penick & Shymansky, 1979, p. 545; Tweedy & Hoese, 2005).

Hands-on learning includes the following: (1) learning by doing; (2) involves the student in a total learning experience, which enhances the student's ability to think critically; (3) does not simply manipulating things, but is engaging in in-depth investigations with objects, ideas, and drawing meaning; and (4) requires students to become active participants instead of passive learners who listen to lectures or watch films (Haury & Rillero, 1994). "An investigative science learning environment helps students not only understand the concepts and gain the knowledge of the experimental evidence supporting the concepts, but may also enrich their epistemological development" (Zou, 2003, p.105).

Students are not to be expected to learn science successfully without doing science. The process of science can only be experienced in the laboratory. A review of several recent researches (Bryant & Marek, 1987; Renner, Abraham & Burnie, 1985) reported that students like a lab-centered science. Students prefer laboratory activities in science courses because those activities help them to remember. They are less confusing and more concrete than other instructional formats. Laboratory makes learning an active experience (Ertepınar & Geban, 1996).

On the other hand, a promising alternative to hands-on experiments is computer-simulated experiments. As a result of technological development, microcomputers have become important tools in science education. The studies on these topics bring up that computer usage makes the learning environment wider and forms some changes on the quality of education. Computer literacy should be widened at every level of education by providing students with the opportunity to get acquainted with the computer and getting them to use computers in the learning and teaching process.

Ertepınar (1995) stated that, "Several capabilities of computers such as providing individualized instruction, teaching and problem solving and immediate feedback make computers as the instructional devices for developing learning outcomes" (p.21). In a research done by Dobson, Hill and Turner (1995), students received feedback from the computer program more than they received from a laboratory supervisor. Well-designed computer programs have the potential to promote more active, effective and efficient learning, and increased student motivation.

Studies indicated that the use of computers in education in the instructional process caused significantly higher achievement in science courses (e.g., Geban et al., 1992; Ertepınar, Demircioğlu, Geban, & Yavuz, 1998; Rowe & Gregor, 1999; Chang, 2002; Shim, Park, Kim, Park, & Ryu, 2003; Tsai & Chou, 2002; Powell et al., 2003; Law, & Lee, 2004; Gürbüz, 2007). Some researchers showed that physics achievements of students who are taught by CAI were improved (Gale, 1980; Hewson, 1985; Bennett, 1986). But the study by Miller (1986) did not find a significant increase in achievement among students using CAI materials in a community college biology laboratory course. Moreover, Alacapınar (2007) concluded that there is no significant difference between computer assisted education and traditional education in terms of total achievement averages.

When computers are used in the science laboratory, they may offer effective lab activities. Through simulations we can offer learners a laboratory in areas such as the social science and human relations as well as in areas related to the physical sciences, where laboratories have long been taken for granted. Computer simulations seem to be a satisfactory approach that can be used to investigate phenomenon in science laboratories. With the advent of low-cost, real-time computer power, many departments have begun to introduce the microcomputers into their laboratory programs (Feinberg & Knittel, 1985; Hughes, 2002). Because, the real-time microcomputer-based lab experiments - the use of microcomputers for student direct data acquisition, display and analysis - allow students to see and feel the connection between a physical event and its graphical representation (Brasell, 1987; Beichner, 1990).

Many studies have been conducted to investigate the effectiveness of CSE on achievement. Some research indicated that students who participated in CSE had higher science achievement than those in conventional laboratory (Lewis, 1984; Brasell, 1987; Geban et al., 1992; Svec & Anderson, 1995; Redish, Saul, & Steinberg, 1997; Law & Lee, 2004). In another study on achievement in science subjects, however, Miller (1986) and Choi and Gennaro (1987) found no significant differences between computer-simulated experiment group and conventional laboratory group.

Based on implications in the literature, CSE seems to be a satisfactory approach that can be used to promote students' science achievement, and it is important to test how successful it will be when compared to HOL study. For this reason, the present study was planned to compare the effects of CSE and HOL on students' physics achievement related to displacement and velocity concepts.

The main purpose of this study was to investigate the effectiveness of CSE over HOL study on the understanding of velocity and displacement concepts when both teaching methods were used as a supplement to regular classroom instruction. The second purpose was to identify whether logical thinking ability accounted for a significant portion of variation in achievement related to velocity and displacement concepts.

Method

Research Design

In this study, the pretest/post-test control group design was used. Each treatment (CSE & HOL) was randomly assigned to the experiment group and the control group. Both groups were administered a pretest of Velocity and Displacement Concepts Achievement Test (VDCAT) and a Logical Thinking Ability Test (LTAT) as dependent variables. Then, both groups were post-tested with the same VDCAT.

Sample

The sample of the present study consisted of 61 tenth grade students enrolled in two physics classes of the same teacher in a high school in Turkey. Each of the two supplementary approaches (CSE and HOL) used in this study was randomly assigned to one class. While the experiment group (n= 31) was taught with CSE, the other group (n= 30) continued their laboratory sessions with HOL activities. The students in the sample were coming from a variety of social-economic backgrounds. All of them had computer experience. They had taken a Computer Applications course in ninth grade. To control the students' previous learning in physics related to velocity and displacement concepts and logical thinking ability before the treatment, all of the subjects were administered two pretests: VDCAT and LTAT. The results showed that no significant differences were found between two groups in terms of physics achievement ($t = 0.33$, $p>0.05$) and logical thinking ability ($t = 0.30$, $p>0.05$).

Research Instruments

Velocity and Displacement Concepts Achievement Test (VDCAT). To measure students' velocity and displacement concepts achievement, velocity and displacement concepts achievement test (VDCAT) was developed by the authors of this study. Firstly, it was administered to a pilot study group of students at the eleventh grade in the same school. An 18 item multiple-choice test was developed to assess students' performance on velocity and displacement concepts from an initial set of 25 items after item analysis (item difficulty, discrimination indices, and response to the various distracters). The test was designed from the lecture materials. It was independent of the experimental treatments. It did not contain questions that were covered specifically within either the CSE or the HOL. Content validity of the test was examined by a group of experts in physics and science education and by the classroom teachers for the appropriateness of the items related to representativeness of high school physics. The alpha reliability coefficient was found to be 0.82. Sample questions are given below.

1. The graph shows the displacement versus time graph of a moving object. The slope of this graph gives___________ .

a) distance b) displacement

c) velocity d) acceleration

e) position

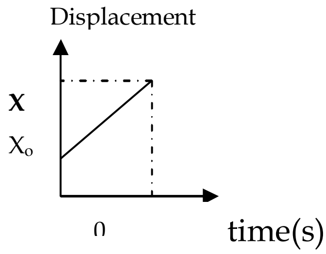


Figure-1

2. The position versus time graph of an object is given in figure-2. Which one(s) of the following statements is/are true?

I. In region I, the object slows down

II. In region II, the object speeds up

III. In region I, the object moves in (-x) direction with constant velocity

III. In region I, the object moves in (+x) direction with constant velocity

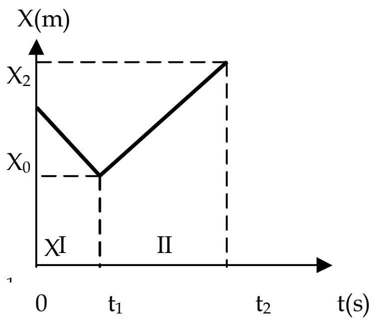


Figure-2

a) IV b) II, IV c) III, IV d) I, IV e) I, III

*Logical Thinking Ability Test (LTAT)***.** Tobin and Copie (1981) originally developed this test and it was translated and adapted into Turkish by Geban et al. in 1992. It is a 10-item, paper-and-pencil test, which contains questions related to identifying and controlling variable and to proportional, correlational, probabilistic, and combinational reasoning. The reliability of the test was found to be 0.74. In this test, the students were expected to answer multiple choice questions and select a reason from a list.

Sample questions are given below:

Sample Questions

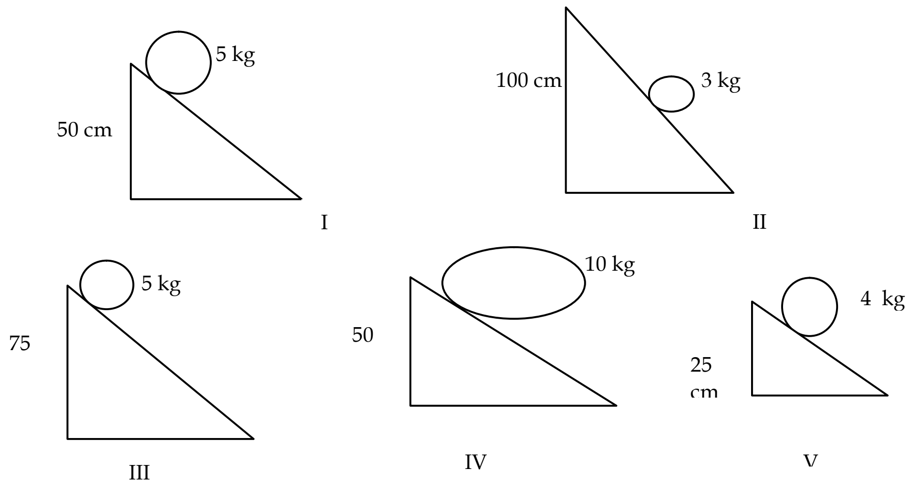
Q1. A housepainter used four boxes of dye to paint six identical rooms. How many rooms can he paint by using eight boxes of dye?

a) 7 rooms b) 8 rooms c) 9 rooms d) 10 rooms e) None

Reasons:

1. The ratio between the number of rooms and the number of dyes is always 3/2.
2. The difference can be reduced by using more dye boxes.
3. The difference between the number of rooms and the number of boxes is two.
4. As the difference was two in four boxes, the difference should be the same as six boxes was used.
5. It is impossible to expect how many boxes can be used.

Q2. In order to find a relation between the distance covered after the inclined plane and the height of the inclined plane, you need to make an experiment. Which inclined planes would you use?



Reasons:

1. The highest and the lowest planes should be compared.
2. All of them should be compared.
3. As the height increases, the weight of the ball decreases.
4. Heights should be the same, but weight should be different.
5. Heights should be different, but weight should be the same.

Procedure

This study was conducted over four weeks during the first semester of the school year. Each teaching approach was randomly assigned to one class. Each instructional approach utilized in this study had two components, which are classroom instruction and hands-on activities and classroom instruction and computer-simulated experiments. The material was introduced by the researchers to the physics teacher before the treatment. Both groups were administered a pretest of Velocity and Displacement Concepts Achievement Test (VDCAT) and a Logical Thinking Ability Test (LTAT).

The details of simulated experiments, hands-on experiments, and the microcomputer courseware are given below.

Simulated Experiments versus Hands-on Experiments. As a result of technological development, microcomputers have become important tools in science education. A change in the technology has provided an opportunity to compare the academic performance of students experiencing simulations with those doing traditional hands on experiments. The hands-on laboratory class did four experiments about position, displacement, velocity, and acceleration in four class hours and the students set up and manipulate their own materials. After taking necessary data, they plotted graphs and calculated the slopes of the graphs. Finally, they answered the questions in given laboratory sheets. In the simulated experiment however, the student used a computer simulation of the isolated air-table experiment about the same topics in which the student typed the variables and observed the changes in the plotted graphs and answered the question asked by the computer program. The simulation program gave immediate feedback to answers, and according to the results, the program directed the student to restudy or change the variables. The schedule followed by the students also contained some questions designed to test understanding of the theoretical implications of the measurement that had been made.

In the teaching process, CSE was presented to students via data-show by the teacher, and then the students had the opportunity to work on the same program. Educational activities in CSE were organized around observing figures, graphs, awarding and providing animation, solving problems rather than reading long, boring scientific knowledge or oral explanation done by the teacher. The same teacher who had experience about CSE and laboratory study taught the classroom instruction, CSE, and hands-on study. The classroom instruction of the groups had three 45-minute sessions per week. The teacher directed strategy represented the customary approach used in class hours. The classroom teacher provided instruction through lectures and discussion in the classroom. The computer-simulated and hands-on activities were instructed after class hours.

The VDCAT and LTAT were given at the beginning of the treatment to determine whether there would be a significant difference between the groups in terms of subject achievement and reasoning ability. A post-test to measure students' performance related to velocity and displacement was given to students in both groups at the end of the treatment.

The Microcomputer Courseware. Students were exposed to CSE for a total of 4 hours during the 3 weeks. Since the school's computer laboratory had only 15 personal computers, two students worked with one computer in the computer laboratory. Prior to the beginning of the treatment, 30 minutes was devoted to a description of the courseware. In the design of the courseware, terminal objectives were identified for major concepts and a proper sequence of material was established to lead to the students in the realization of the stated objectives. The courseware offers an interface through a series of interaction objects such as: (1) controls that allow students adjust simulation parameters before and during a simulation's execution; and (2) meters, that allow measurement of the relevant physical quantities in digital, graphical or bar form. The program provided text material that included the basic definitions, concepts and formulas and graphic displays when necessary, and experiment related to velocity and displacement. The software also provided immediate feedback, learner control, and interactivity. The students were allowed to go back and forth within each section of the program in a learner control strategy. The simulations were designed to solve problems during the simulated experiments. The feedback from the computer to the student on the correctness of formulation and computation was immediate. After the correct answer, the program provided immeditate feedback verifying that the answer was correct. Whenever the student entered an incorrect response, she/he was asked to try again, or was provided a hint.

The computer program included theory part in the introduction menu. From this menu bar, one could move from one window to another, and study some physical concepts such as displacement, velocity, etc.

The program presented descriptions or representations of one-dimensional motion (position, displacement, position versus time graphs, and velocity versus time graphs). The aim of the program was to enable the students to translate from one representation to another.

In the first part of the program, a help screen about how to use this program was presented, and then the purpose of the experiment was introduced. In each of the screens, students were able to receive help from the help menu.

In the second part of the program, a video about straight-line motion with constant velocity was shown. The video explained the procedure to do the experiment. Here again, the learner could control the video, go back and forth.

In the third part, there was a stationary car on the left of the screen. The students were free to move the car any place on the line. By using start and stop buttons, the student could control the motion of the car. When the student stopped the car, the displacement and the total distance travelled by the car were asked. The students were required to calculate and write the response to the empty places. Then, immediate feedback was provided. After correct answers, the program provided feedback verifying that the answer was correct. After wrong answers, the program indicated that the response was incorrect and provided a second chance to do it. If the response was again incorrect, the program gave a chance to study the misunderstood or unknown concept.

After studying it, the learner could go back to the experiment. If the last response was still incorrect, the correct answer to the question was given.

In the next part, while the car was moving, dots appeared and each dot showed the position of the car with respect to the initial position of the car. The data were displaced on the table as they were collected as shown in Figure-3. The students were required to find out the velocity of a car after responding some multiple-choice type of questions with three choices. Again immediate feedback was provided. Yet this time, if the response was incorrect only the correct one was informed and an advice was given to the student to study the related concept.

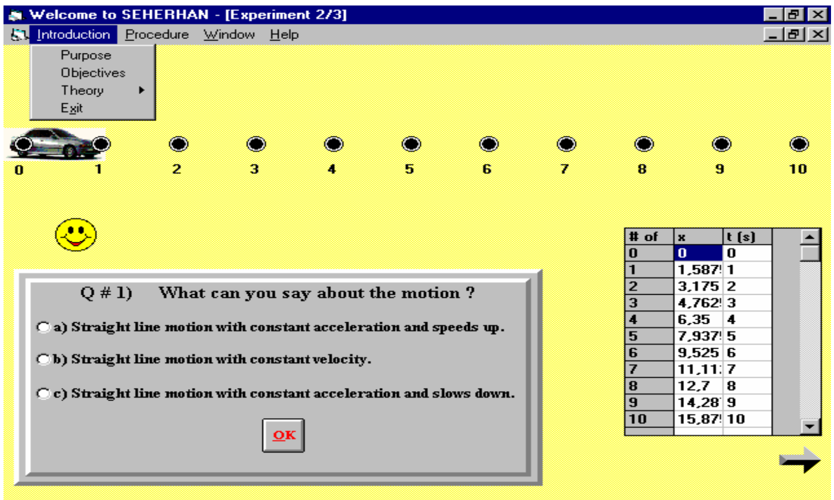


Figure-3. Display example of the program on the screen

In the last part, the student could change the velocity of the car and observe its motion. Then, from the position versus time graph, they would find the velocity of the car same as they selected.

Hands-on Laboratory. The traditional group participated in the same laboratory activities related to the velocity and displacement concepts as those used with the computerized simulations. The laboratory sheet was prepared for the experiment. On the laboratory sheet, concepts and principles to be studied in the experiment were introduced. This group was constructed in a deductive format. In the laboratory sheet there were detailed explanations of the problem, apparatus, and modes of measurement. The students knew what the procedure was. They followed the procedure and collected data. Then they compared the results with known results.

Findings and Results

To examine the effect of the treatment on the dependent variables, and to control the students' previous learning in physics related to velocity and displacement concepts and logical thinking ability before the treatment, all of the subjects were administered two pretests including VDCAT and LTAT. The results showed that no significant differences were found between the two groups in terms of physics achievement ($t = 0.33$, $p>0.05$) and logical thinking ability ($t = 0.30$, $p>0.05$).

The analysis of covariance was used, with treatment as the independent variable, logical thinking ability as the covariance, and post-test scores related to physics achievement as the dependent variable. Statistical results were obtained using the SPSS/PC (Statistical Package for Social Science for Personal Computer). The means and standard deviations of the pre- and post-test results of the test utilized in this study are presented in Table 1.

Table 1

Mean and Standard Deviations of Logical Thinking Ability Test (LTAT), and Pre- and Post-Velocity-Displacement Concepts Achievement Test (VDCAT)

		LTAT		Pre – VDCAT		Post - VDCAT	
Treatment	**Number of Students**	**Mean**	**Standard Deviation**	**Mean**	**Standard Deviation**	**Mean**	**Standard deviation**
CSE	31	7.00	1.50	3.65	1.17	12.16	2.02
Hands-on	30	7.10	1.90	3.77	1.69	10.00	2.80

Post-test of the test scores revealed that a significant difference was obtained between the mean scores attained by the CSE group and hands-on group with respect to physics achievement. Table 2 shows a summary table of analysis of covariance.

Table 2

Summary Table of ANCOVA

Source	df	SS	MS	F	P
Covariate (Logical Thinking Ability)	1	74.07	74.07	15.56	0.05
Treatment	1	76.92	76.92	16.16	0.05
Error	58	276.13	4.76		

The CSE group scored significantly higher than the hands-on group with respect to achievement in physics related to velocity and displacement concepts. On the other hand, logical-thinking ability accounted for a significant portion of variance in physics achievement.

The results of the present study are consistent with these studies showing that computerized activities in teaching and learning science have been found to enhance understanding of concepts (e.g. Hewson, 1985; Brasell, 1987; Mokros & Tinker, 1987; Geban et al., 1992; Svec & Anderson, 1995; Redish et al., 1997; Jimoyiannis & Komis, 2001; Hughes, 2002; Chang, 2002; Shim et al., 2003; Law, & Lee, 2004). The CSE was as effective as hands-on laboratory experiences. Hence, it is possible to use a CSE in the teaching of some physics concepts such as displacement and velocity.

Also, the results of this study are complementary to the results obtained by Brasell (1987), Mokros & Tinker (1987), Hewson (1985), Svec & Anderson (1995), and Redish et. al. (1997). Brasell (1987) revealed that a microcomputer based laboratory method is sufficient for high school students to improve their comprehension of distance, and velocity graph when compared with a traditional laboratory method.

Conclusions and Recommendations

This study investigated the relative effectiveness of the CSE approach and hands-on approach to supplement regular classroom instruction in velocity-displacement concepts. It indicated that the students exposed to the CSE performed significantly better than those exposed to the hands-on activities.

Because the computer program provided learner control, and lessons were designed in such a way that it enabled the learners to re-examine each part of the lesson, the students who used CSE might have understood the concepts and problems better.

The attributes of the computer program such as learner control or response checking and immediate feedback may have developed achievement better (Shim et al., 2003). When compared with the hands-on activities, the students solved more problems related to the experiments and re-examined each part of the lesson. Because the learner-controlled strategy was employed by allowing students to go back and forth within the program, they were allowed to investigate any part of the experiment that was not understood. The students were motivated to control their own learning. The findings of the present study concur with some studies in which learner control in computerized programs improve student performance (Hannafin & Sullivan, 1995; Shim et al., 2003).

When simulations are used in education, learners must be evaluated immediately after their response to the program (Rieber, 1996; Huppert et al., 2002). The program required the students to be active by encouraging them to answer each question. Feedback reflects the quality of the instruction and can affect students' achievement. The students who used CSE got immediate feedback on their responses. Following their responses to a question, immediate feedback was provided. On the other hand, generally students in HOL have no immediate or continues feedback. The immediate correction of erroneous responses may be the most important function of feedback, because erroneous information is likely to be preserved and interfere with future learning unless corrected. Feedback in the simulated experiments was in a linear sequence, asking the students to give an answer for each step. In this manner, the students could comprehend the concepts and their interrelationships in the problems more accurately. Appropriate questions were asked in the program. More meaningful learning is probable if students are asked to respond to succession of more appropriate questions, and to explain relationships. Moreover, Evans & Gibbons (2007) stated that "interactive systems facilitate deep learning by actively engaging the learner in the learning process" (p. 1147).

It is not necessary to discover everything in the laboratory. Some laboratory investigations may involve excessive work in setting up equipment and in gathering data. Moreover, another advantage of computer-simulated experiments was that the students dealt with data in a controlled setting with respect to the traditional HOL approach (Huppert et al., 2002). The data obtained under the HOL conditions were not fully reliable because of uncontrolled variables or measurement errors.

Computer-simulated laboratory experiments, together with classroom instruction, appear to be a practical strategy to implementing a physics program. They can be organized such that the application of physics concepts is stressed. This approach will improve understanding of physics subject matter. Well-designed computer simulations can be used for the teaching of some concepts without extra needed effort and time from the teacher to prepare materials. It appears that using CSE in science education can be effective and cost effective as well.

The CSE can be used for the teaching of some concepts, velocity and displacement for example, without extra needed effort and time from the teacher to prepare materials. It is also possible that a computer program could be used to replace more expensive instrumentations or materials in many traditional hands-on laboratory experiences if schools already have microcomputers.

Another implication of this study is that when the CSE is used, experiments can be done in a short period of time compared to the hands-on laboratory experiences.

There is a continuous need for further research seeking to establish the relationship between the computer simulated experiments (CSE) approach and different teaching approaches on understanding of physics concepts. Real-time graphing of data appears to be a key feature for both cognition and motivation. As Brasell (1987) indicated, "It allows students to process information about a physical event and its graph simultaneously rather than serially" (p.392). Focusing further research on this feature of CAI could provide some valuable insights into information processing and motivation. Further research is also needed to test the effectiveness of different modes of the CAI on the students' understanding of physics concepts (e.g., CSE versus Tutorial, CSE versus Drill-practice, etc.).

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Bilgisayar Benzetimli Deneylerin Lise Öğrencilerinin Yerdeğiştirme ve Hız Kavramlarını Anlamadaki Etkisi

(Özet)

Problem Durumu: Yapılan araştırmalar, lise öğrencilerinin temel fizik kavramlarını ve teorilerini anlamada ve uygulamada sıkıntılar yaşadıklarını göstermektedir. Buna bağlı olarak, bazı araştırmalarda öğrencilerin derslere belirli fizik kavramlarını öğrenmelerini engelleyecek naif yargılarla gelmekte olduğunu göstermiştir. Bu tür yanlış kavramalar sanıldığından daha geniş kapsamlıdır ve sınıf performansı üzerinde etkili olmaktadır. Aslında, öğrenciler önemli fizik kavramlarını tam anlamıyla öğrenmeden sınıflarını geçmektedirler. Öğrencilerin matematik denklemlerini kullanarak fizik problemlerini çözebilmeleri, fizik kavramlarını tam anlamıyla anlamış olduklarını göstermemektedir. Fizik derslerinde diğer disiplinlere göre ana konular arasındaki ilişki sayıca daha fazladır. Öğrenilmesi gereken karmaşık konu sayısı oldukça fazladır ve bu konuların öğrenilmesinde yalnız tanımlarının bilinmesi yeterli değildir. Ayrıca genel özellikleri de anlaşılmalıdır.

Laboratuar çalışması öğrencilerin fizik dersindeki başarısını artırmakta önemli bir rol oynamaktadır. Laboratuar çalışması; 1) yaparak öğrenmedir, 2) öğrencinin kritik düşünme yeteneğini geliştirir, 3) öğrencilerin aktif olmasını sağlayan bir öğrenmedir. Öğrencilerin bilim yapmadan bilimi öğrenmeleri beklenemez ve bu sadece laboratuar da gerçekleşir. Yapılan bazı araştırmalar, öğrencilerin laboratuar çalışmasını sevdiklerini göstermektedir.

Bilgisayarın eğitimde kullanılması, öğrenme alanını genişletmekte ve eğitim kalitesini olumlu yönde etkilemektedir. Bundan dolayı, her düzeyde öğrencinin bilgisayar okuryazarlığı becerilerini geliştirmesi sağlanarak onların eğitim ve öğretim sürecinde bilgisayarı kullanmaları teşvik edilmelidir. Çünkü bilgisayarların farklı eğitim araçlarını aynı anda kullanma ve kontrol etme özellikleri vardır. Bilgisayar Destekli Eğitimin çeşitli tanımları verilmektedir. Bu tanımlardan ilkine göre Bilgisayar Destekli Eğitim bilgisayar teknolojisinin öğretim sürecindeki uygulamalarının her biridir. Bu uygulamalar bilgi sunmak, özel öğretmenlik yapmak, bir becerinin gelişmesine katkıda bulunmak, benzeşim gerçekleştirmek ve sorun çözücü veri sağlamak olabilir. Başka bir tanıma göre ise, Bilgisayar Destekli Eğitim, öğrencilerinin bilgisayar sistemine programlanmış olan dersleri etkileşimde programlanmış olan dersleri etkileşimde bulunarak, doğrudan alabilmeleridir. BDE de öğrenciler eğitsel materyalleri sunan ve gösteren bilgisayar ile direk temas içindedir. Bu çalışmanın asıl amacı, fizik dersi ile birlikte verilen bilgisayar benzetişimli deneylerin yerdeğiştirme ve hız kavramlarını anlamadaki etkisini yine dersle birlikte verilen geleneksel laboratuar çalışması ile

karşılaştırmaktır. Benzeşim bazı gerçek yaşam olay ve uygulamalarının soyutlanması ve basitleştirilmesidir. Benzeşimde katılımcılar diğer kişi ve/veya taklit edilmiş ortam ile devamlı olarak bir ilişki içindedir. Birçok benzeşimin amacı, sıralı olay ve bilgileri anlatabilmektir. Öğrenciyi bir sonraki basamağa atlatabilmek için öğrencinin vereceği cevaplara göre, bilgisayar ya bilgi sunacak ya da geri iletimde bulunacaktır. Her bir basamak yeni bir bilgi sunacaktır. Bu şekilde hedeflenen amaca ulaşılacaktır.

Öğrencilerin klasik ders anlatım metotları ile hız ve ivme gibi konuları kavramaları her zaman mümkün olmayabilir. Laboratuar çalışması, bilgisayar destekli eğitim gibi farklı metotların kullanılması uygun olabilir. Yapılan araştırmalara göre, Bilgisayar Benzetimli Deneylerin (BBD) öğrencilerin başarısını yükseltmek için uygun bir metot olduğu düşünülmektedir. Dolayısı ile BBD'nin etkililiği Geleneksel Laboratuar (GL) çalışmaları ile karşılaştırarak araştırılmalıdır.

Araştırmanın Amacı: Bu çalışmanın sorunlu amacı fizik dersi ile birlikte verilen bilgisayar benzetimli deneylerin yerdeğiştirme ve hız kavramlarını anlamadaki etkisini yine dersle birlikte verilen geleneksel laboratuar çalışması ile karşılaştırmaktır. Çalışmanın diğer amacı ise uygulanan öğretim yöntemi, mantıksal düşünme yeteneği ve aralarındaki etkileşimin birlikte hız ve yer değiştirme konularında öğrenci başarısına anlamlı bir katkıda bulunup bulunmadığını saptamaktır.

Araştırmanın Yöntemi: Çalışmada, ön-test-son-test kontrol gruplu deneme modeli kullanılmıştır. Her bir yöntem (BBD ve GL) kontrol ve deney gruplarına rastgele atanmıştır. Öğrencilerin Yerdeğiştirme ve Hız kavramlarındaki bilgilerini ölçmek için Yerdeğiştirme ve Hız Konuları Başarı Testi (YHKBT) öntest ve sontest olarak uygulanmıştır. Hazırlanan bu test Bloom'un ilk dört taxonomisini (bilgi, kavrama, uygulama ve analiz etme) içermektedir. Test hazırlanırken ders notları ve bazı fizik ders kitaplarından yararlanılmıştır. İlk aşamada 25 adet beş seçenekli test olarak hazırlanan test uzmanlar, eğitim bilimciler ve ders öğretmeni tarafından incelenmiştir. Soruların zorluk seviyesi ve ayırt ediciliğinin ölçülmesi için 75 kişilik 11. Sınıf öğrencilerine YHKBT uygulanmıştır. Soru analizi sonucunda 18 soru seçilmiştir ve soruların aynı değişkeni ölçtüğüne dair güvenilirlik katsayısı (Cronbach alfa) 0.82 olarak hesaplanmıştır. Öğrencilerin muhakeme yeteneklerini kontrol etmek için Mantıklı Düşünme Testi (MDT) uygulama başlamadan önce uygulanmıştır. MDT değişkenleri anlayabilme ve hakim olabilme, orantı kurarak korelasyon sağlayabilme, ihtimalleri değerlendirerek mantık yürütmeye dayalı sorular içermektedir. Bu çalışmanın evrenini onuncu sınıf Fizik dersini alan öğrenciler, örneklemini ise aynı öğretmenin ders verdiği iki fizik sınıfındaki 61 onuncu sınıf öğrencisi oluşturmaktadır. Verileri analiz etmek için t-test ve çoklu regresyon metotları kullanılmıştır.

Bilgisayar Benzetimli Deney Programı: Bilgisayar Benzetimli Deney Programı Microsoft Visual Basic programı kullanılarak Bilgisayar Destekli Eğitim ve Bilgisayar Benzetimli Deney Programlarından yararlanılarak geliştirilmiştir. İstenilen amaçlara ulaşabilmek için konular belirli bir sıralamada ve kullanıcıyı aktif tutabilecek şekilde hazırlanmıştır. Öğrencinin her an aktif olduğu, gerekli zamanlarda bilgilerin sunulduğu ve öğrenciye geri dönüşümlerin sıklıkla yapıldığı bu program MS-Windows uygulamalarını kullanabilen herkes tarafından oldukça kolay bir şekilde kullanılabilir.

Laboratuar Deney Kağıdı: Kontrol grubu öğrencileri için konu özetini, deney amacını, kullanılacak malzemeleri ve deney sıralamasını içeren laboratuar deney kâğıdı hazırlanmıştır. Deney basamakları yapıldıkça veriler elde edilmekte ve sonuçları bilinen değerlerle kıyaslanmaktadır.

Araştırmanın Bulguları: Ön-test sonuçlarına göre yerdeğiştirme ve hız kavramlarını öğrenme ve mantıksal düşünme yeteneği açısından iki grup arasında anlamlı bir fark gözlenmemiştir. Son-test sonuçlarına göre, bilgisayar benzetimli deneylerden faydalanan öğrenci grubunun hız ve yerdeğiştirme kavramlarını anlamada istatistiksel olarak daha iyi olduklarını ortaya koymuştur. BBD grubunun KL grubuna göre daha yüksek bir fizik başarı ortalamasına sahip olduğu tespit edilmiştir. Diğer yandan uygulanan öğretim yöntemi, mantıksal düşünme yeteneği ve aralarındaki etkileşimin birlikte hız ve yer değiştirme konularındaki başarıya anlamlı bir katkıda bulunduğu saptanmıştır. Öğretim yöntemi ve mantıksal düşünme yeteneğinin başarıya katkısı ayrı anlamlıyken, aralarındaki etkileşimin tek başına başarıya katkısı anlamlı çıkmamıştır.

Araştırmanın Sonuçları ve Öneriler: Sınıf içi ders anlatımları ile beraber Bilgisayar Benzetimli Deneylerin kullanılması fizik dersi programının uygulamasında pratiklik kazandırmıştır. Bu yaklaşım ile derslerin işlenmesi fizik konularının anlaşılmasını kolaylaştırmıştır. İyi tasarlanmış bilgisayar simülasyonları kullanarak yerdeğiştirme, hız, ivme gibi konular, materyal hazırlamak için fazla enerji ve zaman harcamadan öğretilebilir. (1) Uygulama, (2) mantıksal düşünme yeteneği ve (3) mantıksal düşünme yeteneği ile uygulama arasındaki ilişki istatiksel olarak yerdeğiştirme ve hız kavramlarındaki başarıdaki farklılıklara katkı sağlamıştır. Uygulama ve mantıksal düşünme yeteneğinin her ikisi de yerdeğiştirme ve hız kavramlarını algılamadaki başarıyı tahmin edici kuvvetli faktörlerdir.

Bu çalışmaya ek olarak aşağıda belirtilen konular üzerinde çalışmalar yapılabilir: Bilgisayar benzetimli deney uygulaması ile başka öğretme metotları arasındaki ilişkinin incelenmesine ihtiyaç vardır. Bilgisayar oyunlarının ve problem çözmenin lise öğrencilerinin fizik konularını algılamalarına olan etkisini inceleyen araştırmalar yapılabilir. Diğer bilgisayar destekli eğitim metotlarının fizik konularını anlamaya etkisini araştıran çalışmalar yapılabilir. Ayrıca, öğrencinin sosyo-ekonomik durumu, kişiliği, ilgi alanlarının bilgisayar destekli eğitim ile fizik başarısı arasındaki ilişkisi incelenebilir.

Anahtar Sözcükler: Bilgisayar Benzetimli Deneyler, Bilgisayar Destekli Eğitim, Mantıksal Düşünme Yeteneği, Fizik Eğitimi