

TO COMPARE THE EFFECTS OF COMPUTER BASED LEARNING AND THE LABORATORY BASED LEARNING ON STUDENTS' ACHIEVEMENT REGARDING ELECTRIC CIRCUITS

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ABSTRACT

In this study, the research problem was: “Is the computer based physics instruction as effective as laboratory intensive physics instruction with regards to academic success on electric circuits 9th grade students?” For this research of experimental quality the design of pre-test and post-test are applied with an experiment and a control group. The data are collected by “Computer Laboratory Interest Survey (CLIS)”, “Physics Laboratory Interest Survey (PLIS)”, “Electrical Circuits Success Test (ECST)”. For the analyses of the data, the arithmetic mean, the standard deviation, dependent and independent t-tests are used. At the end of the study it is seen that there does not exist a significant difference between the instruction in laboratory and the instruction with computer to influence the success of the students. Thereby, it can be concluded that the computer based learning is as effective as the laboratory based learning on students' achievement.

KEY-WORDS: Physics Instruction, Computer Based Learning, Laboratory Based Learning, Simulation Teaching Programs, Electrical Circuits.

ÖZET

Bu araştırmada, “9. sınıf öğrencilerinin elektrik devreleri konusundaki akademik başarısında, simülasyon programı kullanılarak yapılan bilgisayar destekli fizik öğretimi, laboratuvar destekli fizik öğretimi kadar etkili midir?” sorusuna cevap aranmıştır. Deneysel nitelikli bu araştırma için deney ve kontrol gruplu ön test-son test deney deseni uygulanmıştır. Araştırma verileri; “Bilgisayar Laboratuvarı İlgi Anketi”, “Fizik Laboratuvarı İlgi Anketi” ve “Elektrik Devreleri Başarı Testi” ile toplanmıştır. Verilerinin analizinde Aritmetik Ortalama, standart sapma, bağımlı ve bağımsız t-testi kullanılmıştır. Çalışma sonunda; laboratuvar destekli öğretimin öğrenci başarısına etkisi ile bilgisayar (simülasyon) destekli öğretimin öğrenci başarısına etkisi arasında anlamlı bir fark bulunamamıştır. Buna göre; araştırma sonucu olarak öğrencilerin akademik başarısında bilgisayar (simülasyon) destekli fizik öğretiminin laboratuvar destekli fizik öğretimi kadar etkili olduğu söylenebilir.

Anahtar Kelimeler: Bilgisayar Destekli Fizik Öğretimi, Laboratuvar Destekli Fizik Öğretimi, Elektrik Devreleri Simülasyon Öğretim Programları, Elektrik Devreleri.

INTRODUCTION

The subjects of science are usually complex and abstract. A number of students attending primary and secondary schools need experiences which they will be able to get through concrete materials in laboratories to comprehend the abstract subjects. The active participation of the student in the analyses of the real events and in the process of collecting data is the main element of the program which is depended on the philosophy of inquisitive approach. This provides ease for the student to understand the method and the essence of the science, to improve the ability of solving problems, to have ability of making inquisitions and generalizations, to get the scientific knowledge and to improve positive attitudes (Tamir,1978).

The students can learn the knowledge the most easily in real surroundings where they can observe the concepts and processes. But in these surroundings it can not always be possible to make observations. To teach this kind of knowledge simulated environments such as laboratories are widely used. In laboratories, studies can be done by means of concrete, real or artificial materials. The studies done in laboratories increase the interests and successes of the students for the subjects of science. Freedman (1997) reaches the following results:

The students who attend to the education of laboratory regularly,

- become more successful in the achievement test of science.
- there is a positive correlation between the students' interests and their successes at Science.
- the studies in laboratory make a positive influence on the interests of them over Science.

The researches that have been done for a long time show that the laboratory studies increase the interest and the abilities of the students for the science subjects (Bryant and Morek, 1987; Bekar, 1996; Algan, 1999; Bağcı,1999).

Although the laboratory method has a very important place in science education, it has some limits and problems about its use. The main problems are as follows:

- The laboratory activities are expensive as they are carried out and arranged with equipment.
- It takes too much planning time for the teachers and to apply it.
- Loss of time in the studies of individual and group experiment is too much.
- Checking the students at a large class becomes difficult.

In the cases where the laboratory study isn't done to the extent that it is desired to be, technological devices like concrete materials and models used in the process of education instruction increase the interest and motivation of the students for the lessons and increase learning qualities. The first objects to remember are the computers when one mentions technological educational means. During the educational and instructional studies, the computers play very important roles nowadays. When we look at the forms of the use of computers in education, in perspective of our subject-matter computer based teaching is in demand.

Computer based teaching and learning is increasingly becoming widespread and it has been important especially at difficult subjects in science for over two decades. Computer based learning is a method, which uses computers in a learning media and strengthens students' motivation and educational processes. It gives opportunities to both students and teachers to learn and teach more quickly and to combine active learning with computer technology. Collette & Collette (1989) explains that using computers increases motivation and desire for the lectures and laboratory in the process of learning (Akçay et. al., 2005).

It has been shown through researches done so far that computer based learning influences the successes of the students much more positively than in any other traditional methods (Reed, 1986; McCoy,1991; Geban and other,1992 İbiş,1999; Yiğit and Akdeniz,2003). It has also been identified that the successes of the students increase in physics lessons taught by computers (Bennett,1986; Yiğit and Akdeniz, 2003; Meyveci, 1997).

The teaching simulations prepared to be used in educational activities as one of the software types are able to create a teaching atmosphere like laboratories where students are active.

Various interference possibilities in simulation programs for example, the user giving different initial values in the experiment in computer medium give the possibility of "Learning through inventing" which is one of the different methods (Şen, 2001). Simulations are also simplified and abstracted parts of some real events and applications (Şengel et. al, 2002).

Simulations are the transfers of the events with specific limitations in daily life to the computer medium. Computer based learning is the closest one to the laboratory medium and offers a student interaction. Simulations help the students to form their own cognitive models about events and processes. Simulations also offer the opportunities for observing easily the events that occur too slowly or too fast in the lab and they are very dangerous to be tested in it and cost dearly.

The laboratories equipped with computers and especially with simulations (due to the reason that they are very productive in terms of time) give opportunities to the students to ask questions of changeable nature like "if X is. ..., then what Y is...." As the students feel free for asking questions in this manner and take feedbacks immediately, they enter a process that works well in terms of conceptual changes. Computer transforms difficult and boring activities into easy ones in Science subjects. For this reason, computers encourage the students to be the part of science classes and participate in similar learning experiences (Riche, 200; Soylu and İbiş,1999; Gülçiçek and Güneş, 2004).

Jimoyiannis and Komis (2001) examined the effect of the computer simulations on students to understand the orbital movements, by using basic concepts related with kinematics, in a study made in physics teaching. As a result of this study, it is seen that teaching basic concepts of kinematics through simulations has brought about successful results and has contributed highly to learning process.

In a study in which the influence of computer based physics activities on students' acquisitions is searched on the subject of Simple Harmonic Motion, it is concluded that the teaching realized by the simulation program with an applied dynamic system is more successful than the teaching implemented by traditional methods (Karamustafaoğlu and the others, 2005). And also in this study it is stressed that a well-prepared simulation isn't very adequate by itself and it is necessary to support the simulations considered to be used in order to be able to obtain good results from instruction with the instructive programs concerning related subjects and concepts .

The studies show that computer based learning by way of simulation programs makes the concepts and processes more concrete and causes the students to understand more easily the relationship between them and as a result of this, a more permanent learning is achieved.

Recently some studies have been performed about whether the computer simulation experiments or traditional laboratory experiments are effective on the students’ successes about Science subjects. Some parts of this studies show that the computer simulation experiments are more effective. (Geban and the other. 1992; Svec& Anderson, 1995; Redish and et al., 1997) But Miller (1986) Choi & Gennaro couldn’t find a meaningful difference between computer simulation experiments and traditional laboratory experiments (Şengel and et al., 2002).

The objective of this study is to compare the computer based learning implemented by using simulation programs and the lab based learning on the subject of “Electrical Circuits” in physics class of the 9th graders in terms of student success.

METHOD

The Process of Research Method

A design of pre and post tests is applied to the experiment and control groups as a research method. The process of the research method is shown in Table 1.

Table -1. The Process of Research Method

Group	Determining Groups	Groups	Measurement	Process	Measurement
Students	Physics Lab. Interest Survey (PLIS) and Computer Lab. Interest Survey (CLIS)	Physics Lab. Group (Control G.)	Pre-Test (ECST)	Lab Based Learning	Post-Test (ECST)
		Computer Lab. Group. (Experiment G.)		Computer Based Learning	

Forming the Research Groups

The research group is made up of a total of 28 students who are the 9th graders of a secondary school in a Azdavay district of Kastamonu province in Turkey. While forming the students’ groups, the results of PLIS and CLIS were taken into consideration. In the research students’ interests and curiosities for the computer and lab medium were quite significant. Therefore, surveys were conducted to determine the level of students’ interests and according to survey results, it was discovered that the experiment / control groups’ interests in computer and Physics Labs were the same.

Measurement Tools

To form two groups of students whose interests on Physics and Computer Labs are the same, a Computer Laboratory Interest Survey (CLIS) and a Physics Laboratory Interest Survey (PLIS), comprising Likert Scale Type of questions with five choices were developed. In this area, these surveys developed at the consequence of literature research were accepted to be proper by consulting to the experts. These surveys were applied to a different group of 40 students having the same properties with the study groups. As a result of the data obtained, it was established that the reliability of (PLIS) was .94 and the reliability of (CLIS) was 74.

To get the experimental data of this study first of all, considering the students’ acquisitions provided by the Ministry of National Education regarding Electrical Circuits a multiple choice of an Electrical Circuit Achievement Test was prepared. For the validity and reliability first, this measurement tool was applied to a different group of 39 people having the same qualities with the study groups and according to the results obtained, making necessary arrangements and consulting to the experts the number of the questions was dropped by 33. The reliability coefficient of KR-20 of the formed ECST was found as .94 and the level of difficulty as .37.

Determining the lesson Software to be Used in Research

The simulation programs comprising the subjects of electricity to be used in the implementation of lab based physics learning were detected. Three programs as having suitable levels to be used in the study were

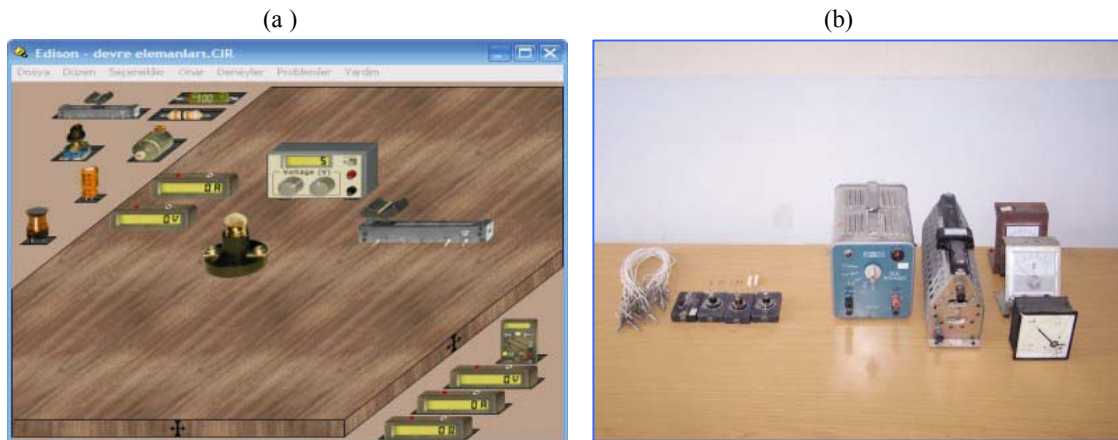
determined. In order to evaluate and determine the suitability of the selected number of software two physics teachers and two academicians that are expert in their own fields were requested to examine such software. At the consequence of the examinations performed, the experts' comments and views were evaluated through Software Evaluation Form (Şahin and Yıldırım, 1999). At the consequence of the data obtained, the program of Edison 4.0 was chosen as a lesson software. Making contacts with the Turkish distributor of the software, negotiations were made with him regarding the supply of the lesson software and necessary support was provided for the Turkish version of the program.

Application and Analysis

First, for the experiment / control group of 14 students whose interests are the same for computer and physics labs an Electrical Circuits Achievement Test (ECST) as a pre-test was given. Later on, for a 4 -week period the computer lab of the school was changed into the Physics Lab one day in a week and was changed into the Computer lab another day in a week and the application was conducted this way. Each week the lesson software was reloaded into computers and was deleted at the end of each class session. Thus, the software of lessons loaded to the computers again every week and at the end of the lesson it is deleted from the computer. Thus, the probability of using the lesson software of the physics lab group students in their leisure time activities was eliminated.

First Week: The Edison Program was introduced to the students in the experiment group and information on how to use the program was given to them. (Picture 1-a); and the components of the circuit (Picture 1-b) were introduced to the students of control group. Both groups were wanted to make a simple electrical circuit and were also demanded to measure the potential differences found among the points of circuit components in the circuit.

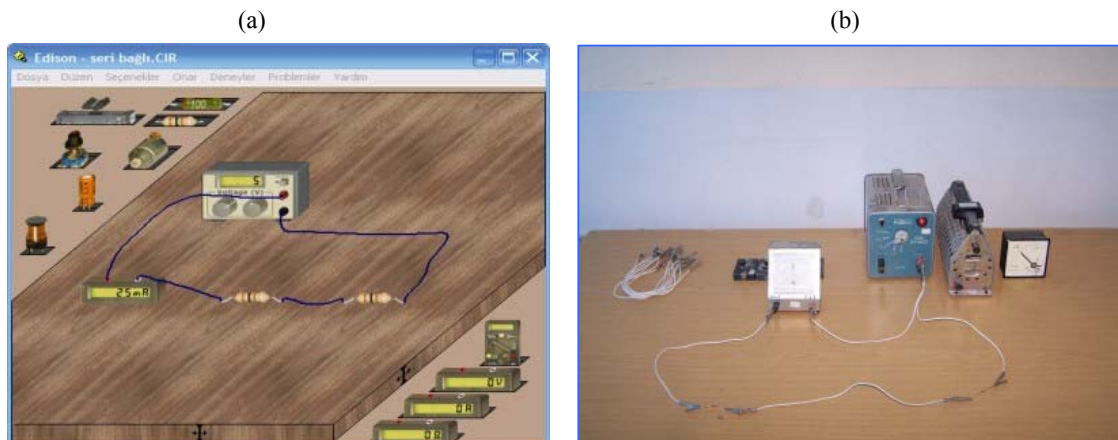
Picture 1: Physical environment views of experiment group (a) and the control group (b)



Second Week: The students from both groups starting to work the relationship between the current and potential difference discovered the Ohm's Law on the established circuit and the relation of resistance with the current was examined.

Third Week: The students in the groups were made to determine the current in a serial circuit and the currents in a parallel circuit and the main arm in a mixed connected circuit and the currents in parallel arms.

Picture 2 : Serial circuit views of the experiment group (a) and the control group (b).



Fourth Week: Students were made to compare the brightness of the lamps in serial and parallel circuits that will be prepared by them and to identify the relationship of the brightness with the current that runs over the lamps.

At the end of the class session a lesson content in the form of photocopy materials were handed out to the students. Additionally, experiment reports made in the class sessions were collected in the following hour and checked in detail. At the end of four –week period the (ECST) was applied to both groups as a post - test. The results obtained from the measurement tools were examined statistically and they were analyzed. In the analysis of the data, t-test was used for both independent and dependent (connected) measures.

FINDINGS

Whether any important differences occurred or not between the scores of the experiment and control groups in the interest surveys of Likert Type test questions with 5 choices was analyzed. The results of the analysis are given in Table-2.

Table-2. The Results of t-Test for the Comparison of the Interest Surveys of Experiment and Control Groups.

Survey	Groups	N	\bar{X}	S.S.	S.D.	t	P
(PLIS)	Experiment Group (EG)	14	87,79	12,07	26	0,426	.673
	Control Group (CG)	14	89,43	7,89			
(CLIS)	Experiment Group (EG)	14	89,29	11,76	26	0,427	.673
	Control Group (CG)	14	87,71	7,18			

According to the data in table, there are not any significant differences between the interest survey means of experiment and control groups ($p > .05$) regarding the physics lab. According to the survey results, it was seen that there were not any significant differences between the experiment and control groups’ interests and abilities for computer and physics labs. Although there was not a significant difference between the mean scores, one of the groups was chosen as the experiment group because the scores taken from CLIS were higher than that of the other one.

Following the teaching methods conducted during four-week period, the pre-test and post-test scores and means of experiment and control groups taken from ECST are given in Table-3)

Table 3. The Results of The Pre-Post Test Scores of the Students Taken From ECST

EG Students	Pre-test Score	Post - test Score	CG Students	Pre-test Score	Post test Score
E1	12	16	C1	11	21
E2	11	23	C2	8	18
E3	8	18	C3	10	20
E4	9	28	C4	10	29
E5	9	10	C5	13	21
E6	9	21	C6	6	17
E7	12	29	C7	6	13
E8	13	19	C8	14	18
E9	12	22	C9	8	24
E10	12	26	C0	12	17
E11	8	25	C11	11	12
E12	11	24	C12	11	14
E13	8	15	C13	10	23
E14	9	10	C14	13	24
Mean	10,21	20,42	Mean	10,21	19,35

It was analyzed whether there was a significant difference or not between the pre and post test scores of the experiment and control groups and their results are shown in Table-4.

Table 4. The results of t-Test to compare the pre and post test scores of the groups.

Group	Test	N	\bar{X}	S.S.	S.D.	t	P
EG	Pretest	14	10,21	1,80	13	6.612	.000*
	Posttest	14	20,42	6,07			
CG	Pretest	14	10,21	2,48	13	6.877	.000*
	Posttest	14	19,35	4,74			

The mean of the pre test scores of the experiment groups is 10,21 (+/- 1,8) and the mean of the post test points is 20,42 (+/- 6,07). When the results of the pre test and post test of experimental group are compared with the other; it is seen that the mean score of the pre test is statistically and meaningfully higher than the mean score of the post test [t (26) = 6,877; p< 0,5].

The results of the t-test are given in Table - 5 to determine whether there is a significant difference between the mean scores of the pre test and post test of the experiment and the control groups.

To determine whether the mean score of pre and post tests applied to the experiment and control groups are meaningfully different or not, the results of t-test are given in Table -5 .

Tablo -5: ECST Test Results

Group	Test	N	\bar{X}	S.S.	S.D.	t	P
Pretest	EG	14	10,21	1,8	26	0	1.000
	CG	14	10,21	2,48			
Posttest	EG	14	20,42	6,07	26	0,520	.608
	CG	14	19,35	4,74			

According to the data in the table, as the mean scores of both groups are the same, there is not a significant difference between the mean scores of the pretest of the groups. [t (26) = 0 ; p> 0,5]

The mean score of the post test of the experiment group is 20,42 (+/- 6,07), but the mean score of the post test of the control group is 19,35 (+/- 4,74). According to this data, the difference between the mean of post test scores of the control group and the experiment group is not meaningful statistically. It also shows that the results of the post test of the two groups are not different from each other.

RESULTS

At the end of this study a significant difference was not determined between the effect of lab based learning on student success and the effect of computer (simulation) based learning. Thus, as a result of research for the student's academic success it can be said that computer (simulation) based physics learning is as effective as lab based physics learning.

Depending on the results of this research, the following offers can be made:

- In a research performed in our country, science teachers stated that due to inadequacy of the labs at schools, large classes etc., they could not make effective use of them (Uluçınar et.al, 2004). So, in cases where lab activities can not be performed for various reasons (inadequate materials, limited time, large classes and the difficulty to control the students), using simulation software of physics subject with necessary design and educational qualities in teaching environments will help students learn the topics in physics much better.
- The physics software simulations having the necessary qualities about electrical circuits offer an opportunity for the students to study at a virtual environment and increase the academic successes of the students as if they studied at a real lab environment.

DISCUSSION

Depending on the applications conducted during this study, the hardships met, evaluations made and the results obtained, the other determinations reached by the researchers are as follows:

- The lab possibilities in our schools aren't good enough to make experimental studies individually. So, the number of materials at physics labs in schools should be increased.
- Like this study about comparing the influence on the students' success between the computer based learning and lab based learning on the subject of electrical circuits, there is the need for doing researches like this one on the other topics of physics.
- In this study only the influence on the student's success of computer and lab based learning was examined. Besides, there is the need for doing researches to compare the students' attitudes and developments in scientific process abilities.
- Nowadays, the schools in our country have begun to use the computer based learning method and a specific level is reached on this subject. But still there are so many schools without computer labs. These schools should be determined immediately and computer labs should be installed in them.
- The number of comprehensive Turkish software in compliance with the teaching principles or even the number of software to be used in computer based physics teaching is so low. Software firms should pay attention to this important subject. The lesson software prepared abroad can be used in our country after being translated. Or Turkish Physics lesson software can be prepared in such a way that it does not give the knowledge directly but is appropriate for the teaching principles, and includes educational properties, which tend the students to do research and discover.
- For the success of computer based learning applications in Physics lessons, in the educational programs of teacher training faculties and in-service training courses arranged for teachers, some changes can be made so as to gain the ability to use the computer actively, to determine the required lesson software, to choose the optimum one according to the changing conditions among the alternative programs and use them and to have the ability to prepare computer based materials (presentation, animation and simulation) on a specific topic in parallel with the determined objectives, where necessary.

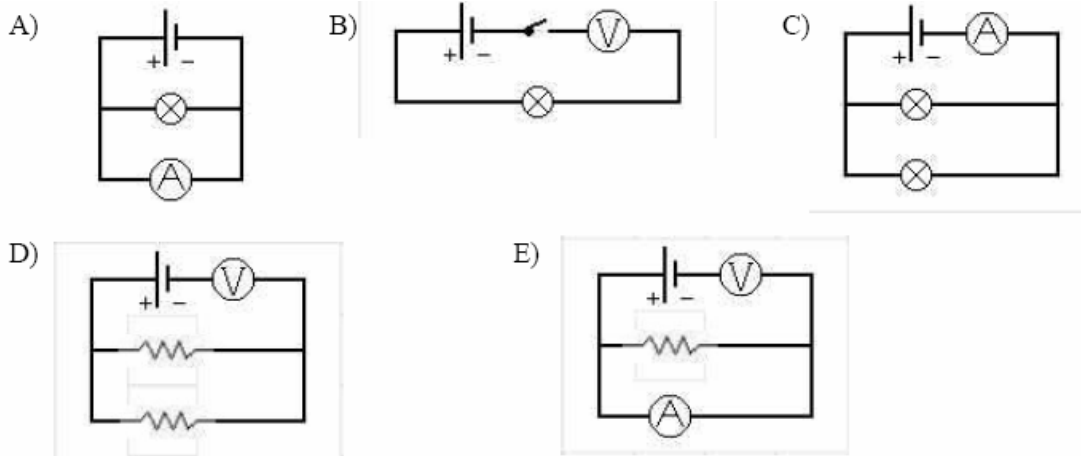
REFERENCES

- Algan, Ş. (1999). *The influence of the Computer Based Physics Teaching on the success of the student and Modern Mathematics and Science Programs applied in Turkey in the years between 1962 and 1985*. Ankara: Gazi University, Institute of Science (Unpublished Master Thesis).
- Bağcı, N. & Şimşek, S. (1999). The influence of different teaching methods in teaching physics subjects on student's success, *The Journal of Gazi Education Faculty*. 19 (3), 79-88.
- Bekar, S. (1996). *The influence of Lab Based Science Teaching on student's success*. Ankara. Gazi University, Institute of Science (Unpublished Master Thesis).
- Bennett, R. (1986). *The Effect of Computer Assisted Instruction and Reinforcement Schedules on Physics Achievement and Attitudes Toward Physics of High School Students*. Dissertation Abstracts International, 46(2), 3670A.
- Bryant, R. J. & Edmunt, A. M. (1987). They Like Lab-Centered Science. *The Science Teacher*, 54(8), 42-45.
- Choi, B. & Gennaro, E. (1987). The Effectiveness of Using Computer Simulated Experiments on Junior High Students' Understanding of The Volume Displacement Concept. *Journal of Research in Science Teaching*, 24, 539-552.
- Collette, A.T. & Collette, E.L. (1989). *Science introduction in the middle and secondary schools* (2nd end.). Ohio, USA: Merrill Publishing Company.
- Freedman, M. P. (1997). Relationship Among Laboratory Instruction, Attitude Toward Science, and Achievement in Science Knowledge. *Journal of Research in Science Teaching*, 34(4), 343-357.
- Gülççek Ç. & Güneş, B. (2004). Materializing the concepts during Science Instruction: Modeling Strategy, Computer Simulations and Analogies. *Science and Education*, 29(134), 36-48
- Ibiş, M. (1999). *The influence of Computer assisted Science Instruction on the success of the students*. Ankara: Gazi University, Institute of Educational Sciences (Unpublished Master Thesis)
- Jimoyiannis, A. & Komis, V. (2001). Computer Simulations in Physics Teaching and Learning: A Case Study on Students' Understanding of Trajectory Motion. *Computers & Education*, 36, 183-204.

- Karamustafaoğlu, O., Aydın, M. & Özmen, H. (2005). The influence of the Physics activities supported with computer to the learning of students : An example of Simple Harmonic Activity. *The Turkish Online Journal of Educational Technology* – TOJET October 2005 ISSN: 1303-6521 volume 4 Issue 4 Article 10
- Mccooy, L. P. (1991). The Effect of Geometry Tool Software on High School Geometry Achievement. *Journal of Computers in Mathematics and Science Teaching*, 10, 51-57.
- Meyveci, N. (1997). *The influence of Science instruction supported with computer to the success of the students and to the attitude of the students against computer*. Ankara. Ankara University Social Science Institute (Unpublished Master Thesis)
- Miller, D. G. (1986). The Integration of Computer Simulation into The Community College General Biology Laboratory. *Dissertation Abstract International*, 47(6), 2106-A.
- Redish, F. E., Jeffery S. M., and Steinberg R. N. (1997). *On the Effectiveness of Active Engagement Microcomputer based laboratories*. Department of Physics. University of Maryland College Park, MD20742
- Reed, B. B. (1986). The Effects of Computer Assisted Instruction on Achievement and Attitudes of Underachievers in High School Biology. *Dissertation Abstracts International* , 47(4), 1270-A.
- Riche, R. D. (2000). Strategies for Assisting Students Overcome Their Misconceptions in High School Physics. *Memorial University of Newfoundland Education* 6390.
- Özçinar, Z. (1995). *Evaluating the laboratory activities during Science Instructions at primary schools*. Ankara: Ankara University Social Science Institute (Unpublished Master Thesis)
- Soylu, H., & Ibiş, M. (1999). Science Education supported with Computer, 3rd Science Education Symposium. The Ministry of Education. ÖYGM.
- Svec, M., T., & Anderson, H., (1995). Effect of Microcomputer-Based Laboratory on Students Graphing Interpretation Skills and Conceptual Understanding of Motion. *Dissertation Abstracts International* , 55(8), 2338-A.
- Şen A. İ. (2001) “New Approaches in Science Instruction supported with Computer” *Journal of Gazi Education Faculty*, v:21, No. 3
- Şengel, E., Özden, M. Y.& Geban, Ö.. (2002). The Influence of the simulated experiments supported with computer on high school students comprehending the Replacement and Velocity concepts. *V. National Science and Mathematics Education Symposium* .Ankara: ODTÜ.
- Tamir, P.(1978) “An Analysis of Laboratory Activities in Two Modern Science Curricula; Profect Physics and PSSC.” Paper Presented at the National Association for Research in Science Teaching Annual Meeting in Toronto, Ontario.
- Uluçinar, Ş., Cansaran, A. & Karaca, A. (2004) “Evaluating the applications of Science Laboratory” *Türk Eğitim Bilimleri Dergisi* v:2, No. 4.
- Yavru, Ö. (1998). The influence of the laboratory experiments on the success of the 4th and 5th graders of the primary schools about the subject of Mechanics and on internalizing these concepts. Istanbul: Marmara Universty, Institute of Educational Sciences (Unpublished Master Thesis).
- Yiğit, N. & Akdeniz, A. R. (2000). Developing the Materials during Physics instructions supported with computer; students’ working papers. *IV. National Science Symposium, Hacettepe Education Faculty*. Ankara: 711-716.

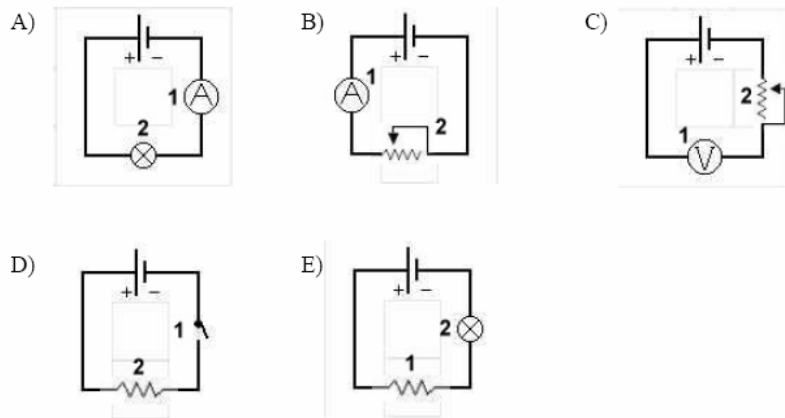
*** Some sample questions from ECST**

Q.3. Which of the followings are the circuit components connected as true?

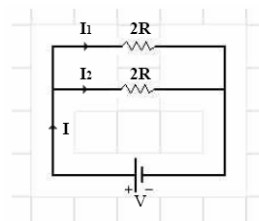


Q.4. Which of the followings that are written about electric current is wrong?

- A) All the conductors show a specific resistance to electric current.
- B) The current running on a conductor decreases as the resistance of the conductor increases.
- C) The current running on a conductor is direct proportional to the potential difference between the two points of the conductor.
- D) In an electrical circuit the current entering the resistance is greater than the one going out of it.
- E) In an Electrical circuit the direction of the electrical current is from positive pole to negative pole.
- F)



Q.8. 1. Circuit component: It measures the current which circulates in the circuit.
 2. Circuit component: It changes the current which circulates in the circuit..
 The duties of the two circuit components used in the electrical circuit are explained above. According to this, in which of the following circuits these circuit components are shown correctly?



Q26 : Relating to the electrical circuit on the right side, which of the followings are wrong?

- A) $I = I_1 + I_2$
- B) $R_{eq} = 4R$
- C) The potential difference between the two points is V .
- D) The current at the main arm is equal to V/R
- E) The current I_2 is equal to $V/2R$.

Q31 : The lamps in the circuits shown in the each figure are identical. According to this, what is the relationship between the brightness of the lamps?

- A) $1=2=3=4$ B) $1<2<3=4$ C) $1>2>3=4$ D) $2<1=3=4$ E) $1=3=4<2$

