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Computer-Assisted and Laboratory-Assisted Teaching Methods in Physics Teaching: The Effect on Student Physics Achievement and Attitude towards Physics

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Abstract

Does the computer-assisted teaching method as effective as the laboratory-assisted teaching method on student physics achievement and attitude towards physics? To seek for answering this question is the aim of the present study. The computer-assisted teaching method of the study includes the programs of Crocodile Physics and Edison 4.0 in the subject of "simple electric circuits" on 9^{th} grade level. By using the experimental pretest-post-test-experimental-control group design, "Physics Achievement Test" and "Physics Laboratory Attitude Scale" administered two times as pre-test and post-test were used as the data collection tools and they were administered to 50 9^{th} grade students. The data were then analyzed by using SPSS 16.0 statistical analysis program and statistics such as mean, Standard Deviation were calculated and independent t-test statistical techniques were used. According to the data analysis, there is a significant difference on students' physics achievements in favor of the computer-assisted teaching method and also both for two different teaching methods there is a significant difference on students' attitudes towards physics. Thus, it can be said that to develop students' physics achievements and attitudes towards physics using the computer-assisted teaching method can be more effective than the laboratory-assisted teaching method.

Key Words: Computer-Assisted Teaching; Laboratory-Assisted Teaching; Physics Achievement; Attitude

Introduction

It can be realized with the help of lots of researches in physics education that activities in laboratories increase students learning, positive attitudes towards physics and permanence of knowledge. The one of the main goals of using the laboratories in physics education is to teach students the philosophy, branches, topics, theories, laws of physics; the other one is to gain steps of the scientific method namely science process skills while learning the philosophy, branches, topics, theories, laws of physics. Tamir (1977) listed the aims of widely using laboratories in science education as follow: laboratories provide a) to get students to comprehend abstract and complex scientific concepts by using concrete materials; b) to gain

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students problem solving and analyzing skills by comprehending the nature of science; c) to develop practical experiences and special talents of students; d) to enjoy students with laboratory activities and by this way to develop positive attitude towards scientifically working.

To examination of the related literature, laboratory education have not achieved its main goals, not provided meaningful learning, and not developed positive attitudes towards the science in recent years. As a result, today, more essential resources and time have been allocated in order to enhance the effectiveness of laboratories in science teaching both in primary and secondary education. In the study of Roth (1994) it was emphasized that the laboratory activities in science teaching were put into effect in the 1960s. However, students could not reach the desired levels by using these activities. Yager, Engen and Snider (1969) concluded that laboratory experiences are not meaningful adequately for students and therefore they do not make a significant contribution to their conceptual understanding. Renner (1986) emphasized that the importance of laboratory applications for science learning is agreed with everyone; however the actual role of the laboratories is not like this. According to Hofstein (1988), students were still performing experiments in the laboratory in a "cook-book" approach which focused on development of low level science skills. Few opportunities are provided for the students to discuss both experiment and its results, make and test hypothesizes or to design an experiment and finally perform an experiment actually. Besides these, some physics experiments in secondary level cannot perform due to the time consuming, being harmful and expensive, deficiency of lab equipments, not representing the related concept or event precisely, teachers' anxiety about the completion of the curriculum (Kurt, 2002). However, to overcome these obstacles, it is possible by using computer programs to form simulations and animations of experiments. Therefore, students perform these experiments on computers with the help of imaginary experiments environments formed by simulations and animations.

One of the main purposes of the physics education is to raise scientifically literate individuals so there is a strong relationship between science and technology. To gain individuals with higher order cognitive process skills and to increase creativity of them physics education should be technologically based. In this process, teachers have an important role to transfer technological innovations to aim at productivity in physics education to the instructional implementations. For this reason, technology is the effective tool while a teacher developing the scientific literacy. Qualified physics teacher should have the ability of understanding physics, considering the importance of physics in the future, comprehending the relation of science, society with technology, and also understanding negative and positive effects of them on each other. Yet, according to researches, lots of teachers either do not aware of technological devices or do not use effectively these technological devices especially computers although they can easily access the technology and technological devices (Francis-Pelton & Pelton, 1996). The majority of teachers believe the advantage of using computers and other technological devices in physics education. But, they are not volunteer using of them since some teachers have not experience about using technology, positive attitude towards technological devices and self-confident (Rohmer & Simonson, 1981; Okebukola, 1993; McInerney & Sinclair, 1994; Francis-Pelton & Pelton, 1996; Gökdaş, 2003).

In recent years, it is shown that computer technology developed rapidly and its reflection of computer-assisted education are more effective on students' achievement than traditional methods. Especially, to support physics laboratory and to teach physical topics more easily computer programs such as interactive physics, Phet interactive simulation, Crocodile Physic, Edison 4.0 and Virtual Labs are prepared. Using these programs in physics education is more useful on students' achievement than traditional teaching methods (Bennet, 1986; Güneş, 1991; Geban, Askar & Özkan, 1992; Meyveci, 1997; Şengel, Özden & Geban, 2002; Yiğit & Akdeniz, 2003; Görpeli, 2003; Bozkurt & Sarıkoç, 2008). But, Miller (1986) did not found a significant relationship between students' biology achievement and computer-assisted education or traditional teaching methods.

On the other hand, physics laboratory lessons are the most favorite and preferable for students and in daily life, students benefit from the laboratory applications. Besides, students who teach with laboratory-assisted education are more successful than students who teach with traditional methods and also the learning with laboratory practices parallel with its theoretical knowledge in physics course increases the success. The laboratory applications also increase the permanence of students' knowledge. Some researches (Geban, Askar & Özkan, 1992; Svec & Anderson, 1995; Redish, Saul & Steinberg, 1997) revealed that computer simulation experiments are more effective than traditional experiments: but some researches (Miller, 1986; Choi & Gennaro, 1987; Jimoyiannis & Komis, 2000; Bayrak, Kanlı & Kandil İngeç, 2007) did not found any difference between their effectiveness.

Research Questions

This present study sought to provide answers to the following questions:

1. Is there a significant difference between physics achievement of experimental group, which were administered the Computer-Assisted Teaching Method (CATM), and of control group, which were administered the Laboratory-Assisted Teaching Method (LATM), according to pre-test and post-test scores of the students?

2. Is there a significant difference between attitudes towards physics laboratory of experimental group, which were administered the CATM and of control group, which were administered the LATM, according to pre-test and post-test scores of the students?

Method

Experimental designs enable the production of the data to be observed under the control of the researcher in order to investigate cause and effect relations (Fraenkel & Wallen, 2003). After detailed literature review to compare the effects of two different teaching methods which were designed according to computer-assisted and laboratory-assisted on students' physics achievements and students' attitudes towards physics, the quasi experimental pre-test-post-test-experimental control group design was decided to use. As a pre-test "Physics Achievement Test" and "Physics Laboratory Attitude Scale" were administered 50 9^{th} grade level students. During the research, experiments designed according to the CATM were performed in experimental group whereas experiments designed according to the LATM were performed in control group. After then, students were administered same data collection tools as post-tests.

Sample and Instruments

The sample of the study was composed of 50 students who receive education in 9-A and 9-B classes in a randomly selected high school in central district of Zonguldak during the 2009-10 academic years. The sample includes 23 females and 27 males. Moreover, having the same attitudes and physics achievement was taken into consideration while forming the control and experimental groups.

Physics Achievement Test

The Physics Achievement Test (PAT) composed of multiple choice 20 questions about the unit of "Electric Current" was developed by the researcher in order to investigate whether there is a significant difference between the experimental and the control group in terms of physics achievement in advance of the experimental process. Firstly, to determine the objectives of the students about the unit of "Electric Current", a table of specification was prepared. Afterwards, a test composed of 30 multiple choice questions was prepared and as a pilot study administered to 50 students of the 9th grade in a high school to test the learning outcomes related with the topic. Students were given 40 minutes for answering the questions in the test. Test statistics were made for each question and according to this item analysis ten questions whose discrimination index was below 0.20 were excluded. Therefore, reliability coefficient (KR-20) of the PAT which included 20 questions was calculated as 0.70.

Physics Laboratory Attitude Scale

Following the literature review, the "Physics Laboratory Attitude Scale" (PLAS) developed in order to measure the attitudes of pre-service teachers towards the physics laboratory by Nuhoğlu and Yalçın (2004) was benefited from. They examined similar attitude scales in the literature and then formed the PLAS. The pilot study of the PLAS was conducted on 310 pre-service teachers of Kırşehir education faculty of Gazi University. It was composed of 19 positive and 17 negative items and has the reliability coefficient of α=0.89. The scale encompassed 36 items with five-point Likert type. The answers to items were as follows: "strongly agree", "agree", "undecided", "disagree" and "strongly disagree".

Data Collection and Analysis

The data obtained by administrating the PAT and PLAS to 50 students of the 9th grade was analyzed by using SPSS 16.0 program. For analysis of data, firstly the data obtained from the PLAS scored by 5, 4, 3, 2, 1 respectively for the choice of "strongly agree", "agree", "undecided", "disagree" and "strongly disagree" for all items. The minimum score of this five-point Likert scale is 36 and the maximum score is 180. Then, to compare the effects of two different teaching methods which were designed according to computer-assisted and laboratory-assisted on student physics achievement and student attitudes towards physics, arithmetic mean ($\overline{X}$), standard deviation (SD) and independent t-test statistical techniques were used with SPSS 16.0 program.

Findings

This section presents the findings derived from the statistical analysis of data acquired from the administration of the PAT and the PLAS on experimental and control groups according to two research questions. For the first research question, statistical results about the comparison of pre-test and post-test scores of the experimental and the control group students in the PAT are given in Table 1.

Table 1. Statistical results of the comparison of pre-test and post-test scores of the experimental group and the control group in the PAT

PAT	Group	N	$\overline{X}$	SD	df	t	p*
Pre-test	Experimental	25	16.40	5.50	48	1.31	0.19
	Control	25	14.40	5.27			
Post-test	Experimental	25	68.00	9.47	48	6.12	0.00
	Control	25	53.00	7.77			

Note: *statistically significance defined as $p< 0.05$

As given in Table 1, the pre-test mean of the PAT was $\overline{X}$ = 16.40 in the experimental group, the post-test mean was $\overline{X}$= 68.00. There was a difference equal to $\overline{X}_{post}$ - $\overline{X}_{pre}$ = 51.60 between the pre-test and post-test scores of the experimental group in favor of post-test. While the mean of pre-test scores in the control group was $\overline{X}$= 14.40, the mean of post-test scores was $\overline{X}$ = 53.00. There was a difference with the score of $\overline{X}_{post}$ - $\overline{X}_{pre}$ = 38.60 between the arithmetic mean of these two tests in favor of post-test. Independent t-test was used to investigate whether the difference in physics achievement according to the pre-test and post-test scores of the experimental group and the control group was significant and according to the independent t-test results, there is a significant difference between groups' post-test scores of the PAT ($t=6.12$, $p<0.05$) in favor of experimental group.

For the second research question, statistical results about the comparison of pre-test and post-test scores acquired from the PLAS by the students in the experimental and control groups are presented in Table 2.

Tablo 2. Statistical results of the comparison of pre-test and post-test scores of the experimental group and the control group in the PLAS

PLAS	Group	N	$\overline{X}$	SD	df	t	p*
Pre-test	Experimental	25	80.56	19.69	48	1.63	0.11
	Control	25	73.72	7.39			
Post-test	Experimental	25	114.48	19.03	48	2.31	0.03
	Control	25	104.92	8.13			

Note: *statistically significance defined as p< 0.05

According to Table 2, the pre-test mean of the PLAS was $\overline{X}$ = 80.56 in the experimental group, the post-test mean was $\overline{X}$= 114.48. There was a difference equal to $\overline{X}_{post}$ - $\overline{X}_{pre}$ = 33.92 between the pre-test and post-test scores of the experimental group in favor of post-test. While the mean of pre-test scores in the control group was $\overline{X}$= 73.72, the mean of post-test scores was $\overline{X}$ = 104.92. There was a difference with the score of $\overline{X}_{post}$ - $\overline{X}_{pre}$ = 31.20 between the arithmetic mean of these two tests in favor of post-test. Independent t-test was used to investigate whether the difference in attitude towards physics according to the pre-test and post-test scores of the experimental group and the control group was significant and according to the independent t-test results, there is a significant difference between groups' post-test scores of the PLAS ($t=2.31$; $p<0.05$) in favor of experimental group.

Consequently, post-tests results of the PAT and PLAS indicated that using the CATM can be more effective than the LATM for developing student physics achievement and attitude towards physics are shown in Table 3.

Tablo 3. Statistical results of the comparison of post-test scores of the experimental group and the control group in the PAT and the PLAS.

	Group	N	$\overline{X}$	SD	df	t	p*
PAT as Post-test	Experimental	25	68.00	9.47	48	6.12	0.00
	Control	25	53.00	7.78			
PLAS as Post-test	Experimental	25	114.48	19.03	48	2.31	0.03
	Control	25	104.92	8.13			

Note: *statistically significance defined as p< 0.05

Results and Discussion

The present study aims is to compare the effects of two different teaching methods which were designed according to computer-assisted and laboratory-assisted on student physics achievement and student attitudes towards physics. In the related literature, lots of studies were conducted to examine the effectiveness of computer simulation experiments and traditional experiments. Some researchers did not found any difference between their effectiveness (Miller, 1986; Choi Gennaro, 1987; Jimoyiannis & Komis, 2000; Şengel et al., 2002; Bayrak, Kanlı & Kandil, İngeç, 2007). On the other hand, according to the some researches, using computer technology in teaching implementations enhances the students' achievements in science education (Bennet, 1986; Güneş, 1991; Geban, Askar & Özkan, 1992; Svec & Anderson, 1995; Redish, Saul & Steinberg, 1997; Meyveci, 2005). Similarly, at the end of this study the significant difference is found between student achievements in physics in favor of the CATM.

Besides, according to this research finding, there is a significant difference between student attitudes towards both the CATM and the LATM. In the same way, Tamir (1977) emphasized the importance of laboratory activities to develop positive attitude towards scientifically working. Consequently, to develop students' physics achievements and attitudes towards physics using the CATM can be more effective than the LATM. This result can be inferred from this research finding.

Suggestions

According to research results, it should be suggested using computer-assisted methods like interactive physics, Phet interactive simulation, Crocodile Physic, Edison 4.0 and Virtual Labs in physics laboratory to form simulations and animations of real-life situations, experiments and by this way to gain abstract concepts to the students and so to increase students' achievements. Moreover, using these programs is suggested by also other researchers (Şengel, Özden & Geban, 2002; Yiğit & Akdeniz, 2003; Görpeli, 2003; Bozkurt & Sarıkoç, 2008).

In physics laboratory, imaginary experiments environments should be formed by using computers to prevent harmful effects of experiments and to represent the related concept or event. Also, due to the time consuming and being expensive, deficiency of lab equipment, teachers' anxiety about the completion of the curriculum as stated in the study of Kurt (2002), these computer-assisted methods above should be used.

To raise scientifically literate students, there should be strong relationship between science and technology. Teachers are the implementers of technology based curriculum. The problem here is that not awareness of teachers about technological devices, not using effectively these technological devices especially computers, not being volunteer using of them, not having experience about using technology, positive attitude towards technological devices and self-confident (Rohmer & Simonson, 1981; Okebukola, 1993; McInerney & Sinclair, 1994; Francis-Pelton & Pelton, 1996; Gökdaş, 2003). Therefore, ıt is suggested that teacher training about technology should be take into consideration by teacher training programs and these programs developers also.

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