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Chemistry laboratory applications supported with simulation

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Abstract

The aim of this research is to determine the effect of chemistry laboratory applications supported with simulations on the chemistry achievements, chemical laboratory anxiety and attitudes towards the use of technology of pre-service teachers. The sampling of the research consisted of 31 teacher candidates enrolled at Hacettepe University Faculty of Education. In the research, chemistry achievement test, chemistry laboratory anxiety scale and attitude scale regarding the use of technology in education were used as data collection tools. As a result of the research, it was found that the laboratory practices supported with simulations were more effective than the traditional verification laboratory approach in improving the pre-service teachers in chemistry achievement and attitudes towards education technology as well as decreasing the level of their anxieties about the chemistry laboratory.

Keywords: chemsitry laboratory, simualtions, pre-serivce teachers;

1. Introduction

As technology becomes more involved in our daily lives and more widespread, it is inevitable that education has become associated with technology. Individuals who are not good technology users are nearly impossible to adapt to their environment (Alkan, 1995). Quality of use of technology influences both the quality of life (Li and Perkins, 2007) and education (Ferdig, 2006). Although use of technology is not a solution that can overcome all problems related to education, today technology has become necessary for education environment (Kirschner and Selinger, 2003); because technology carries daily life into education environment, provides instruments for developing

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learning and gives more opportunity to teachers and students for feedback, thinking and correcting (Bransford, Brown and Cocking, 2000). As technology makes interaction between teacher, student, manager and family, it provides appropriate environment for teacher to develop as well (Çobanoğlu, 2010). Technology is constantly changing and developing. Lectures become more important and interesting thanks to modern technology.

Increasing amount of knowledge, enhancement of communication facilities, wide spreading of technology have changed the expectations from education. Educational institutions are expected to cultivate individuals, who can use technology effectively. The education system expects the same function from teachers. This expectation includes not only the teaching of how to use the technology but also integration of technology into teaching activities. More continuous, effective and productive learning can be ensured via using technology especially in the environments, in which scientific practices are carried out, especially laboratories. Laboratory application is an important factor that affects teacher training. The basic aim of laboratory is to observe and results performing practical trial of theories. Teacher candidates studying at Department of Secondary Science Education have to apply the experiments related to their field before they begin their profession and be informed of methods used in laboratories (MEB, 2005).

Chemistry laboratory applications are expected to have a structure directing to use information and think critically, to have technical equipment to develop cognitive process capability and hand skills. Therefore, the effects of use of technology in laboratory on pre-service teachers describing a new problem, explaining an observation and deciding on an issue should be researched; since teacher candidates do not always have the opportunity to learn, observe basic information and reach to a meaningful result with laboratory applications. Within this frame, experiments supported with simulations and laboratory applications are considered to complete these lacks using technology.

The objective of this study is to determine the contributions of experimental simulations to wholesomely conduct of laboratory activities and ensuring appropriate learning in laboratories. By this way, it is aimed to increase the success of pre-service teachers in chemistry laboratories, decreasing the concerns regarding laboratories, and determining the benefits of the use of technology for educational purposes.

2. Method

In the study, the pre and posttest research design was used with control and treatment groups. Members of the control and treatment groups were determined according to unbiased sampling method. While the teaching of the treatment group was carried out within the chemistry laboratory supported with simulations, the teaching of the control group was carried out with the traditional verification laboratory approach.

2.1. Sampling

The sampling of the research consisted of 31 pre-service teachers enrolled at Hacettepe University, Faculty of Education. In the research, chemistry achievement test, chemistry laboratory anxiety scale and attitude scale regarding the use of technology in education were used as data collection tools.

2.2. Data collection tools

2.2.1. Chemistry achievement test: Performances of pre-service teachers were determined via the chemistry achievement test, which was developed by the researchers. The chemistry achievement test consisted of 15 multiple-choice questions regarding volumetric analysis. The validity and reliability studies of the chemistry achievement test were carried out with the participation of 231 pre-service teachers. The item analysis was carried out with ITEMAN Windows Version 3.50 statistics program. The average difficulty, average distinctiveness value and reliability coefficient of the chemistry achievement test were determined to be 0.49, 0.62 and 0.75 respectively.

2.2.2. Chemistry laboratory anxiety scale: The anxiety of teacher candidates towards chemistry laboratory were determined by the “Chemistry Laboratory Anxiety Scale” developed by Bowen (1999) and the Turkish adaptation studies made by Azizoğlu and Uzuntiryaki (2006). The anxiety scale consisted of 20 statements in a 5-point Likert Type. The scale had four sub dimensions. The Cronbach Alpha reliability coefficicent of the use of laboratory instruments and chemicals sub dimension was 0.88, work with other students sub dimension was 0.87, data collection sub dimension was 0.86 and using laboratory time sub dimension was 0.87.

2.2.3. Attitude scale regarding the use of technology in education: The attitudes of the pre-service teachers towards education technologies were determined by the “Attitude Scale Regarding the Use of Technology in Education” developed by Öztürk (2006). The attitude scale consisted of 39 statements in a 5-point Likert Type. The

scale had three sub dimensions. These dimensions were reflection of technology use in education on teaching processes, self-improvement regarding the use of technology in education, classroom management and technology use in education. Cronbach Alpha reliability coefficient of the scale was 0.90.

2.3. Data analyses

In the research, preliminary test and final test points were examined for the data obtained from the treatment and control groups. During the analysis of the data obtained from the research, nonparametric tests were used since the number of participants was below the value recommended in the literature and normality assumption was not fulfilled (Green & Salkind, 2008). While examining the data obtained from the chemistry achievement test, chemistry laboratory anxiety scale and attitude scale regarding the use of technology in education, Mann-Whitney U-Test was used to find out potential differences between the treatment and control groups prior to the application. The difference between the pre and posttest scores after the traditional verification laboratory approach, which was supported with simulations, was examined with Wilcoxon signed-rank test.

3. Results

The descriptive statistics regarding the pre and posttest averages of the scales applied within the scope of the chemistry laboratory research, which was supported with simulations, were summarized in Table 1.

Table 1. Descriptive statistics of Pre- and Posttest scores.

			Pretest		Postest	
Scale	Group	N	M	SD	M	SD
Chemistry achievement	Treatment	16	6.25	2.32	11.75	2.17
	Control	15	5.60	2.29	7.73	1.67
Chemistry laboratory anxiety	Treatment	16	2.27	0.52	1.89	0.53
	Control	15	2.36	0.59	2.24	0.45
Attitudes regarding the use of technology in education	Treatment	16	3.78	0.40	3.98	0.39
	Control	15	3.79	0.53	3.86	0.47

Findings regarding the chemistry achievement;

In the research, the averages of the pre-application chemistry achievement test for the pre-service teachers in control group to whom traditional verification laboratory approach was applied and the treatment group, who were educated with simulation-assisted teaching, were analysed with Mann Whitney U-Test. According to the result of the analysis, no significant difference was identified between the pretest average scores of the control and treatment groups in the chemistry achievement test ($U=102.500$; $p>0.05$). This result indicated that, prior to application there were no significant differences between the knowledge levels of the pre-service teachers in treatment and control groups about the given topic.

As a result of the traditional verification laboratory approach applications, which were supported with simulations, the difference between the pre and posttest scores of the pre-service teachers in terms of their chemistry achievements was examined with Wilcoxon signed-rank test. The obtained findings were summarized in Table 2.

Table 2. Wilcoxon signed-rank test results of chemistry achievement.

Chemistry achievement	N	M	SD	Z	p
Treatment group pretest	16	6.25	2.32	-3.333	.001
Treatment group posttest	16	11.75	2.17		
Control group pretest	15	5.60	2.29	-2.255	.024
Control group posttest	15	7.73	1.67		

When the Table was examined, it was seen that the chemistry achievements of the pre-service teachers in the control and treatment groups increased after the applications and this increase was statistically significant (Z:-3.333; -2.255; $p<0.05$). This result showed that the traditional verification laboratory approach, which was supported with simulations, was effective in increasing the chemistry achievement levels of the pre-service teachers.

The posttest averages of the pre-service teachers were analysed through the Mann Whitney U-test. According to the result of the analysis, there was no significant difference between the posttest scores of the pre-service teachers in the control and treatment group obtained from the chemistry achievement test (U=19.000; $p>0.05$). According to this result, the average of the posttest on chemistry achievement obtained by the traditional verification laboratory approach applications supported with simulations, which was applied to the pre-service teachers in the treatment group, was higher than the scores obtained by the traditional verification laboratory approach, and this created a significant statistical difference in favour of the treatment group.

Findings regarding the chemistry laboratory anxiety;

In the research, no significant difference was identified between the pretest scores obtained by the pre-service teachers in the control and treatment groups for the chemistry laboratory anxiety (U=95.500; $p>0.05$).

The findings regarding the chemistry laboratory anxiety pre and posttest average scores of the pre-service teachers in the control and treatment groups were indicated in Table 3.

Table 3. Wilcoxon signed-rank test results of chemistry laboratory anxiety.

Chemistry laboratory anxiety	N	M	SD	Z	p
Treatment group pretest	16	2.27	0.52	-1.990	.047
Treatment group posttest	16	1.89	0.53		
Control group pretest	15	2.36	0.59	-1.083	.279
Control group posttest	15	2.24	0.45		

It was seen that the chemistry laboratory anxiety averages of the pre-service teachers in the control and treatment groups decreased after the application. A significant difference was identified between pre and posttest average scores obtained by the pre-service teachers in the treatment group from the chemistry laboratory anxiety test (Z:-1.990; $p<0.05$). It was determined that the observed increase in the scores of the control group was not statistically significant (Z:-1.083; $p>0.05$). This result indicated that the laboratory approach supported with simulations, which was applied to the treatment group, was effective in decreasing the chemistry laboratory anxiety levels of the pre-service teachers, while the traditional verification laboratory approach applied to the control group was not effective. There was no significant difference between the chemistry lab anxiety posttest averages of the pre-service teachers in the control and treatment groups (U=87.50; $p>0.05$).

The results of the analysis carried out for the comparison of the pre and posttest scores with respect to the sub dimensions of the chemistry laboratory anxiety of the treatment and control group after the application and posttest averages of the experiment-control group were summarized in Table 4.

Table 4. Wilcoxon signed-rank test and mann whitney u –test results of chemistry laboratory anxiety sub dimensions.

Chemistry laboratory anxiety	Gorup	Pretest		Posttest		Wilcoxon signed-rank test		Mann whitney u – test	
		M	SD	M	SD	Z	p	U	p
Use of laboratory instruments and chemicals	Treatment	2.07	0.77	1.85	0.63	-0.881	.378	212.500	.081
	Control	2.32	0.67	2.33	0.59	-0.085	.932		
Work with other students	Treatment	2.14	0.68	1.89	0.65	-1.476	.140	112.500	.764
	Control	2.20	0.54	2.00	0.63	-1.209	.227		
Data collection	Treatment	2.42	0.69	1.97	0.57	-1.892	.058	79.000	.102
	Control	2.37	0.75	2.30	0.42	-0.526	.599		
Using laboratory time	Treatment	2.47	0.75	1.85	0.52	-2.559	*.011*	69.500	*.040*
	Control	2.55	1.02	2.25	0.62	-1.206	.228		

According to the Table, the decrease observed in the sub dimensions of the chemistry laboratory anxiety scale with respect to the pre and posttest averages of the pre-service teachers in the control and treatment groups were

quite outstanding. However, this decrease observed in the scores revealed a statistically significant difference in using laboratory time dimension. When the posttest averages were examined in order to explain the effects of the teaching methods applied to the control and treatment groups on the sub dimensions of the chemistry laboratory anxiety scale, a significant difference was detected between the control groups regarding the use of laboratory time.

Findings regarding the approach for education technologies;

Findings related to the attitudes of pre-service teachers in control and treatment groups towards education technologies were given in Table 5.

Table 5. Wilcoxon signed-rank test results of attitude regarding the use of technology in education.

Attitude regarding the use of technology in education	N	M	SD	Z	p
Treatment group pretest	16	3.78	0.40	-2.743	.006
Treatment group posttest	16	3.98	0.39		
Control group pretest	15	3.79	0.53	-1.024	.306
Control group posttest	15	3.86	0.47		

It was observed that the averages of the pre-service teachers in the control and treatment groups regarding education technologies increased after the application. A significant difference was identified between the average pre and posttest scores of the pre-service teachers in the treatment group regarding education technologies (Z:-2.743; $p<0.05$). It was determined that the observed increase in the attitude scores of the control group regarding education technologies was not statistically significant (Z:-1.024; $p>0.05$). This result indicated that the laboratory approach supported with simulations, which was applied to the treatment group, was significantly effective in improving attitudes of the pre-service teachers towards education technologies, while the traditional verification laboratory approach applied to the control group was not effective. There was no significant difference between the posttest average scores of the pre-service teachers in the treatment group and control group regarding education technologies ($U=95.000$; $p>0.05$).

The results of the analysis carried out for the comparison of the pre and posttest scores in the sub dimensions of attitudes towards education technologies obtained by the pre-service teachers in the control and treatment after the application and the posttest scores of the treatment and control groups were summarized in Table 6.

Table 6. Wilcoxon signed-rank test and mann whitney u –test results of attitude regarding the use of technology in education sub dimensions.

Attitude regarding the use of technology in education	Gorup	Pretest		Posttest		Wilcoxon signed-rank test		Mann whitney u – test	
		M	SD	M	SD	Z	p	U	p
Reflection of the using technology in education in the teaching process	Treatment	3.82	0.39	3.97	0.44	-1.565	.118	112.000	.750
	Control	3.79	0.47	3.89	0.44	-1.051	.293		
Self-improvement in the using technology in education	Treatment	3.69	0.52	4.00	0.50	-2.332	*.020*	96.500	.352
	Control	3.79	0.87	3.80	0.74	-0.377	.706		
The using technology in education and classroom management	Treatment	3.85	0.55	3.96	0.54	-0.959	.338	110.000	.692
	Control	3.80	0.63	3.89	0.78	-0.817	.414		

According to Table 6, the improvement in attitudes towards education technologies with respect to the sub dimensions observed in pre and posttest scores of the pre-service teachers in the control and treatment groups were quite outstanding. When the pre and posttest scores were examined, no statistically significant difference was found in the treatment group regarding self-improvement in using technology in education. However; there was a statistically significant difference in the treatment and control groups when the posttest scores were examined.

4. Conclusion and discussion

As a result of the research, it was found that the laboratory practices supported with simulations were more effective than the traditional verification laboratory approach in improving the pre-service teachers in chemistry achievement and attitudes towards education technology as well as decreasing the level of their anxieties about the chemistry laboratory.

Reaching a modern education level would only be possible through integrating the developments in information and communication technologies into education programs. Computer technology has enabled the graphical and symbolical creation of the information in the memory of individuals. Computer technology has made learning more meaningful and ensured recalling of the learnt knowledge through ensuring the correlation of graphics and symbols among themselves while creating knowledge. It is believed that due to these functions, technological applications enable the increase of success levels and improve the attitudes of pre-service teachers while decreasing the levels of their anxieties. The literature contains varied studies, which obtained findings that are supportive of the research result. (She and Fischer, 2003; Yenice, 2003; Arıkan, 2007; Çağlar, 2007; Hançer and Yalçın, 2007; Sambur and Can, 2007; Bayram, 2012; Bilen-Kaya, 2012;).

Educational technology increases the quality of the learning and teaching process and makes this process more productive and effective for both teachers and students (Uşun, 2000). It is important to present teaching materials according to the learning speed and capacity of each student (Demirel, 2004). The activities supported with technology provide learners with the opportunity to prepare for the activities in their own learning speed. Therefore, technology-assisted teaching may increase the exam scores of students, and affect the general satisfaction and confidence levels towards subjects positively (Day and Foley, 2006). The researchers observed that technology-assisted activities increased students' interest in courses, decreased the time to achieve the teaching objective, and made students more effective in class. It was also observed that the experimental practices on virtual platform helped students understand the points they should pay attention during the practices in laboratories (Kıyıcı and Yumuşak, 2005). The effectiveness of the laboratory approach supported with simulations could be predicted through its increasing effect in the quality of the learning-teaching process, making the process more productive and effective, creating an environment for teachers, where students could prepare and learn the chemical experiments in their own learning speeds.

Chemistry is one of the science subjects interested in abstract incidents. Therefore, visual representations are of great importance for the description of abstract incidents in learning and teaching chemistry (Crawford & Cullin, 2004). Kozma and Russell (1997) reported that chemistry, as a field of study, was based on representations or symbols due to its nature and therefore, symbols and other forms should be used in order to create a clear meaning. Some researchers have indicated that three-dimensional visual representations enabled the understanding of chemical structures and related features (Urhahne, Nick & Schanze, 2009). The contribution of using technology in chemistry classes to teaching is a proven fact in terms of enabling the conceptualization of abstract statements with the help of visualization (Waight, Liu, Gregorius, Smith & Park, 2014). The abstract information of the pre-service teachers regarding volumetric analysis became concrete presentations with the simulation visuals used in laboratory practices. These concrete presentations decreased the cognitive burdens of the pre-service teachers and they became more successful accordingly.

This research emphasizes that individual differences should be taken into account while education activities are carried out. The properties of technology-assisted chemistry laboratory practices such as facilitating understanding and remembering, providing reinforcement, making lessons interesting and enjoyable, improving experimental skills, enabling the identifying of the tools and chemical substances to be used during experiments, have also contributed to the research results. This study is of great importance for ensuring the pre-service teachers, who will be the teachers of the future, to keep up with the age, which is rapidly developing and changing, and to guide their students in becoming well-equipped individuals. Therefore, it is very important to increase the number of studies in this field as well as contributing to the literature with new resources.

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