The Effect of Chemistry Laboratory Activities on Students' Chemistry Perception and Laboratory Anxiety Levels

Cemil Aydoğdu [i]
University of Hacettepe

Abstract
Chemistry lesson should be supported with experiments to understand the lecture effectively. For safety laboratory environment and to prevent laboratory accidents; chemical substances' properties, working principles for chemical substances' usage should be learnt. Aim of the present study was to analyze the effect of experiments which depend on laboratory usage techniques on science teacher canditates' laboratory anxiety and chemistry perception. The study was conducted with 41 science teacher candidates who registered General Chemistry-II course in Bartın. In the study a pre-test and post-test procedure was applied. To collect data Chemistry Laboratory Anxiety Instrument and Chemistry Perception Qestionnaire were used. Chemistry Laboratory Anxiety Instrument was developed by Bowen (1999) and adapted into Turkish by Azizoglu and Tiryaki (2006). Moreover, Chemistry Perception Questionnaire, was developed by Wells (2003) and adapted by Tosun (2013). At the beginning of the semester, the scales were administrated to science teacher canditates as pre-test. During the semester, experiments which depend laboratory usage techniques have been conducted. At the end of the semester, the scales were administrated to science teacher canditates as post-test. Findings of the study revealed that, science teacher canditates' anxiety level decreased on the other hand there was no statistically significant difference for teacher canditates' about chemistry perception.

Keywords: Chemistry perception questionnaire, laboratory anxiety scale, experiments, science teacher candidates

[i] **Cemil Aydoğdu,** Hacettepe University, Turkey.
Correspondence: caydogdu@hacettepe.edu.tr

Introduction

Laboratory is part of science education and plays a significant role in science education (Hofstein & Lunetta, 1982; Hofstein & Mamlok-Naaman, 2007). Laboratory education includes definition of the nature of science and the features of scientific theory, the use of scientific notation, the development and use of models, the development of experiment systems to test hypothesis, understanding the differences between observation and inference, and presentation of data (Lawson, 1995). Studies suggest that laboratory work is influential in improving these skills, academical achievement, attitudes towards laboratory skills and in reducing laboratory anxiety (Alkan & Erdem, 2013; Can, 2013; Aydogdu, 2012; Erokten, 2010; Freedman, 1997).

Teachers report that laboratory work is necessary in science education. However, there are certain problems inhibiting the full use of labs in science education, including inefficient physical setting, the lack of materials, teachers' insufficient information about lab materials and laboratory usage techniques Laboratory usage techniques are related to knowing the properties of glass and chemicals used in laboratory, laboratory safety rules, steps to be taken to avoid accidents in laboratory and what to do if any accident occurs during the laboratory work (Boyuk et. al., 2010; Aydogdu, 1999).

Yilmaz (2004) examined the chemicals used in the experiments covered in high school third grade science textbooks in terms of the hazard characteristics and it was found that textbooks contained no information about safety. In addition, it was concluded that although students reported the hazardous nature of the acids and bases commonly used in the experiments, but they could not give the related examples. Aydogdu and Yardimci (2013) suggested what should be done to avoid the potential laboratory accidents and what to do if the laboratory accidents occur. For examples, if mercury is poured, which may cause poisoning, sulphur should be used to prevent its evaporation; knowing that spirit contains alcohol, which is volatile, and that while using a spirit stove these should be taken into consideration and the type of glass used in experiment tubes should be knowed.

Eddy (1996) carried out a study on the comprehension of chemophobia. In the study it was found that during studying, mixing or transmitting unfamiliar chemicals, students experience anxiety. Mallow (2006) argued that science anxiety can be defined as fear of learning science. It may be originated from negative thoughts about science, lack of analytical thinking at the early levels of education and from teachers or role models. Bowen (1999) first used the term chemistry laboratory anxiety and developed Chemistry Laboratory Anxiety Instrument. The scale has the following sub dimensions; working with chemicals, using equipment and procedures, collecting data, working with other students and having adequate time. These dimensions may refer to the laboratory usage techniques (Bowen, 1999). Students may also have anxiety about other courses (Berber, 2013; Azizoglu & Uzuntiryaki, 2006; Bowen, 1999; Eddy, 1996). For instance, Berber (2013) concluded that during the physics laboratory students experience anxiety while drawing graphics and studying independently. In addition, it was found that students reported to have difficulty in understanding the goal of laboratory work, in converting units and in using laboratory materials.

In order to comprehend a concept about science education it should be well known. Belief and attitude, which is related to individuals' experience and acts and which can be learned, are not the same (Koballa, 1988). Attitude statements refer to one's attitude towards science such as "I like science", "I hate science", and "science is horrible". However, such statements as "science is complex", "science mostly covers mathematics" are about beliefs of individuals (Koballa & Crawley, 1985). Perception is a general concept and includes attitudes, views, beliefs or thought. Wells (2003) developed Chemistry Perception Qestionnaire in order to reveal students' perceptions about chemistry. The sub dimensions of the scale are aptitude, chemophobia, discipline, ethnicity and gender (Wells, 2003).

Aim of the present study is to analyze the effect of laboratory activities which depend on laboratory usage techniques on science teacher canditates' laboratory anxiety and chemistry perception. In parallel to this aim the study attempts to answer the following research questions:

1. Is there any effect of laboratory experiments which are convenient with laboratory usage techniques on science teacher canditates' laboratory anxiety?

2. Is there any effect of laboratory experiments which are convenient with laboratory usage techniques on on science teacher canditates' perceptions about chemistry?

Method

The participants of the study were a total of 41 science teacher canditates, who registered the course General Chemistry Laboratory-II at Bartın University during the spring semester of the academic year 2013-2014. The data of the study were collected by using Chemistry Laboratory Anxiety Instrument and Chemistry Perception Questionnaire. The study was designed as a pre-post test without control group research. Karasar (2012) argued that in the model of one group pre-post test independent variable is implemented on the group and before and after the implementation it is measured. The independent and dependent variables employed in the study are as follows:

Dependent variable 1: Laboratory anxiety

Dependent variable 2: Chemistry perception

Independent variable: The implementation process of the laboratory experiments carried out taking into consideration the laboratory usage techniques

The laboratory usage techniques refer to the safety of teacher, students, equipment and school during the experiemntal activities in laboratory, the technical specifications and the use of the laboratory equipment, properties of chemicals and the techniques of the use of them, inefficient reactions of teachers and students in the face of undesirable events in laboratory and approaching problems using a scientific approach (Aydogdu & Candan, 2012; Aydogdu & Şener, 2016).

Data collection tools

Chemistry Laboratory Anxiety Scale

Chemistry Laboratory Anxiety Instrument was developed by Bowen (1999) and adopted into Turkish by Azizoglu and Tiryaki (2006). The scale consists of 20 and 4 subdimensions. The sub-dimensions are as follows: using laboratory equipment and chemicals (6 items), working with other students (4 items), data collection (6 items) and the effective use of laboratory time (4 items). The Cronbach Alpha internal consistency coefficient for the sub-dimensions ranges between 0.86 and 0.88. In the scale there are fifteen positive and five negative items (Azizoglu & Tiryaki, 2006).

Chemistry Perception Questionnaire

Wells (2003) developed Chemistry Perception Questionnaire, which was adopted into Turkish by Tosun (2013). The scale is consisted of twenty items and five subdimensions. The subdimensions included in the scale are gender (5 items), value (5 items), chemophobia (3 items), the scope of chemistry (4 items) and aptitude (3 items). The Cronbach Alpha internal consistency coefficients for the subdimensions range between .445 and .864. The Cronbach Alpha internal consistency coefficient for the scale as a whole is .745 (Tosun, 2013).

Chemistry Laboratory Anxiety Instrument and Chemistry Perception Questionnaire were used as both pre-test and post-test. Following the implementation science teacher canditates' pretest and posttest scores were compared. Science teacher canditates' anxiety before and after laboratory experiments carried out taking into consideration laboratory usage techniques, perceptions before and after the implementation and the comparison of their anxiety and perceptions were analysed.

Data analysis

The data obtained were analysed using PASW 18 in order to determine whether there is statistically difference between the pre-test and post-test scores, dependent sample t-test was employed. In addition, the scores from the pre-test and post-test were compared.

Findings

Findings related to first sub-problem of research

For Chemistry Laboratory Anxiety Instrument and Chemistry Perception Qestionnaire, the answers of science teacher canditates for the positive statements were coded as fully agree (5), partially agree (4), undecided (3), partially disagree (2), disagree (1). For negative statements the answers were recoded as fully agree (1), partially agree (2), undecided (3), partially disagree (4), disagree (5). The results of dependent sample t-test about the pre-test mean scores and post-test mean scores on Chemistry Laboratory Anxiety Instrument are given in Table 1.

Table 1. *t-test results about the pre-test mean scores and post-test mean scores on the anxiety scale*

		N	$\overline{X}$	sd	df	t	p
Anxiety	**Pre test**	41	70.4	15.17	40	-2.39	.022
	Post test	41	76.3	14.40			

Table 1 presents that there is statistically significant difference between the mean pre-test scores ($\overline{X}$ =70.4, sd=15.17) and mean post-test scores of the participants on the anxiety scale ($\overline{X}$=76.3, sd=14.40) (t (40)= -2.39, p<.05). Table 2 presents the findings about the mean scores in the subdimensions of Chemistry Laboratory Anxiety Scale.

Table 2. *t-test results about the pre-test mean scores and post-test mean scores in the subdimensions of Chemistry Laboratory Anxiety Instrument*

Chemistry Laboratory Anxiety Instrument			**Pre test**		**Post test**		**Sd**	**t**	**p**
Sub dimensions		**N**	$\overline{X}$	**Sd**	$\overline{X}$	**Sd**			
I	Using laboratory equipment and chemicals	41	20.95	6.21	23.80	5.91	40	-2.55	.01
II	Studying with other students		14.87	4.55	14.90	3.77		-0.03	.97
III	Data collection		20.80	5.66	13.78	4.96		-2.20	.033
IV	The effective use of laboratory time		13.78	4.13	14.75	3.65		-2.39	.13

Table 2 shows that the mean scores for three sub-dimensions of the laboratory anxiety scale on the pre-and post-tests are found to be significantly different: using laboratory equipment and chemicals (t (40)=-2.55, p<.05), anxiety about productively use of lab time (t (40)=-0.03, p<.05) and data collection (t (40)=-2.20, p<.05). However, there is no significant difference between the mean scores for studying with other students (t (40)=-2.39, p>.05). Table 3 shows the percentage of the science teacher candidates scores for pre-test and post-test of Chemistry Laboratory Anxiety Instrument based on each item.

Table 3. *Pre-test and post-test percentage distributions of science teacher canditates for items of Chemistry Laboratory Anxiety Instrument*

Item	**Pre test (%)**			**Post test (%)**		
	1-2	**3**	**4-5**	**1-2**	**3**	**4-5**
1	39.0	12.2	48.8	29.3	14.6	56.1
2*	14.6	9.8	75.6	7.3	4.9	87.8
3	43.9	19.5	36.6	36.6	22.0	41.5
4	22.0	14.6	63.4	26.8	12.2	61.0

5	24.4	24.4	51.2	34.1	19.5	46.3
6	34.1	19.5	46.4	14.6	9.8	75.6
7	22.0	19.5	58.6	9.8	12.2	78.0
8	22.0	24.4	53.7	12.2	17.1	70.7
9*	14.6	19.5	65.8	19.5	12.2	68.2
10	22.0	29.3	48.8	22.0	19.5	58.5
11*	29.3	14.6	56.1	26.8	0	73.2
12	39.0	14.6	46.3	12.2	9.8	78.0
13	24.4	19.5	56.1	12.2	17.1	70.7
14	17.1	22.0	61.0	24.4	14.6	61.0
15	22.0	26.8	51.2	12.2	19.5	68.3
16	29.3	9.8	61.0	14.6	4.9	80.5
17	31.7	14.6	53.7	22.0	0	78.1
18*	17.1	31.7	51.3	17.1	19.5	63.4
19	26.8	17.1	56.1	14.6	12.2	73.2
20*	22.0	19.5	58.5	4.9	39.0	56.1

***** positive statements

According to Table 3, in the pre-test the percentages of answers given as partial or full disagreement for negative items (items representing anxiety; 1., 3., 6., 7., 8., 10., 12., 13., 15., 16., 17. and 19.) is less, but it incresases in the post-test. Similarly, in the pre-test the percentage of the answers indicating partial or full agreement to the positive items (items representing non-anxiety; 2., 9., 11. and 18) is less, but it incresases in the post-test. The following is the examples for the items for which an increase was observed:

1. statement "I am anxious when I use chemicals during lab." in the pre-test 48.8% of the participants did not either fully or partially agree with this item. However, in the post-test 56.1% of the participants did not either fully or partially disagree with this item.

2. statement "When I work in the chemistry lab, I feel at ease using the equipment." in the pre-test 75.6% of the participants either fully or partially agree with this item. However, in the post-test 87.8% of the participants either fully or partially disagreed with this item.

3. statement "When I get ready for lab, I get concerned about recording the data we will generate." in the pre-test 36.6% of the participants either fully or partially disagreed with this item. However, in the post-test 41.5 % of the participants either fully or partially disagreed with this item.

6. statement "When I get ready for chemistry lab, I get concerned about the chemicals we will use." in the pre-test 46.4% of the participants either fully or partially disagree with this item. However, in the post-test 75.6 % of the participants either fully or partially disagreed with this item.

7. statement "When working in the chemistry lab, I feel nervous carrying out the lab procedures." In the pre-test 58.6% of the participants either fully or partially disagreed with this item. However, in the post-test 78.0 % of the participants either fully or partially disagreed with this item.

8. statement "I am anxious when I record data during lab." in the pre-test 53.7% of the participants either fully or partially disagreed with this item. However, in the post-test 70.7% of the participants either fully or partially disagreed with this item.

9. statement "I feel comfortable working with other students when I am in lab." in the pre-test 65.8% of the participants either fully or partially agreed with this item. However, in the post-test 68.2% of the participants either fully or partially agreed with this item.

10. statement "When working in the lab, I am nervous about the time it will take." In the pre-test 48.8% of the participants either fully or partially disagree with this item. However, in the post-test 58.5% of the participants either fully or partially disagreed with this item.

11. statement "I am comfortable being near chemicals when I am in lab." in the pre-test 56.1% of the participants fully or partially agreed with this item. However, the percentage of such answers increased to 73.2% to this item.
12. statement "I am anxious when I carry out a lab procedure." in the pre-test 46.3% of the participants fully or partially agreed with this item. However, the percentage of such answers increased to 78.0% to this item.
13. statement "When working in the chemistry lab, I feel nervous about recording the data I will need." In the pre-test 56.1% of the participants fully or partially disagreed with this item. However, the percentage of such answers increased to 70.7% to this item.
15. statement "When preparing for lab, I am concerned about the time available for doing the experiment." in the pre-test 51.2% of the participants fully or partially disagreed with this item. However, the percentage of such answers increased to 68.3% to this item.
16. statement "When working in the chemistry lab, I feel nervous being around the chemicals." In the pre-test 61% of the participants fully or partially disagreed with this item. However, the percentage of such answers increased to 80.5% to this item.
17. statement "I feel anxious when I use equipment during lab." in the pre-test 53.7% of the participants fully or partially disagreed with this item. However, the percentage of such answers increased to 78.1% to this item.
18. statement "When working in the chemistry lab, I feel at ease recording the necessary data." in the pre-test 51.3 % of the participants fully or partially agreed with this item. However, the percentage of such answers increased to 63.4% to this item.
19. statement "When I get ready for chemistry lab, I get concerned about working with other students" in the pre-test 56.1% of the participants fully or partially agreed with this item. However, the percentage of such answers increased to 73.2% to this item.

Findings related to second sub-problem of research

Table 4 shows the results of t-test concerning the pre-test and post-test scores on the Chemistry Perception Qestionnaire.

Table 4. *T-test results of the pre and post-test scores on the Chemistry Perception Qestionnaire*

		N	$\overline{X}$	sd	df	t	p
Perception	**Pre test**	41	76.59	9.21	40	-1.86	.070
	Post test	41	79.15	8.60			

According to Table 4 the mean of pre-test scores ($\overline{X}$=76.59, sd=9.21) and the mean of post-test scores ($\overline{X}$=79.15, sd=8.60) on the chemistry preception scale are not significantly different (t (40)= -1.86, p>.05). Table 5 presents the results of t-test about the pre-test and post-test scores regarding the subdimension of the chemistry perception test.

Table 5. *Results of t-test about the pre- and post-test scores regarding the subdimension of the chemistry perception test*

Chemistry Perception			**Pre test**		**Post test**		**df**	**t**	**p**
Sub dimensions		**N**	$\overline{X}$	**sd**	$\overline{X}$	**sd**			
I	Gender	41	22.71	2.94	22.17	2.80	40	1.23	.23
II	Value		20.61	2.90	20.29	3.30		.73	.47
III	Chemophobia		11.80	2.92	12.51	2.35		-1.68	.09
IV	Scope of chemistry		11.07	2.70	12.39	2.99		-2.67	.01
V	Aptitude		10.39	2.05	11.17	2.45		-2.36	.02

Tablo 5 presents that there is a statistically significant difference between the mean pre-test scores and the mean post-test scores for the subdimensions of the scale: scope of chemistry (t(40)=-2.67, p<.05) and tendency (t(40)=-2.36, p<.05). However, there is not statistically significant difference between the mean pre-test scores and the mean post-test scores for the subdimensions of

the scale: gender (t(40)=1.23, p>.05), value (t(40)=.73, p>.05) and uneasiness (t(40)=-1.68, p>.05). Table 6 shows the percentage of the science teacher canditates' mean scores in pre-test and post-test on the Chemistry Perception Qestionnaire based on each item.

Table 6. *Percantages of the item scores in pre- and post-tests on the Chemistry Perception Qestionnaire*

Item	Pre test (%)			Post test (%)		
	1-2	**3**	**4-5**	**1-2**	**3**	**4-5**
1*	19.5	17.1	63.4	9.8	22.0	68.3
2	9.8	14.6	75.6	12.2	9.8	78.0
3	53.7	22.0	24.4	31.7	29.3	39.1
4	7.3	17.1	75.6	9.8	12.2	78.0
5*	2.4	24.4	73.2	4.9	22.0	73.1
6	36.6	34.1	29.3	14.6	24.4	60.9
7	26.8	22.0	51.2	14.6	36.6	48.8
8	2.4	2.4	95.1	4.9	4.9	90.2
9*	4.9	9.8	85.4	7.3	14.6	78.1
10*	7.3	26.8	64.8	9.8	31.7	58.5
11	12.2	24.4	63.4	4.9	12.2	83.0
12	73.2	12.2	14.7	58.5	14.6	26.8
13	4.9	2.4	92.6	0	7.3	92.6
14	2.4	7.3	92.7	0	7.3	92.7
15	41.5	34.1	24.4	34.1	26.8	39.0
16	2.4	7.3	90.2	2.4	12.2	85.4
17*	7.3	41.5	51.2	14.6	34.1	51.2
18	9.8	9.8	80.5	9.8	9.8	80.5
19	2.4	4.9	95.1	0	2.4	97.6
20*	0	22.0	78.0	2.4	22.0	75.6

*****positive statements

According to Table 6, in the pre-test the disagreement answers (both fully or partially) for the negative items (items 2., 3., 4., 6., 11., 12., 15. and 19.) in the Chemistry Perception Qestionnaire had lower percentages, which increased in the post-test. In regard to the first statement, the answers of "completely agree" and "agree" had lower percentage in the pre test, while it increased in the post test. The following examples reflect such items:

1. statement "Chemistry is interesting to me." in the pre-test 63.4% of the participants fully or partially agreed with this item. However, the percentage of such answers increased to 68.3% to this item.

2. statement "I am afraid that I could get injured in chemistry labs." in the pre-test 75.6% of the participants fully or partially disagreed with this item. However, the percentage of such answers increased to 78.0% to this item.

3. statement "Chemistry has too much math." in the pre-test 24.4% of the participants fully or partially disagreed with this item. However, the percentage of such answers increased to 39.1% to this item.

4. statement "Males are better at chemistry than females are." in the pre-test 75.6% of the participants fully or partially disagreed with this item. However, the percentage of such answers increased to 78.0% to this item.

6. statement "I don't have enough math background to do well in chemistry." in the pre-test 29.3% of the participants fully or partially disagreed with this item. However, the percentage of such answers increased to 60.9% to this item.

11. statement "I am afraid that chemistry might expose me to dangerous chemicals." in the pre-test 63.4% of the participants fully or partially disagreed with this item. However, the percentage of such answers increased to 83.0% to this item.

12. statement "Chemistry has too many concepts or ideas." In the pre-test 14.7% of the participants fully or partially disagreed with this item. However, the percentage of such answers increased to 26.8% to this item.
15. statement "Chemistry requires the learning of too many unrelated facts." in the pre-test 24.4% of the participants fully or partially disagreed with this item. However, the percentage of such answers increased to 39.0% to this item.
19. statement "Chemistry is more difficult for females." In the pre-test 95.1% of the participants fully or partially disagreed with this item. However, the percentage of such answers increased to 97.6% to this item.

Conclusion and Suggestions

The major findings and the suggestions based on these findings of the study which carried out with the aim of examining the effects of the chemistry laboratory experiments performed taking into consideration the laboratory usage techniques on the perceptions and anxiety of science teacher canditates can be given as follows:

The post-test mean scores of science teacher canditates ($\overline{X}$=76.3) are higher than their mean score in the pre-test ($\overline{X}$=70.4) on the chemistry laboratory anxiety scale. The results of t-test showed that this difference is statistically significant (t(40)= -2.39, p<.05). Therefore, it is safe to argue that following the implementation the anxiety of the participants about the chemistry laboratory activities reduced. It was also seen that the percentage of the items on the Chemistry Laboratory Anxiety Instrument mostly increased after the implementation. Concerning the subdimensions of the Chemistry Laboratory Anxiety Instrumentit was found that the anxiety of the participants decreased in terms of using the laboratory materials, using chemicals, working with other students, and time management. These findings are consistent with the previous findings (Anilan et. al., 2009; Erokten, 2010; Can, 2013). Some of the major findings of the studies dealing with the views of the science teacher canditates about the accidents at the science laboratories are as follows: for them the reasons for the accidents at the science laboratories are not knowing the techniques of laboratory usage and of working with chemicals (Aydogdu, 2015). The findings about the subdimensions of the chemistry laboratory anxiety are consistent with the previous findings.

Science teacher canditates' mean post-test scores ($\overline{X}$=76.59) and their mean pre-test scores ($\overline{X}$=79.15) are similar on the Chemistry Perception Qestionnaire. The results of t-test showed that this difference is not statistically significant (t (40)= -1.86, p>.05). However, the percentage of the items on the Chemistry Perception Qestionnaire showed that there was a positive change in the perceptions of the participants about chemistry and chemistry laboratory. Because the post-test scores show that they are less afraid of injuiry during the experiements and being subject to hazardous chemicals during the course. In the laboratory activities performed taking into consideration the laboratory usage techniques they learn what to use how and where. Such a learning positively affect their perceptions about chemistry. In addition, the scores for the two subdimensions of the Chemistry Perception Qestionnaire were found to be statistically significant in t-test: scope of chemistry (t(40)=-2.67, p<.05) and tendency (t(40)=-2.36, p<.05). Wells (2003) argued that tendency refers to one's chemical ability or his interest in chemistry. Therefore, this finding suggests that the interest of the participants in chemistry improved.

In short, laboratory experiments performed taking into consideration the laboratory usage techniques work for the goals. Such laboratory experiments reduce the anxiety of teacher canditates about laboratory and positively affect their perceptions. In laboratory work it seems that the information and skills of teacher canditates improve. However, future studies should be expanded to analyse the level of anxiety and perceptions of science teacher canditates to make it easier for them to employ the laboratory use techniques.

References

Alkan, F. & Erdem, E. (2013). The effect of self-directed learning on the success, readiness, attitudes towards laboratory skills and anxiety in laboratory. *Hacettepe University Journal of Education, 44,* 15-26.

Anilan, B., Gorgulu, A. & Balbag, M. Z. (2009). Anxiety of teaching canditates over chemistry labs (an example of ESOGU). *e-journal of New World Sciences Academy, 4*(3), 954-974.

Aydogdu, C. & Candan S. (2012). Fen ve teknoloji dersine ait bazı etkinliklerin laboratuvar kullanım tekniği açısından incelenmesi. Journal of Contemporary Education Academic,1(4), 32-43.

Aydogdu, C. & Şener, F. (2016). Fen eğitiminde laboratuvar kullanım tekniğinin ve güvenliği önemi ve CLP tüzüğünün getirileri üzerine bir araştırma. *Eskişehir Osmangazi Üniversitesi Türk Dünyası uygulama ve Araştırma Merkezi (ESTÜDAM) Eğitim Dergisi*,1(1).

Aydogdu, C. & Yardimci E. (2013). Accidents occured in elementary science laboratories and teachers' behaviour manners toward these accidents. *Hacettepe University Journal of Education, 44,* 52-60.

Aydogdu, C. (1999). Kimya laboratuvar uygulamalarında karşılaşılan güçlüklerin saptanması. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi, 15*, 30-35.

Aydogdu, C. (2012).The effect of problem based learning strategy in electrolysis and battery subject teaching. *Hacettepe University Journal of Education, 42,* 48-59.

Aydogdu, C. (2015). Science and technology teachers' views about the causes of laboratory accidents. *International Journal of Progressive Education, 11*(3),106-120.

Azizoglu, N. & Uzuntiryaki, E. (2006). Chemistry laboratory anxiety scale. *Hacettepe University Journal of Education, 30,* 55-62.

Berber, N. C. (2013). Anxieties, preferences, expectations and opinions of pre-service teachers related to physic laboratory. *Educatioanl Research and Reviews, 8*(15), 1220-1230.

Bowen, C. W. (1999). Development and score validation of a chemistry laboratory anxiety instrument (CLAI) for college chemistry students. *Educational and Psychological Measurement, 59*(1), 171-187.

Boyuk, U., Demir, S. & Erol, M. (2010). Analyzing the proficiency views of science and technologyteachers on laboratory studies in terms of different variables. *TUBAV Bilim Dergisi, 3*(4), 342-349.

Can, S. (2013). Pre-service science teachers' concerns about chemistry laboratory (case of Muğla University-Turkey). *Procedia-Social and Behavioral Sciences, 106*, 2102-2111.

Eddy, R. M. (1996). *Chemophobia in the college classroom: Extent, sources and student characteristics.* Unpublished doctoral dissertation. University of Pittsburgh.

Erokten, S., (2010). The evaluation of chemistry laboratory experiences on science students' anxiety levels. *Hacettepe University Journal of Education, 38,* 107-114.

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.

Hofstein, A. & Lunetta, V. N. (1982). The role of the laboratory in science teaching: neglected aspects of research. *Review of Educational Research, 52,* 201-217.

Hofstein, A. & Mamlok-Naaman. (2007). The laboratory in science education: the state of the art. *Chemistry Education Research and Practice, 8*, 105-107.

Karasar, N. (2012). *Bilimsel araştırma yöntemleri,* Nobel Yayınevi, Ankara.

Koballa, T. R. & Crawley, F. E. (1985). The influence of attitude on science teaching and learning. *School Science and Mathematics Volume 85*(3), 222-232.

Koballa, T. R. (1988). Attitude and related concepts in science education. *Science Education 72*(2), 115-126.

Lawson, A. E. (1995). *Science teaching and the development of thinking* (Second edition). Belmont, California: Wadsworth Publishing Company.

Mallow, J. (2006). *Science anxiety: research and action*. National Science Teacher Association.

Tosun, C. (2013). Adaptation of chemistry perception questionnaire into Turkish: a validity and reliability study with exploratory and confirmatory factor analysis. *Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education. 7*(1), 142-165.

Wells, R. R. (2003). *The development of an instrument to assess chemistry perceptions.* Doctoral Dissertation. Texas Tech University.

Yilmaz, A. (2004). The knowledge levels of the students about the chemical substances used in the experiments available in the high school 3rd class chemıstry book regarding their dangerous features related to human health and laboratory security and suggestions. *Hacettepe University Journal of Education, 27,* 251-259.