

INVESTIGATION OF PRE-SERVICE CHEMISTRY TEACHERS' CHEMISTRY LABORATORY ANXIETY LEVELS

Dr. Ebru KAYA
Selcuk University
Konya, TURKEY

Assist. Prof. Dr. Pinar Seda CETIN
Abant Izzet Baysal University
Bolu, TURKEY

ABSTRACT

This study aimed to determine pre-service chemistry teachers' anxiety levels in chemistry laboratory with respect to their grade level and gender and the relationship between pre-service chemistry teachers' laboratory anxiety levels and their achievement in chemistry laboratory. The participants are pre-service chemistry teachers in a public university in Turkey. Chemistry Laboratory Anxiety Scale developed by Bowen (1999) was used to identify their anxiety levels. This scale adapted into Turkish by Azizoglu and Uzuntiryaki (2006) includes four subscales: using equipment and chemicals, working with other students, collecting data, and having adequate time. MANOVA was used to analyze the difference between pre-service chemistry teachers' whole scores of chemistry laboratory anxiety scale and scores of each factor in this scale regarding gender and grade levels. In addition, the correlation coefficient was calculated to find the relationship between their anxiety and achievement levels. The results show that gender and grade level are not effective in laboratory anxiety levels. Furthermore, a significant relationship was found between both anxiety about using equipment and chemicals, and laboratory achievement, and anxiety about having adequate time and laboratory achievement. The study also presents some implications about the role of students' anxiety levels in their achievement in chemistry.

Key Words: Chemistry Laboratory, Anxiety, Pre-service Teachers.

INTRODUCTION

Laboratory activities as students' learning experiences to interact with materials and/or with models in order to observe and understand the connection between science and the natural world are of valuable importance in science and chemical education (Hofstein & Lunetta, 2004; Lunetta, 1998). These activities have a potential to enhance students' conceptual understanding, development of some affective dimensions such as motivation and attitude with respect to science learning, scientific practical skills and problem solving abilities, and understanding of nature of science (Bowen, 1999; Hofstein & Lunetta, 2004). In addition, students have a chance to construct social relationships in a laboratory environment because they work cooperatively in small groups in this environment (Hofstein & Lunetta, 1982; Lazarowitz & Tamir, 1994).

The literature presents some evidence that students' attitudes toward science and their anxiety levels with respect to science courses affect their learning or achievement in science (Atwater, Gardner, & Wiggins, 1995; Koballa & Glynn, 2007; Osborne & Collins, 2000; Simpson & Oliver, 1990). The students with more positive attitude toward science or chemistry are likely to be more successful in science or chemistry lessons (McCarthy & Widanski, 2009). Therefore, in a laboratory environment, students are aimed to be able to not only design experiments and make observations, but also develop more positive attitude and decreased anxiety. Anxiety as one of the affective dimensions of learning has a detrimental effect on students' learning and performance in a laboratory environment as well as classroom environment (Bowen, 1999; Ericson & Gardner, 1992; Keeves &

Morgenstern, 1992). Students' anxiety levels related to chemistry laboratory also has a key role in their attitudes toward chemistry and their achievement in the laboratory. Students might give more importance and are interested in the issues related to safety and risks than chemistry learning in chemistry laboratory (Högström, Ottander, & Benckert, 2010). Furthermore, students need to be given sufficient time and opportunities for interaction and reflection in chemistry laboratory (Gunstone & Champagne, 1990). Using chemical materials and using time effectively to complete an experiment are some issues about which students might have anxiety in chemistry laboratory (Eddy, 2000). Hofstein and Lunetta (2004) argue that teachers' expectations and assessment practices affect students' perceptions of laboratory. An anxious student about chemistry laboratory is likely to have a poor performance in carrying out laboratory activities. That is to say, chemistry laboratory anxiety has a negative effect on students' self efficacy in performance in chemistry laboratory (Kurbanoglu & Akim, 2010). Therefore, determining the extent and the sources of students' chemistry laboratory anxiety will be useful in selecting the way for reducing anxiety levels of the students (Azizoglu & Uzuntiryaki, 2006).

Some research has focused on the relationship between chemistry laboratory anxiety and other variables such as attitude and self efficacy (e.g. Kurbanoglu & Akim, 2010), some focused on just determining the chemistry anxiety levels of the students (e.g. Eddy, 2000), and some investigated the effect of some techniques to reduce students' anxiety levels about chemistry or chemistry laboratory (e.g. Abendroth & Friedman, 1983; Erokten, 2010). For example, Kurbanoglu and Akim (2010) investigated the relationship between university students' laboratory anxiety, chemistry attitudes, and self efficacy beliefs. Chemistry Laboratory Anxiety Scale, the Chemistry Attitudes Scale, and the Self-efficacy Scale were administered to 395 first year undergraduates from four universities. The results show that chemistry laboratory anxiety was correlated negatively to chemistry attitudes and to self-efficacy. Additionally, self-efficacy predicted chemistry laboratory anxiety in a negative way.

Eddy (2000) used Derived Chemistry Anxiety Rating Scale in order to measure college students' anxiety levels related to learning chemistry, being evaluated in chemistry, and handling chemicals. He found that students' mean scores with respect to three subscales of the instrument were significantly different from each other. The order of mean anxiety scale from highest to lowest was chemistry evaluation, handling chemicals, and learning chemistry. Additionally, interview results show that math, answering questions in class, and the lack of relation to life contributed to high anxious students' anxiety about learning chemistry. The researchers also addressed that their handling chemistry anxiety results from Bunsen burner, fire, unstructured labs, acid burns, explosions, and getting chemicals on skin. His study also presents that women had significantly higher anxiety levels than men with respect to chemistry anxiety scale. This finding is also consistent with the Cooper's study. Cooper (1994) also points out that girls have poor performance in chemistry laboratory because of anxious feeling when compared to boys.

McCarthy and Widanski (2009) assessed chemistry anxiety levels of 264 undergraduate students enrolled in introductory psychology, general chemistry, and organic chemistry courses through the use of Derived Chemistry Anxiety Rating Scale with three subscales. They found a significant difference between anxiety levels of males and females with respect to chemistry evaluation. Females were more anxious about chemistry evaluation. In addition, there was a significant mean difference between college majors which are science, allied health, social science, business, education, and tech with respect to learning chemistry anxiety. Another finding was that students who had never taken a chemistry course had higher learning chemistry anxiety levels. They suggest that the first step in reducing students' negative attitudes toward chemistry is determining the existence of chemistry anxiety. Decrease in these negative attitudes would lead to increased student enrollment and achievement in chemistry courses.

Abendroth and Friedman (1983) point out that the college students were especially anxious about grade, mathematical problems, and working in a laboratory. The researchers designed a quasi-experimental study.

The control and experimental group consisted of 17 and 23 students, respectively. In the experimental group, a treatment including recognizing anxiety, talking about them, and experiencing some relaxation techniques was applied in the chemistry lab sessions to reduce students' chemistry anxiety and increase their achievement. The results show that this treatment technique reduced students' chemistry anxiety levels. Another study was designed by Erokten (2010) to examine the effect of chemistry laboratory activities on pre-service science teachers' chemistry laboratory anxiety levels. In order to determine pre-service teachers' anxiety levels, Chemistry Laboratory Anxiety Scale was administered to 100 pre-service teachers as a pre-test at the beginning of the semester and as a post-test at the end of the semester. The results show that pre-service science teachers' chemistry laboratory anxiety levels decreased through the laboratory activities.

The chemistry laboratory learning is one of the important components of chemistry learning. Furthermore, achievement in chemistry laboratory has a key role in self efficacy beliefs regarding chemistry. Therefore, pre-service chemistry teachers' anxiety levels affect their achievement in laboratory as well as students. The research about pre-service teachers' chemistry laboratory anxiety is needed to give insight to chemistry teacher education. Therefore, the present study aims to determine pre-service chemistry teachers' chemistry laboratory anxiety levels.

Research Questions

1. Is there a significant mean difference between male and female pre-service chemistry teachers' levels of whole chemistry laboratory anxiety scale and each factor in this scale?
2. Is there a significant mean difference among pre-service chemistry teachers' levels of whole chemistry laboratory anxiety scale and each factor in this scale with respect to their grade levels?
3. Is there a significant relationship between pre-service chemistry teachers' achievement in chemistry laboratory and their levels of whole chemistry laboratory anxiety scale, and each factor in this scale?

METHODOLOGY

Sample of the Study

The sample of the study was 131 pre-service chemistry teachers (78 females and 53 males) from a public university in Turkey. Pre-service teachers varied from first grade to fifth grade level (25 first graders, 25 second graders, 31 third graders, 28 fourth graders, and 22 fifth graders). The pre-service teachers had different experience in chemistry laboratory in terms of time spending in laboratory. Their achievement was evaluated based on the specific laboratory course that they took in their academic term. For instance, general chemistry laboratory score was considered for first graders, analytical chemistry laboratory score for second graders, organic chemistry laboratory score for third graders, physical chemistry laboratory-I score for fourth graders, and physical chemistry laboratory-II score for fifth graders.

Instrument

In order to measure pre-service teachers' chemistry anxiety levels Chemistry Laboratory Anxiety Scale was used. This instrument was originally developed by Bowen (1999) and adapted into Turkish by Azizoglu and Uzuntiryaki (2006). It consists of 20 items (15 positive and 5 negative items) with a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The scale is presented in the Appendix A. There are four factors in the adapted version of the scale whereas the original scale consists of five factors. These factors and related item numbers are presented in Table 1.

Table 1: Factors of Chemistry Laboratory Scale

<i>Factors</i>	<i>Item numbers</i>
Using equipment and chemicals	1, 2, 6, 11, 16, 17
Working with other students	4, 9, 14, 19
Collecting data	3, 7, 8, 12, 13, 18
Having adequate time	5, 10, 15, 20

The participants completed the questionnaire individually in approximately 20 minutes. The Cronbach-alpha reliability scores are 0.88 for the first factor, 0.87 for the second factor, 0.86 for the third factor, and 0.87 for the fourth factor.

RESULTS

Table 2 and Table 3 present the descriptive statistics of pre-service teachers' whole anxiety levels and each factor level with respect to their gender and grade levels, respectively.

Table 2: Descriptive Statistics of Pre-service Teachers' Anxiety Scores with respect to Gender

<i>Gender</i>	<i>Anxiety Levels</i>	<i>N</i>	<i>Min.</i>	<i>Max.</i>	<i>Mean</i>	<i>Standard Deviation</i>
Female	Whole scale	78	20.0	65.0	46.5	10.4
	Using equipment and chemicals	78	6.00	26.0	14.4	4.51
	Working with other students	78	4.00	16.0	8.41	3.01
	Collecting data	78	6.00	25.0	14.9	4.08
	Having adequate time	78	4.00	15.0	8.82	2.47
Male	Whole scale	53	20.0	95.0	46.2	14.7
	Using equipment and chemicals	53	6.00	30.0	14.8	5.62
	Working with other students	53	4.00	19.0	8.49	3.48
	Collecting data	53	6.00	29.0	13.8	4.90
	Having adequate time	53	4.00	19.0	9.11	3.29

When Table 2 is examined, it is seen that the mean total score of males and females is very similar ($\bar{X}_f = 46.5$; $\bar{X}_m = 46.2$). Additionally, as seen in Table 3, it can be noticed that anxiety level does not change with grade level.

Table 3: Descriptive Statistics of Pre-service Teachers' Anxiety Scores with respect to Grade Level

<i>Grade</i>	<i>Anxiety Levels</i>	<i>N</i>	<i>Min.</i>	<i>Max.</i>	<i>Mean</i>	<i>Standard Deviation</i>
1	Whole scale	25	22.0	63.0	43.8	11.5
	Using equipment and chemicals	25	6.00	24.0	13.5	4.50
	Working with other students	25	4.00	14.0	7.64	2.80
	Collecting data	25	6.00	23.0	14.3	4.38
	Having adequate time	25	4.00	15.0	8.36	2.80
2	Whole scale	25	34.0	79.0	46.3	10.7
	Using equipment and chemicals	25	8.00	25.0	14.3	3.95
	Working with other students	25	4.00	16.0	8.48	2.55
	Collecting data	25	8.00	25.0	14.5	4.16

	Having adequate time	25	5.00	15.0	9.04	2.46
3	Whole scale	31	20.0	72.0	44.3	12.6
	Using equipment and chemicals	31	6.00	21.0	14.3	4.60
	Working with other students	31	4.00	16.0	8.17	2.75
	Collecting data	31	6.00	24.0	13.5	4.38
	Having adequate time	31	4.00	13.0	8.36	2.74
4	Whole scale	28	20.0	72.0	44.3	12.6
	Using equipment and chemicals	28	6.00	21.0	14.3	4.60
	Working with other students	28	4.00	16.0	8.18	2.75
	Collecting data	28	6.00	24.0	13.5	4.38
	Having adequate time	28	4.00	13.0	8.36	2.74
5	Whole scale	22	20.0	64.0	48.0	9.66
	Using equipment and chemicals	22	6.00	28.0	15.0	5.19
	Working with other students	22	4.00	16.0	9.40	3.92
	Collecting data	22	6.00	21.0	14.6	3.84
	Having adequate time	22	4.00	15.0	9.40	2.52

In order to answer our first research question which is related to mean difference between male and female pre-service chemistry teachers' total chemistry laboratory anxiety scores and scores of each factor in chemistry laboratory anxiety scale, MANOVA was used. The results show that there was not a significant mean difference for male and female pre-service teachers; Wilks' $\lambda = .950$, $F(1,129) = 1.67$, $p > 0.05$. These results suggest that pre-service chemistry teachers' anxiety levels are not affected by their gender.

In order to answer our second research question which is related to mean difference among pre-service chemistry teachers' total and sub- chemistry laboratory anxiety scores with respect to their grade levels we conducted another MANOVA. The results point out that there was not a significant effect of grade level on students' whole scores in anxiety scale and each factor scores in the scale (Wilks' $\lambda = .929$, $F(4, 126) = 0.571$, $p > 0.05$).

In order to answer third research question, we investigated the correlation between pre-service chemistry teachers' achievement in chemistry laboratory and their levels of whole chemistry laboratory anxiety scale, and each factor in this scale. Table 4 shows that there is a negative significant correlation between levels of whole chemistry laboratory anxiety scale and achievement scores, $r = -0.198$, $n = 131$, $p = 0.024$. The results also indicate that the correlation between pre-service teachers' laboratory achievement is significantly correlated with their anxiety about having adequate time ($r = -0.238$, $n = 131$, $p = 0.006$) and using equipment and chemicals ($r = -0.014$, $n = 131$, $p = 0.024$).

Table 4: Correlations between Anxiety Levels and Achievement Scores

	Achievement		N
	Pearson Correlation	Sig.(2 tailed)	
Laboratory achievement	1	.	131
Whole chemistry laboratory anxiety scale	-,198*	,024	131
Using equipment and chemicals	-,238**	,006	131
Working with other students	-,002	,981	131
Collecting data	-,144	,101	131
Having adequate time	-,215*	,014	131

** .Correlation is significant at the 0.01 level (2-tailed)

* .Correlation is significant at the 0.05 level (2-tailed)

We can conclude that pre-service teachers who had high anxiety about using equipment and chemicals in the laboratory had low achievement in chemistry laboratory. Similarly pre-service teachers, who were anxious about having adequate time, got lower scores in their chemistry laboratory.

DISCUSSION

In this study, pre-service chemistry teachers' chemistry laboratory anxiety levels were examined in terms of gender and grade level. Furthermore, the relationship between pre-service teachers' chemistry laboratory anxiety levels and their achievement in chemistry laboratory was investigated. Although some research findings point out that gender is an important contributor to students' science anxiety in the literature (e.g. Udo, Ramsey, Reynolds-Alpert, & Mallow, 2001), our study documents that gender is not effective in pre-service teachers' chemistry laboratory anxiety levels as consisted with the results of some other research about science anxiety, chemistry anxiety, or laboratory anxiety (e.g. Brownlow, Jacobi, & Rogers, 2000; Davis, 1987; McCarthy & Widanski, 2009). Another finding of this study show that Grade level had not a significant effect on pre-service chemistry teachers' chemistry laboratory anxiety levels. In fact, this result is unexpected because students' experience in laboratory is expected to affect students' anxiety related to laboratory. However, the results indicated that when grade level is increased, students still have similar anxiety levels. A possible explanation for this finding might be the deficiency in teachers' or instructors' consideration of anxious students' in the laboratories. We found a negative relationship between pre-service-teachers' chemistry laboratory anxiety levels and their achievement in chemistry laboratory. There is a widespread consensus in the literature about the relationship between students' anxiety levels and their achievement in science and laboratory courses (Czerniak & Chiarelott, 1985; Zoller & Ben-Chaim, 1988). The results of this study also show that students having high anxiety about "having adequate time" and "using equipment and chemicals" in the laboratory had low achievement in chemistry laboratory.

This study has some implications in chemical education. Students' engagement of appropriate learning strategies in the classroom or laboratory may help them to develop more positive attitude toward lesson and reduce anxiety levels (Feldman, Martinez-Pons, & Shaham, 1995; Kurbanoglu & Akim, 2010; VanZile-Tamsen & Boes, 1997). Therefore, instructors should determine anxious students in the laboratory and use effective instructional strategies to reduce anxiety levels of these students. By this way, a more effective learning environment can be created. As Tan (2008) suggested, defining objectives of the tasks, more engagement of exploration, reflection, and argumentation based activities in the laboratory, and designing more purposeful laboratory tasks might be helpful in reducing or controlling students' anxiety levels in the laboratory. Some instructional strategies that promote students to be actively involved in classroom discourse might also effective in overcoming anxious students in chemistry laboratory. In addition, laboratory activities should be consistent with students' intellectual level otherwise this might increase students' anxiety levels. Furthermore, teachers' attitudes toward students in science lessons and laboratory sessions might lead to increase the number of anxious students (Udo et al., 2001). In conclusion, for a more effective learning environment in chemistry laboratory, anxious students should be determined and instruction in the laboratory should be designed by considering these students. Additionally, while preparing laboratory activities, the ways of reducing students' anxiety levels should be taken into consideration. For further research, the relationship between chemistry laboratory anxiety levels and other variables such as attitude and self-efficacy can be investigated in different contexts. Furthermore, qualitatively designed research focusing on the reasons of students' laboratory anxiety might give more detailed information about chemistry laboratory anxiety.

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BIODATA AND CONTACT ADDRESSES OF AUTHORS



Ebru KAYA is a doctor research assistant in Selcuk University. She received her Ph.D. in Secondary Science and Mathematics Education Department from Middle East Technical University, MSc and BSc in Secondary Science and Mathematics Education Department from Dokuz Eylul University. Her research field is conceptual change, argumentation in science education, philosophy of chemistry, and anxiety in science education.

Dr. Ebru KAYA
Konya University, A.K. Education Faculty
No: B/204, 42090
Meram-Konya/TURKEY
Phone: +90 (332) 3238220/5820
Fax: +90 (332) 3238225
E. Mail: ebrukaya@gmail.com



Pinar Seda CETIN is an assistant professor in Abant Izzet Baysal University. She received her MSc, BSc and Ph.D. in Secondary Science and Mathematics Education Department from Middle East Technical University. Her research interest is misconceptions in chemistry; conceptual change; argumentation in science education; and affective variables in science education.

Assist. Prof. Dr. Pinar Seda CETIN
Abant Izzet Baysal University
Education Faculty, No: 107, 14280
Bolu/TURKEY

Phone: +90 (374) 2541000/1672
Fax: +90 (374) 2534641

E. Mail: pnrsarier@gmail.com

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